

School related anxiety, school performance, mental flexibility, emotional eating and frontal alpha EEG asymmetry of girls aged 9-10, with obesity and normal weight

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Background

Obesity is recognized as an inter-disciplinary issue since the risk factors and related issues have medico-biological, social and psychological causes. Children obesity is a serious concern because of how vulnerable the body of a growing child is. Researchers stress the importance of studying psychological issues associated with obesity since they have a mutual impact upon each other: psychosocial factors may result in an increased risk of obesity, just as obesity may cause psychological issues [1], one of which is increased level of anxiety [2,3]. The level of anxiety is a reflection of an individual's resilience to psychosocial stressors. For children of school age, the main part of their social life is occupied by their studies at school, and anxiety may have a negative correlation with their performance, which in turn may have an impact on the efficiency and quality of their adult life [4]. According to numerous research, the asymmetry of spectral power (SP) of EEG alpha activity in frontal lobe leads serves as a neurophysiological marker of the individual's emotional background, as well as their sensitivity to awards and punishment in motivational processes [5]. An increased activity of the frontal cortex of left brain in relation to the symmetric area in the right brain in rest condition, which manifests as a reduced SP of the alpha activity in the left brain relative to the right brain, is an indicator of a positive emotional background, an individual's increased sensitivity to awards, and prevalence of goal-directed approach behavior, whereas an increased activity of the right frontal cortex is associated with vulnerability to depression and anxiety, an increased sensitivity to punishment, and a preference of a behavioral strategy aimed at avoidance [6-9]. Healthy people with high reward sensitivity have an enhanced level of mental flexibility [10]. In literature, there has been a discussion of the asymmetry of activity of the pre-frontal cortex associated with eating behavior [11]. A link has been established between the relative hyper-activity of the prefrontal cortex in the left brain and over-eating and other complications in eating behavior, for example bulimia [12], a disorder characterized by a negative emotional background and reduced mental flexibility [13]. In this regard, it is assumed [12] that the lateral asymmetry of activity in the pre-frontal cortex may serve as an indicator of motivational orientation of one's behavior (approach vs. withdrawal), irrespectively of the sign of the associated emotions. In particular, it has been assumed that the subjects with obesity who have an increased activity of the left pre-frontal cortex have a tendency toward over-nutrition [12].

Objective

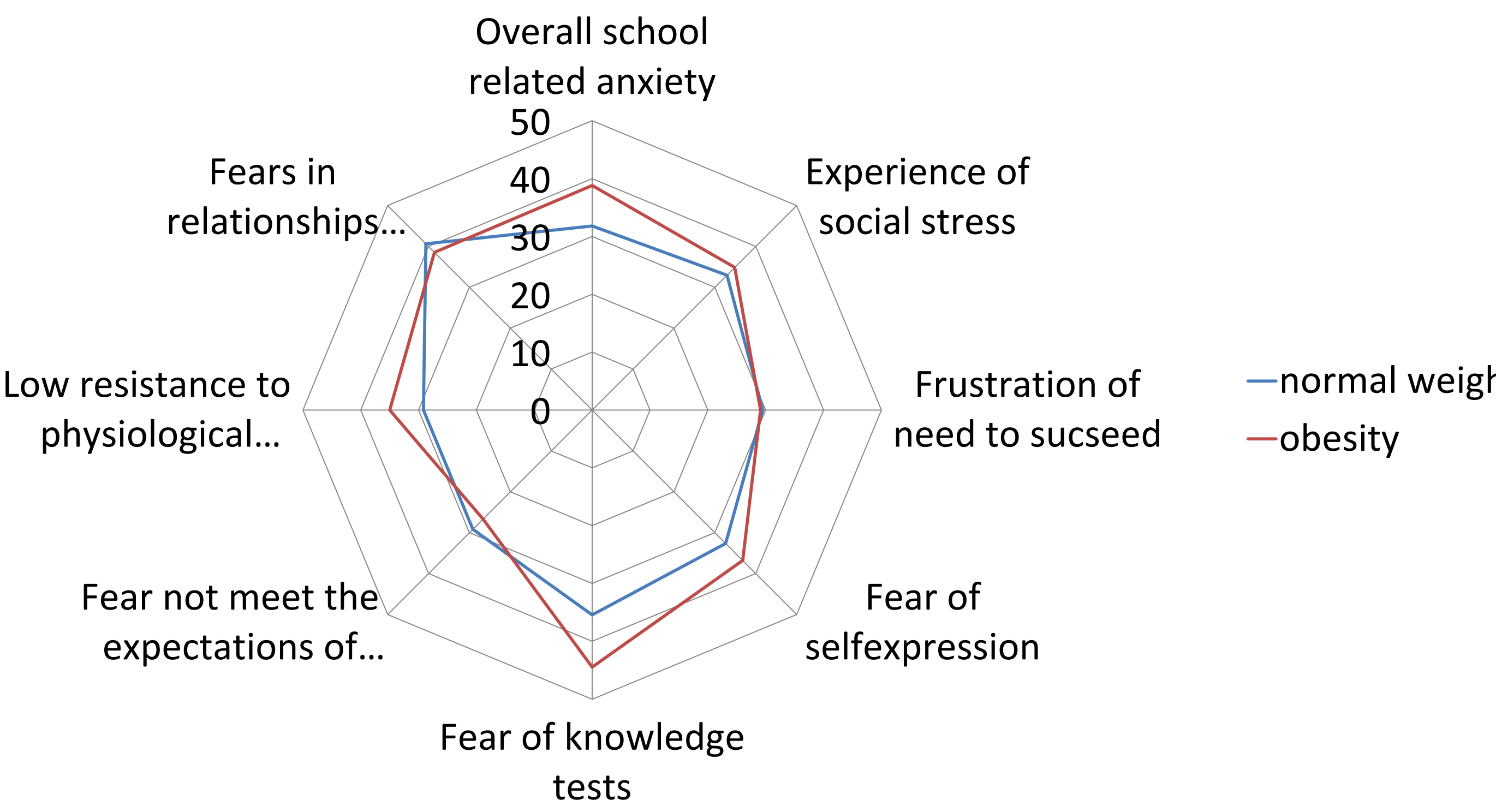
To explore interrelationships between anthropometric markers of obesity, school anxiety, school performance, mental flexibility, emotional eating and frontal alpha EEG asymmetry in girls aged 9-10.

Participants and Methods

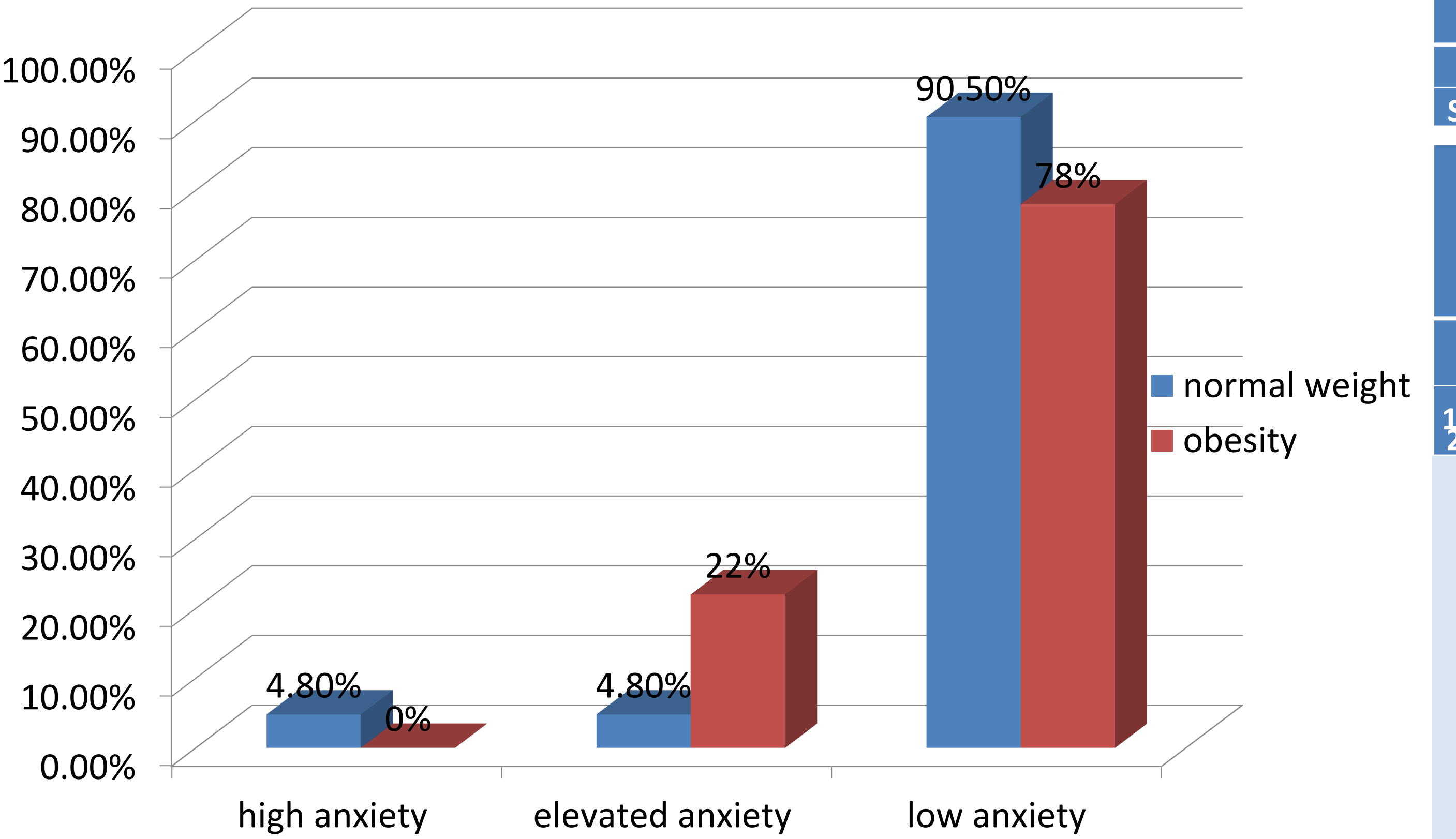
The studied groups included girls who had not been diagnosed with any psycho-neurological disorders and whose EEG, in resting state, demonstrated a steady alpha activity—a total of 27 girls with obesity and 23 girls with normal weight. Children's weight status was determined in accordance with the WHO BMI-for-age standards. We also determined such anthropometric markers of obesity as fat in body composition, waist circumference, and waist-to-hip ratio. The level of school-related anxiety was determined using the *Philips'* questionnaire [14], which evaluates anxiety levels using a scale of eight: overall school anxiety, experience of social stress, frustration in need to succeed, fear of self-expression, fear of knowledge tests, fear of not meeting the expectations of others, a low physiological resistance to stress, and fears in relationships with teachers. School performance was calculated by averaging the annual points across the entire range of study subjects; flexibility was evaluated using a computer test.

Methods

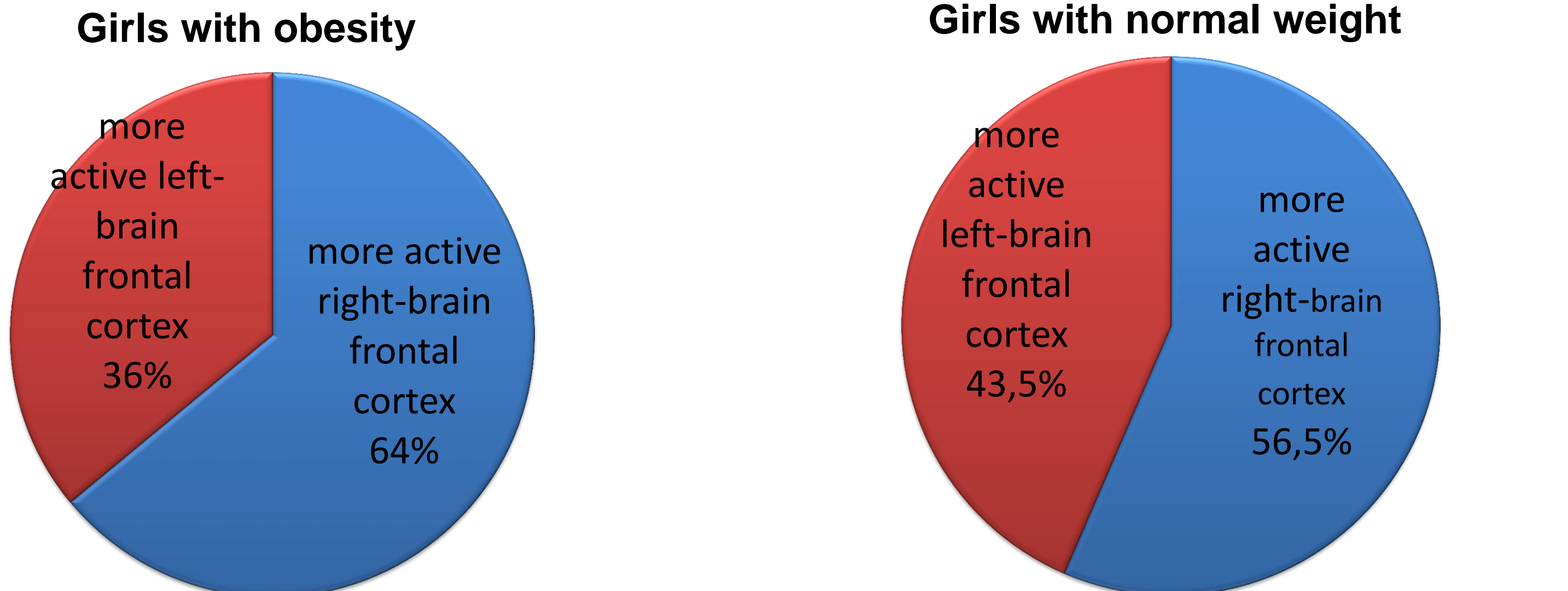
The EEG was registered in a state of rest with eyes closed for a period of three minutes, using a monopolar method (with a unified ipsilateral ear electrode serving as reference) with 19 scalp sites according to the international system 10-20%, with sampling rate of 500 Hz. Only those sections of the EEG that had no artifacts were included in the analysis. The artifacts were determined visually in an off-line mode, and were removed manually. Using the software that came with the EEG equipment, the SP of alpha rhythms (8—13.9 Hz) was determined in the frontal lobe leads F3 and F4 in rest condition with closed eyes. The frontal alpha EEG-asymmetry (FAA) was calculated according to the following formula: FAA = (SP(F4) – SP(F3))/(SP(F4) + SP(F3)). Positive FAA values signaled an increased activity of the left frontal lobe with respect to the right frontal lobe, and negative FAA values spoke of the opposite, since the alpha rhythms experience a reduction when the functional activity of the cortex is increased. [7]. The statistical analysis was performed using the SPSS 16.0 software. We compared the average anxiety and achievement scores of the two groups using the Student's test, since the measured parameters had a normal distribution, as well as the frequency of girls with different levels of anxiety, positive and negative FAA signs in obese and normal-weight groups, using the chi-square test. Additionally, the Pearson coefficient of correlation was evaluated (for normally distributed variables) as well as the Spearman coefficient (for variables whose distribution differed from normal) for all studied parameters.



Pic 1. Girls’ average scores of different scales of school anxiety



Pic2. Number of girls with different levels of overall school related anxiety



Pic. 3. Number of girls with right and left frontal alpha EEG asymmetry

Results and discussion

The obese girls had lower school performance score compared to their lean counterparts: 4.7±0.06 and 4.9±0.03 (p=0.02), respectively, which corresponds to the literature data [15]. The anxiety score, averaged out across the groups (Pic.1) did not reach the level of statistical significance; the girls with obesity had higher points for different scales of anxiety as a tendency (p ranging from 0.18 to 0.84). A larger portion of the girls exhibiting a heightened level of anxiety in the obese girls as compared to the group of girls with normal weight (Pic.2) did not reach the level of statistical significance (p=0.14). The portion of girls with FAA values less than zero (FAA<0) (i.e. whose right-brain frontal cortex was more active than the left-brain) was larger than the portion of girls with FFA>0 (i.e. whose left-brain frontal cortex was more active than the right-brain) in both groups, with the difference more pronounced in the obese group (Pic.3); however, this was not statistically representative (p=0.53 in the normal-weight group, and p=0.16 in the group with obesity). A correlation analysis (Table 1) established a positive correlation between the waist-to-hip ration (WHR) and the level of overall school anxiety, fear of knowledge tests, and low physiological resistance to stress. The direct link between the markers of abdominal obesity and school anxiety which we have established is in agreement with literature data that speak of the increased vulnerability of humans to the stressors who have visceral, not peripheral, fat accumulation, which is directly linked to the level cortisol, the hormone of stress [16]. A negative correlation (Table 1) was established between school performance and waist circumference, level of overall school anxiety, fear of knowledge tests, fear not meet the expectations of others, and low physiological resistance to stress, which also agrees to the results of other studies [4]. No links between FAA, anxiety values and anthropometric markers of obesity were found. However, a correlation analysis conducted separately in the group of girls with obesity and in the group of normal-weight girls detected contradicting trends (Table 2). In the group of lean girls, the BMI have a very strong negative correlation (p=0.06) to the sign of the FAA, whereas in the group of obese girls, to the contrary, the BMI and waist circumference had a positive correlation with the FAA, and the FAA had a negative correlation with mental flexibility. In the lean girls group, the FAA was found to have a negative correlation to the score of experience of social stress, fear of self-expression и emotional eating, which agrees to the literature data of increased anxiety with low FAA values [17].

Table 1	Overall school anxiety	Fear of knowledge tests	Low physiological resistance to stress.	Fear not meet the expectations of others	Waist circumference
Correlation coefficients (CC)					
Waist/hip	0,4 (p=0,007)	0,3 (p=0,05)	0,4 (0,004)	0,1 (p=0,4)	0,5 (p=0,002)
School performance	-0,4 (p=0,002)	-0,4 (p=0,001)	-0,4 (p=0,001)	-0,3 (p=0,06)	-0,3 (p=0,002)

Table 2	BMI		Waist circumference		Experience of social stress		Fear of selfexpression		Emotional eating (1 – prone to emotional eating, 0 – not prone)		Mental flexibility	
CC	obesity	normal weight	obesity	normal weight	obesity	normal weight	obesity	normal weight	obesity	normal weight	obesity	normal weight
FAA	0,6 (p=0,002)	-0,3 (p=0,2)	0,6 (p=0,003)	-0,2 (p=0,5)	0,2 (p=0,3)	-0,5 (p=0,03)	0,3 (p=0,2)	-0,5 (p=0,03)	0,2 (p=0,3)	-0,5 (p=0,02)	-0,4 (p=0,0)	-0,4 (p=0,8)
1 – FAA<0; 2 – FAA>0	0,4 (p=0,04)	-0,4 (p=0,06)	0,3 (p=0,1)	-0,2 (p=0,4)	0,1 (p=0,8)	-0,3 (p=0,3)	0,3 (p=0,1)	-0,3 (p=0,3)	0,04 (p=0,8)	-0,4 (p=0,02)	-0,4 (p=0,5)	0,07 (p=0,7)

Conclusion

School performance of girls aged 9-10 reversely related to obesity and school-related anxiety. The relationships between affective features and FAA in the group of lean girls correspond to the data on a relationship between the activity of the right-brain frontal cortex with the negative emotional background of an individual [7]. The direct link between the increased activity of the left-brain frontal cortex and the manifestation of obesity in combination with a reduced mental flexibility, as the FAA values increase in the group of girls with obesity, perhaps speak of an increased reward sensitivity, tendency toward approach-directed behavior, and a reduced ability to inhibit desirable behavior, even if the consequences may have an adverse impact on health (e.g, over-eating) [18]. The data that have been obtained through this study may be useful in the development of intervention strategies aimed at prevention and treatment of children obesity.

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