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Emotion regulation skills, brain-derived neurotrophic factor, cortisol hormone levels in primary school students in Türkiye: a cross-sectional and correlational analysis study

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Abstract

Background Hormones are molecules that contribute significantly to mental and physical health due to their role in emotion regulation (ER) processes. However, the role and effect of hormones on the ER has not yet been fully elucidated. In this study, it was aimed to examine the salivary Brain-derived neurotrophic factor (BDNF) and cortisol hormone response to support ERS in primary school students depending on some parameters.

Method This cross-sectional and correlational study was conducted in the Eastern Black Sea Region of Türkiye between April 2023 and June 2023. In the sample selection, after the number of students was determined in proportional stratification, the sample selection method was made by simple random selection from each class list, first according to the school and then the grade level of each school. A total of 177 healthy students between the ages of 8 and 10 who attended these schools, were allowed to participate in the research by their families, and were volunteers, were included in the study. Data were collected using the Personal Information Form and the Emotion Regulation Scale for Children and saliva collection cups. Human-specific Brain-derived neurotrophic factor ELISA Kit (BT LAB, Cat.No E1302Hu, CHINA) for measuring BDNF levels in saliva; In measuring the level of cortisol hormone in saliva, Human Cortisol ELISA Kit (BT LAB, Cat.No E 1 003Hu, CHINA) was used in accordance with the procedure specified in the manufacturer's catalogue. Data were evaluated using the SPSS 26.0 for Windows (SPSS, Chicago, Il, USA) package program. Independent Samples Test and One-Way ANOVA test, correlation and Multiple Linear Regression analysis were used to evaluate the data. $P<.01$ and $p<.05$ significance levels were used as statistical significance values.

Results A statistically significant correlation was found between the mean total score of the Emotion Regulation Skills Scale for Children and the mean level of salivary BDNF, and a negative correlation between the mean level of salivary cortisol ($p^{<}0.01$).

Conclusions Within the scope of the data obtained in our current study, BDNF levels were found to be high and cortisol hormone levels to be low in children with high ERS.

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Keywords Emotion regulation, Brain-derived neurotrophic factor, Cortisol, Nursing, Pediatric nursing

Introduction

Emotion regulation is a skill related to the ability of children to be aware of their emotional lives, experience their emotions at an intensity and time that they can cope with, and adjust their emotional-based reactions according to the environment [1]. Children who learn to regulate their emotions are better able to manage and recover from trauma or adverse events. Children who have difficulties in controlling their emotions, on the other hand, experience behavioral problems and anxiety, and this can be reflected in children's social competencies [2]. On the other hand, many clinical (such as anxiety disorders, eating disorders, and clinical depression) and emotional and behavioral disorders (such as emotional dysregulation and oppositional defiant disorder) observed in children are closely related to emotional regulation, or rather lack thereof [3]. In this process, determining the emotional regulation status of students is the duty of the school administration, together with the teachers, and school nurses, especially pediatric nurses, have an important role in the success of primary school students in diagnosing their health status and health risks.

Children's capacity to regulate their reactions to sensory and emotional stimuli depends on their brain development. It has been reported that difficulties in children's ER are associated with minimal activity in the dorsal systems of the cerebral cortex, such as the anterior cingulate cortex [4]. Brain-derived neurotrophic factor (BDNF) promotes neuronal growth and differentiation during brain development and increases synaptic plasticity and maintenance of neurons in adult life [5]. Although BDNF is related to ER, it has a role in the pathogenesis of stress-related disorders [6]. BDNF levels can be measured in human saliva, serum, and plasma [7]. Cortisol is a hormone that is released from the adrenal cortex in response to stress and is known as the stress hormone. While measuring cortisol concentration in saliva is more traditional and common, sampling is simple, non-invasive, and stress-free, whereas blood sampling can be stressful and thus increase cortisol levels [8]. School-age children also experience some problems as a result of their relationships with themselves, their families, peers, school and social environment. The situations that cause stress in children such as the child's personal characteristics, intelligence level (being gifted or experiencing mental retardation), chronic disease status, sociocultural and socioeconomic factors vary. Although stress is a natural reaction of the body in case of any danger that needs to be adapted or reacted, it affects the emotional control and mental health of the child and causes the loss of ER abilities. ER includes the control of both positive and negative emotions [9]. It is recommended to continue studies to understand the effects of stress and various situations related to students' mental health (academic stress, adjustment disorders, addictions, etc.) on salivary BDNF and cortisol levels [10]. It is important to consider children with low ERS levels as the target group for developing ERS and to develop training and counseling programs accordingly. In addition, it is thought that examining ERS and BDNF and cortisol hormone levels will contribute to nurses' practices, programs and strategies in providing effective nursing care and supporting and improving the well-being of pediatric patients. Considering the health consequences of ERS in children, it is thought that it will be a guide especially for school health nursing, pediatric nursing and mental health nursing.

Nurses should focus on the emotional expressions of the child they care for when planning care for children with ER problems and applying interventions in line with the planned care. Emotions expressed by children are important and reliable for shaping care. Bowie's [11] study showed that children aged at least 5.5 years can provide self-regulated information about strong emotions, and this information may be more accurate than adult observations. In this study, it is aimed to examine children's ERS and salivary BDNF and cortisol levels in terms of some variables.

Methods

Study design and participant

This study was conducted in a cross-sectional and correlational model with primary school students of different ages and genders studying in 5 primary schools in a province located in the Eastern Black Sea Region of Türkiye in the 2022–2023 academic year (N:39° 50′ 20″; E:42° 23′ 52″). Proportionately stratified random sample selection was used to determine the sample group [12]. 35 primary schools located in the city center were first separated according to their socio-economic and sociocultural levels, and then 5 primary schools where the research would be carried out were determined by simple random selection. In the sample selection, after the number of students was determined by the proportional stratified sample selection method according to the school and then the grade level of each school, simple random selection was made from each class list. A total of 177 students between the ages of 8–10, who attended these schools, were allowed to participate in the research by their families, and volunteered themselves, were included in the study. Inclusion students, parents other than parents (such as grandparents) and non-voluntary students were excluded from the study.

Procedure

The data were collected face-to-face with the Personal Information Form and the Emotion Regulation Scale for Children (CERS) in an average of 15 min. Saliva samples were also collected from children. The procedure flow chart is given in Fig. 1.

Part 1. collection of saliva samples from children

The children included in the study were told not to eat anything 1 h before saliva collection, not to brush their teeth, not to drink, to stay away from tryptophan-rich diet products such as red meat, eggs, fish, nuts, seeds and yoghurt, and to keep their mouths clean. They were also asked to keep a detailed food diary 24 h before saliva sample collection. Unstimulated saliva samples were collected at a time period of 08:00 to 09:00 in the morning using the passive salivation method in Salivette tubes (Sarstedt, GERMANY) at 5 ml. After centrifuging at 1500 g for 15 min in a refrigerated centrifuge (NF 1200R, NUVE, Ankara, TÜRKİYE) in the laboratory, saliva samples were kept at -80 °C until the analyzes for BDNF and cortisol hormone levels were performed. Human-specific Brain-derived neurotrophic factor ELISA Kit (BT LAB, Cat.No E1302Hu, CHINA) for measuring BDNF levels in saliva; In measuring the level of cortisol hormone in saliva, Human Cortisol ELISA Kit (BT LAB, Cat.No E 1 003Hu, CHINA) was used in accordance with the procedure specified in the manufacturer's catalogue.

Part 2. evaluation of sociodemographic characteristics

The personal information form was created by the researchers by examining the relevant literature. The form questions the child's sociodemographic characteristics such as gender, age, income status, parents' age, education status, job status, and the child's perceived school success. According to the Ministry of National Education's Assessment and Evaluation Regulation published in the Official Gazette dated September 9, 2023, and numbered 32,304, the assessment and evaluation processes in primary schools have been restructured [13]. In this context, the practice of exam hours in primary schools has been abolished, and no short-term exams, such as those featuring multiple-choice questions under the names of readiness, screening, or similar, will be administered. Instead of a results-oriented assessment and evaluation approach, a process-oriented approach has been adopted. Accordingly, assessment tools appropriate to the content of the course will be used to continuously monitor the social and academic development of students. To ensure the ongoing tracking of students throughout the process, individual feedback will be provided regarding incomplete and/or incorrect learning, and teaching-learning processes will be managed accordingly. Additionally, to determine students' perceived levels of success, they were asked to self-assess and rate their performance as "low," "medium," or "high." This method aimed to evaluate students' perceived levels of achievement, with the data obtained being utilized to support individualized learning processes.

Part 3. evaluation of emotion regulation skills in children

Emotion Regulation Scale for Children (CERS) was validated and reliable in Turkish by Harmancı and Aytar [14]. It consists of 29 items related to four sub-dimensions: Anger (9 items), Excitement (5 items), Fear (8 items) and Sadness (7 items). The scale is in 4-point Likert type with 1 to 4 points as "Not at all suitable for me", "Not suitable for me", "It is suitable for me" and "Completely suitable for me" and comments are made on the total score. An increase in the total score indicates an increase in the level of ER. The Cronbach α coefficient for the entire CERS was found to be 0.88. In the current study, the Cronbach α coefficient for the entire CERS was found to be 0.86.

Ethical considerations

The study was approved by the Bayburt University Research Ethics Committee (Decision no: 2023 – 139/5). Before the data were collected by the researchers, parents were informed about the study in accordance with the Declaration of Helsinki and Informed consent was obtained from the children's parents and/or legal guardians. Children who had parental permission and volunteered to participate in the study were briefly informed and included in the study.

Statistical analysis

Data were evaluated using the SPSS 26.0 for Windows (SPSS, Chicago, Il, USA) package program. Whether the data were normally distributed or not was evaluated by the Skewness and Kurtosis coefficients being in the range of (-1) - (+1) [15]. Number, percentage, mean (M) and standard deviation (SD) values for continuous variables were used for descriptive statistics. Parametric tests were applied because the data were normally distributed. Gabriel posthoc analysis was used in groups with homogeneous distribution, and Games-Howell was used in groups that did not, to determine which group caused the difference in more than two groups with equal group variances. The Independent Samples Test and One-Way ANOVA test were used to compare the descriptive characteristics of the children with their scale scores, salivary BDNF and cortisol levels. Whether there was a relationship between the variables was evaluated with Pearson correlation analysis. Multiple Linear Regression analysis using the enter method was used to determine the relationship between dependent and independent variables. Regression analysis results were shown with regression

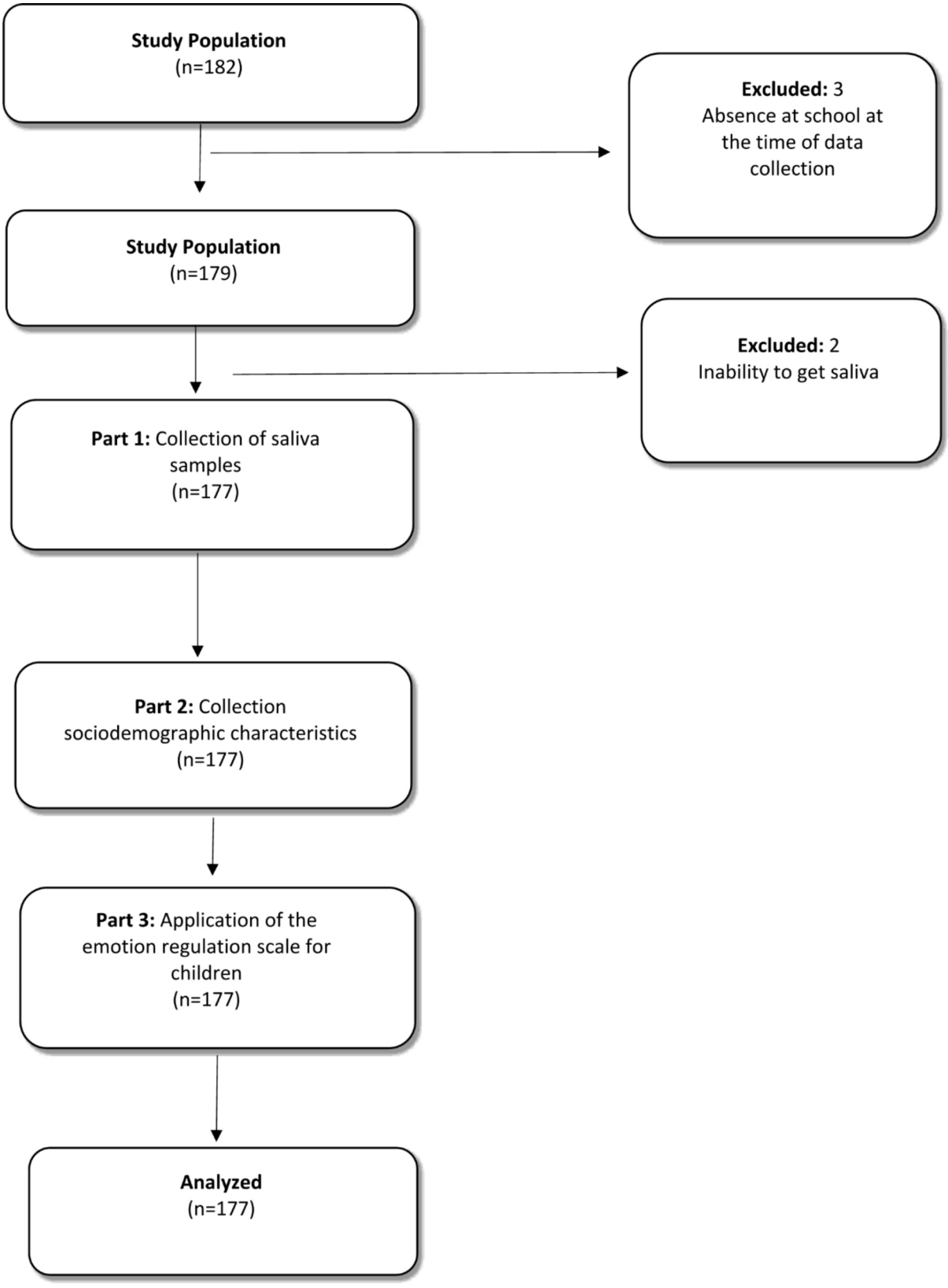

Fig. 1 Procedure Flow Diagram

coefficient (β), coefficient of determination (R / R^2), goodness of model fit (F / t and p), and 95% confidence interval. $P<.01$ and $p<.05$ significance levels were used as statistical significance values.

Results

In the study, Emotion Regulation Scale for Children (CERS) total mean score was 77.10 ± 14.22, CERS-Anger sub-dimension mean score was 24.59 ± 5.16, CERS-Excitement sub-dimension mean score was 12.05 ± 3.97, CERS-Fear sub-dimension mean score was 21.23 ± 5.06, CERS-Sadness sub-dimension mean score was found as 19.22 ± 4.55. A significant difference was found between the CERS total score averages and the child's perceived school success, the educational status of the father ($p<.05$). As a result of the post hoc analysis of the child's school success variable, the mean scores of the CERS total scores were higher among children who perceived their school success as moderate than those who perceived their school success as low. It was found that children who perceived their school success as good were higher than children who perceived their school success as low and moderate (Table 1).

A significant difference was found between the CERS-Anger sub-dimension mean scores and the variables of the child's gender, the child's perceived school success and the father's educational status ($p<.05$). As a result of the post hoc analysis conducted in terms of the child's perceived school success variable determined that the average scores of the CERS-Excitement subscale were higher in those with good school success than those with low and moderate school success (Table 1).

A significant difference was found between the mean scores of the CERS-Excitement sub-dimension and the variables of the child's perceived school success and the father's educational status ($p<.05$). As a result of the posthoc analysis conducted in terms of the child's perceived school success variable, it was determined that the average scores of the CERS-Excitement subscale were higher in those with good school success than those with low and moderate school success. As a result of the post hoc analysis made in terms of the father's educational status variable, it was determined that the mean scores of the CERS-Excitement sub-dimension were higher for those with university or higher education than those with secondary school (Table 1).

A significant difference was found between the CERS-Fear sub-dimension mean scores and the variable of the child's perceived school success ($p<.05$). As a result of the posthoc analysis conducted in terms of the child's perceived school success variable, it was determined that the CERS-Fear subscale mean scores were higher in those with moderate or good school success than those with low school success (Table 1).

A significant difference was found between the CERS-Sadness sub-dimension mean score and the variable of the child's perceived school success ($p<.05$). As a result of the posthoc analysis conducted in terms of the child's perceived school success variable, it was determined that the mean scores of the CERS-Sadness subscale were higher in children who perceived their school success as good than those who perceived their school success as low (Table 1).

The mean salivary BDNF level in the study was found to be 34.52 ± 6.19 pg/mL. A significant difference was found between the salivary BDNF level and the variable of the child's perceived school success ($p<.05$). As a result of the post hoc analysis made regarding the child's perceived school success variable, saliva BDNF level was higher in those with moderate and good school success than those with low school success (Table 2).

The mean salivary cortisol level was 2.78 ± 0.49 µg/dL in the study. A significant difference was found between the average salivary cortisol level and the variables of the child's perceived school success and mother's occupation ($p<.05$). As a result of the posthoc analysis conducted in terms of the child's perceived school success variable, it was found that the salivary cortisol level was higher in children who perceived school success as low than in children who perceived it as moderate and good. It was found that children who perceived their school success as moderate were higher than those who perceived their school success as good (Table 2).

A positive, moderate and statistically significant correlation was found between the mean CERS total score and the salivary BDNF mean level ($p<0.01$). A negative, weak and statistically significant correlation was found between the mean CERS total score and the salivary cortisol mean level ($p<0.01$) (Fig. 2) (Table 3).

A positive, moderate, and statistically significant correlation was found between the mean scores of the CERS-Anger subscales and the salivary BDNF mean level ($p<0.01$). A negative, weak and statistically significant correlation was found between the mean scores of the CERS-Anger subscales and the mean salivary cortisol level ($p<0.01$) (Table 3).

A positive, weak and statistically significant correlation was found between the mean scores of the CERS-Excitement sub-dimension and the salivary BDNF mean level ($p<0.01$). A negative, weak and statistically significant correlation was found between the mean scores of the CERS-Excitement sub-dimension and the salivary cortisol mean level ($p<0.01$) (Table 3).

A positive, weak and statistically significant correlation was found between the mean scores of the CERS-Fear subscale and the salivary BDNF mean level ($p<0.01$). A negative, weak and statistically significant correlation was

Table 1 Comparison of scale and subscale scores with some variability ($n=177$)

Variables	*n* (%)	CERS-Total Score (M/SD)	CERS-Anger (M/SD)	CERS-Exciment (M/SD)	CERS-Fear (M/SD)	CERS-Sadness (M/SD)
Average age of mothers: 36.12 ± 4.744 Average age of fathers: 41.62 ± 5.717						
Gender						
Female	89(50.3)	78.25 ± 13.92	25.57 ± 5.04	12.21 ± 4.00	21.04 ± 5.08	19.42 ± 4.51
Male	88(49.7)	75.94 ± 14.50	23.60 ± 5.13	11.89 ± 3.96	21.43 ± 5.07	19.01 ± 4.60
		t = 1.083	**t = 2.578**	t = 0.527	t=-0.507	t = 0.606
		p =.280	***p* =.011***	*p* =.599	*p* =.613	*p* =.545
Age year						
8	61(34.5)	78.13 ± 14.72	25.00 ± 4.92	12.70 ± 3.85	21.72 ± 5.14	18.70 ± 4.72
9	55(31.0)	75.41 ± 14.45	24.01 ± 5.47	11.50 ± 3.90	20.92 ± 4.88	18.96 ± 4.04
10	61(34.5)	77.60 ± 13.58	24.70 ± 5.15	11.90 ± 4.12	21.03 ± 5.19	19.96 ± 4.77
		F = 0.581	F = 0.541	F = 1.384	F = 0.428	F = 1.305
		p =.561	*p* =.583	*p* =.253	*p* =.653	*p* =.274
Child's perceived school success						
Low[1]	33(18.6)	65.96 ± 14.90	19.96 ± 5.04	10.81 ± 3.65	18.24 ± 4.77	16.93 ± 4.84
Moderate[2]	55(31.1)	75.92 ± 12.37	24.58 ± 4.54	11.29 ± 4.13	21.32 ± 4.58	18.72 ± 4.07
Good[3]	89(50.3)	81.96 ± 12.59	26.31 ± 4.52	12.98 ± 3.80	22.29 ± 5.07	20.37 ± 4.38
		F = 18.603[a]	**F = 22.608[b]**	**F = 5.313[c]**	**F = 8.337[d]**	**F = 7.885[e]**
		p* =.000*	***p* =.000****	*p* =.006	***p* =.000****	***p* =.001****
Mother educational status						
Primary school	39(22.0)	73.05 ± 15.40	23.79 ± 5.64	11.43 ± 4.01	20.12 ± 5.26	17.69 ± 4.89
Middle school	36(20.3)	75.58 ± 14.23	23.11 ± 5.37	10.88 ± 4.21	21.41 ± 5.54	20.16 ± 4.84
High school	37(20.9)	78.45 ± 14.10	25.16 ± 4.95	12.83 ± 3.79	21.08 ± 5.17	19.37 ± 4.15
University and above	65(36.8)	79.61 ± 13.18	25.56 ± 4.70	12.63 ± 3.79	21.89 ± 4.59	19.52 ± 4.25
		F = 2.015	F = 2.268	F = 2.331	F = 1.011	F = 2.136
		p =.114	*p* =.082	*p* =.076	*p* =.389	*p* =.097
Mother's job status						
Housewife	140(79.1)	76.43 ± 14.15	24.28 ± 5.06	11.87 ± 4.07	21.06 ± 5.03	19.20 ± 4.61
Officer/Worker	37(20.9)	79.64 ± 14.39	25.75 ± 5.44	12.72 ± 3.56	21.89 ± 5.20	19.27 ± 4.36
		t=-1.224	t=-1.546	t=-1.159	t=-0.883	t=-0.075
		p =.223	*p* =.124	*p* =.248	*p* =.379	*p* =.940
Father educational status						
Primary school[1]	26(14.7)	71.69 ± 16.29	22.57 ± 5.80	11.76 ± 3.92	20.19 ± 5.26	17.15 ± 5.26
Middle school[2]	25(14.1)	71.48 ± 13.05	22.56 ± 5.33	9.96 ± 3.84	19.60 ± 5.52	19.36 ± 4.04
High school[3]	45(25.4)	79.37 ± 13.19	25.73 ± 4.09	12.51 ± 4.20	22.00 ± 4.62	19.13 ± 4.15
University and above[4]	81(45.8)	79.32 ± 13.70	25.23 ± 5.16	12.54 ± 3.74	21.65 ± 5.02	19.88 ± 4.54
		F = 3.767	**F = 3.945**	**F = 3.066[f]**	F = 1.784	F = 2.442
		p* =.012*	***p* =.009****	***p* =.029****	*p* =.152	*p* =.066
Father's job status						
Self-employment	49(27.6)	76.93 ± 14.18	25.00 ± 5.26	12.26 ± 3.93	21.36 ± 4.75	18.30 ± 4.96
Officer	47(26.6)	78.29 ± 12.40	25.34 ± 4.53	11.95 ± 3.84	21.17 ± 5.55	19.82 ± 4.25
Worker	81(45.8)	76.51 ± 15.31	23.91 ± 5.41	11.98 ± 4.11	21.19 ± 5.01	19.41 ± 4.42
		F = 0.235	F = 1.349	F = 0.093	F = 0.022	F = 1.497
		p =.790	*p* =.262	*p* =.911	*p* =.978	*p* =.227

*Independent T test **One-Way ANOVA [a]Gabriel= 2 > 1, 3 > 1, 3 > 2, [b]Gabriel= 2 > 1, 3 > 1, [c]Gabriel= 3 > 1, 3 > 2, [d]Gabriel= 2 > 1, 3 > 1, [e]Gabriel= 3 > 1, [f]Gabriel= 4>2

found between the mean score of CERS-Fear subscale and the mean salivary cortisol level ($p<0.01$) (Table 3).

A positive, weak and statistically significant correlation was found between CERS-Sadness subscale mean scores and salivary BDNF mean level ($p<0.01$). A negative, weak and statistically significant correlation was found between CERS-Sadness subscale mean scores and salivary cortisol mean level ($p<0.01$). In addition, a negative, strong and statistically significant correlation was found between salivary BDNF and mean cortisol level ($p<0.01$) (Table 3).

Table 2 Comparison of BDNF, cortisol with some variability ($n=177$)

Variables	*n* (%)	BDNF (M/SD)	Kortizol (M/SD)
Gender			
Female	89(50.3)	35.34 ± 5.55	2.78 ± 0.48
Male	88(49.7)	33.70 ± 6.70	2.79 ± 0.50
		t = 1.77	t=-0.104
		p =.078	*p* =.917
Age year			
8	61(34.5)	34.61 ± 6.14	2.75 ± 0.49
9	55 (31.0)	34.28 ± 6.32	2.80 ± 0.51
10	61(34.5)	34.66 ± 6.21	2.80 ± 0.49
		F = 0.063	F = 0.193
		p =.939	*p* =.825
Child's perceived school success			
Low[1]	33(18.6)	24.79 ± 2.19	3.43 ± 0.38
Moderate[2]	55(31.1)	32.89 ± 5.03	2.83 ± 0.50
Good[3]	89(50.3)	39.14 ± 0.79	2.52 ± 0.23
		F = 285.282[a]	**F = 76.213[b]**
		p* =.000*	***p* =.000****
Mother educational status			
Primary school	39(22.0)	35.40 ± 6.03	2.83 ± 0.56
Middle school	36(20.3)	33.59 ± 6.84	2.86 ± 0.48
High school	37(20.9)	34.61 ± 6.25	2.76 ± 0.47
University and above	65(36.8)	34.47 ± 5.93	2.73 ± 0.47
		F = 0.536	F = 0.625
		p =.658	*p* =.600
Mother's job status			
Housewife	140(79.1)	34.28 ± 6.32	2.83 ± 0.48
Officer/Worker	37(20.9)	35.43 ± 5.64	2.63 ± 0.51
		t=-1.070	**t = 2.138**
		p =.289	***p* =.034***
Father educational status			
Primary school[1]	26(14.7)	35.37 ± 6.18	2.87 ± 0.62
Middle school[2]	25(14.1)	33.64 ± 6.34	2.84 ± 0.44
High school[3]	45(25.4)	35.16 ± 5.92	2.74 ± 0.42
University and above[4]	81(45.8)	34.17 ± 6.33	2.77 ± 0.50
		F = 0.575	F = 0.530
		p =.632	*p* =.662
Father's job status			
Self-employment	49(27.6)	36.15 ± 5.60	2.71 ± 0.48
Officer	47(26.6)	34.00 ± 6.30	2.86 ± 0.48
Worker	81(45.8)	33.84 ± 6.35	2.78 ± 0.51
		F = 2.399	F = 1.084
		p =.075	*p* =.341

*Independent T test. **One-Way ANOVA. [a]Games-Howell = 2 > 1, 3 > 1, 3 > 2, [b]Games-Howell = 1 > 2, 1 > 3, 2 > 3

In line with the literature, the relationship between some parent and child variables and CERS and its subdimensions was examined using a multiple linear regression model (Table 3). In the analysis of some variables of parents and children, it was observed that there was a significant model in the evaluation of goodness of model fit (F/p) regression coefficients (R/R^2) ($p<.05$). In the first model created for the dependent variable of the CERS, it was found that 21.2% of the variance was explained by the independent variables (R^2 adjusted = 0.212), and the father's education level and the child's school achievement were found to be positive and statistically significant predictors ($p<.01$). In the second model created for the same dependent variable, it was found that 21.2% of the variance in the dependent variable of the CERS was explained by the independent variables (R^2 adjusted = 0.212), and the father's education level and salivary BDNF level were statistically significant predictors detected ($p<.01$). 26.8% of the variance in the CERS-Anger dependent variable was explained by the independent variables (R^2 adjusted = 0.268), the father's education level and the child's school success were statistically significant predictors ($p<.01$), the salivary cortisol level and the child's gender were negative. It was found to be a statistically significant predictor in the direction ($p<.05$). It was found that 5.8% of the variance in the CERS-Excitement dependent variable was explained by the independent variables (R^2 adjusted = 0.058), and it was a statistically significant positive predictor of the child's school achievement ($p<.01$). It was determined that 10.0% of the variance in the CERS-Sadness dependent variable was explained by the independent variables (R^2 adjusted = 0.100), and the educational status of the father and the child's school success were positive predictors of statistical significance ($p<.05$) (Table 4).

Discussion

In our study, in which we aimed to examine children's ERS and salivary BDNF and cortisol levels in terms of some variables, it was determined that children's ERS were affected by their school success, and the ERS of children who reported good school success were found to be higher than the others. On the other hand, the same situation was determined for the feelings of anger, excitement, fear and sadness, which are the sub-dimensions of the scale. Anger regulation skills were found to be higher in females. In terms of the father's educational status variable, it was determined that it affected the children's ability to regulate their sense of excitement, and the children whose father's education level was university or higher were found to be at a higher level than those with secondary school education. The results of our study are consistent with the research results reported in the literature [16, 17]. In a study conducted with preschool children, it was reported that as the mother's level of education increases, the child's emotion regulation skills increase [18]. When the literature is examined, it is seen that there are various findings indicating that the education level of the mother and father does not make a difference [19], and that as the education level of the mother and/or father increases, the child's emotion regulation

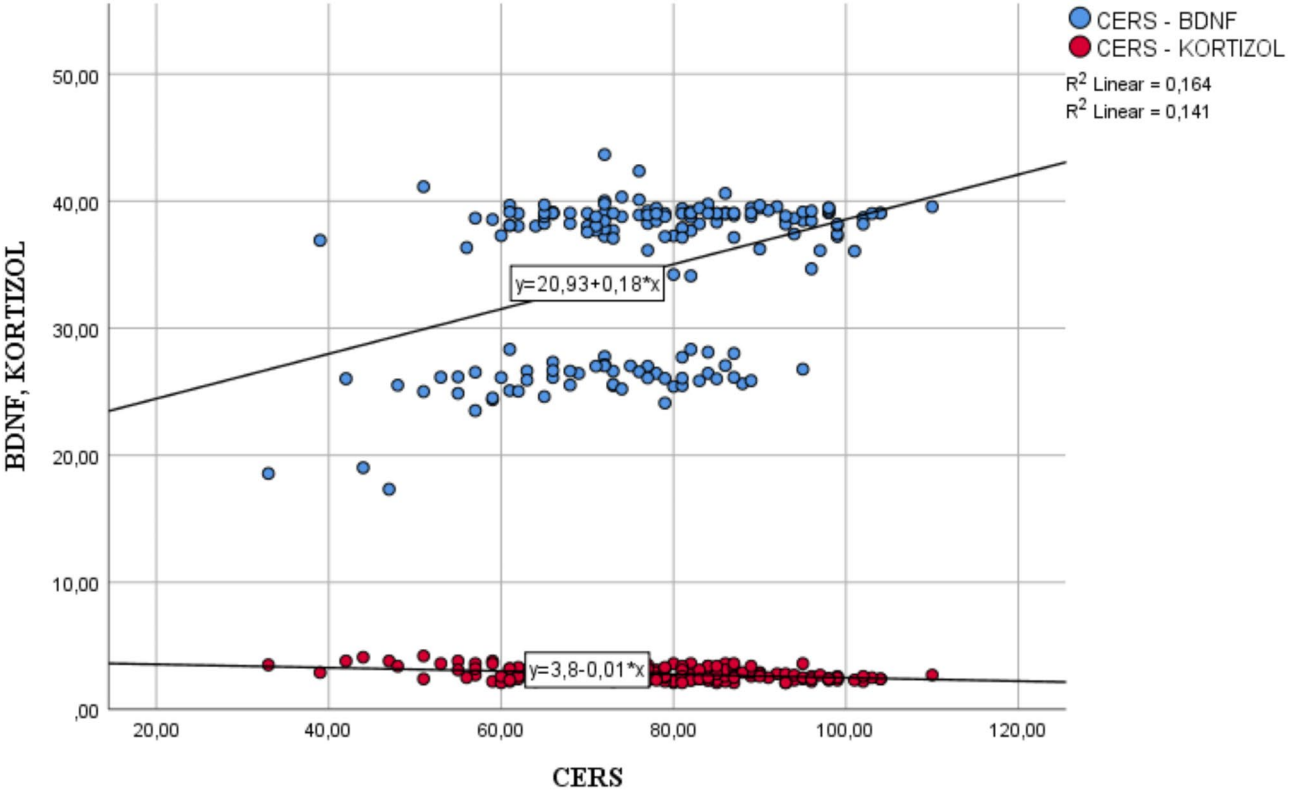

Fig. 2 Correlation relationship between BDNF, Cortisol and CERS

Table 3 Correlation relationship between scale and sub-dimension scores, BDNF, cortisol

Variables		BDNF	Kortisol	CERS Total Score	CERS-Anger	CERS-Exciment	CERS-Fear	CERS-Sadness
BDNF	r	1						
	p							
KORTISOL	r	−0.813*	1					
	p	0.000						
CERS-Total Score	r	0.405*	−0.376*	1				
	p	0.000	0.000					
CERS-Anger	r	0.412*	−0.393*	0.799*	1			
	p	0.000	0.000	0.000				
CERS-Exciment	r	0.248*	−0.245*	0.749*	0.545*	1		
	p	0.001	0.001	0.000	0.000			
CERS-Fear	r	0.296*	−0.260*	0.800*	0.451*	0.538*	1	
	p	0.000	0.000	0.000	0.000	0.000		
CERS-Sadness	r	0.252**	−0.225*	0.673*	0.383*	0.250*	0.404*	1
	p	0.001	0.003	0.000	0.000	0.001	0.000	

*. Correlation is significant at the 0.01 level (2-tailed)

increases [20, 21]. When children's problem-solving skills are examined, they differ from the results of the research that gender and age do not make a significant difference in children's ERS [22, 23]. The difference in BDNF and cortisol hormone levels according to ERS levels in children is related to the physiological development of children's endocrine system and brain. On the other hand, we predict that the the father's educational status affects his child's ER performance and is shaped by the role of BDNF and cortisol hormones on behavioral physiology. A study showed that BDNF levels are an important moderator of the relationship between childhood trauma and emotion regulation [24].

Brain Derived Neurotrophic Factor (BDNF) is an important neurotrophic factor that affects learning and memory. BDNF is critical for short- and long-term

Table 4 Regression analysis between some variables and scale, sub-dimensions

Scale	Variables						95.0 CI		
		B	SE	β	t	p	Lower	Upper	Model fit
CERS-Total Score	(Constant)	77.158	10.661	-	6.581	0.000	49.116	91.201	Adj. R^2 = 0.212 F = 16.796
	Father's job status	2.476	0.874	0.190	2.833	**0.005**	0.751	4.201	
	School achievement	5.424	1.668	0.294	3.252	**0.001**	2.132	8.717	
	Kortisol	-4.696	2.582	−0.164	-1.819	0.071	-9.791	0.400	
CERS-Total Score	(Constant)	34.805	6.106	-	5.700	0.000	22.753	46.857	Adj. R^2 = 0.212 F = 24.621
	Father's job status	3.097	0.872	0.238	3.550	**0.000**	1.375	4.819	
	BDNF	0.954	0.154	0.415	6.199	**0.000**	0.650	1.258	
CERS-Exciment	(Constant)	8.002	1.192	-	6.714	0.000	5.650	10.354	Adj. R2 = 0.058 F = 6.427
	School achievement	1.149	0.379	0.222	3.035	**0.003**	0.402	1.896	
	Father's job status	0.461	0.267	0.127	1.727	0.086	−0.066	0.988	
CERS-Sadness	(Constant)	13.337	1.333	-	10.004	0.000	10.706	15.969	Adj. R^2 = 0.100 F = 10.749
	School achievement	1.646	0.424	0.278	3.887	**0.000**	0.810	2.482	
	Father's job status	0.685	0.299	0.164	2.294	**0.023**	0.096	1.274	
CERS-Anger	(Constant)	24.954	3.951	-	6.316	0.000	17.155	32.754	Adj. R^2 = 0.268 F = 17.056
	Kortisol	-1.943	0.897	−0.190	-2.166	**0.032**	-3.714	−0.172	
	Father's job status	0.924	0.303	0.198	3.048	**0.003**	0.326	1.522	
	School achievement	1.987	0.585	0.300	3.398	**0.001**	0.833	3.142	
	Gender	-1.510	0.667	−0.148	-2.265	**0.025**	-2.826	−0.194	

Adj.R^2: Adjusted R square; B: Partial regression coefficient; β: Standard partial regression coefficient; 95% CI: 95% confidence interval

cognitive performance [25]. The role of BDNF in cognitive performance is mediated through the tropomyosin-related receptor kinase B (TrkB) pathway [26]. In line with the findings of our study, it was determined that salivary BDNF level was higher in children who reported good school success. In comparison, salivary cortisol levels were higher in children who reported low school success. On the other hand, it was determined that the salivary cortisol levels of children whose mothers were working were lower than those whose mothers were housewives.

Cortisol is a hormone that has a potential effect on cognitive development [27]. Cortisol can lead to a decrease in cognitive performance [28]. Michels et al. (2012) studied children's salivary cortisol levels, which were found to be associated with some adverse life events, emotions, and difficulties [29]. In another study, salivary cortisol level was found to be associated with the risk of behavioral-psychosocial-emotional disorders in adolescents. Likewise, salivary cortisol levels have been reported to be associated with the risk of internalizing disorders, externalizing disorders, and attention disorders in adolescents [30]. The results of our study are consistent with the research results reported in the literature [31, 32]. ER skills in children are affected by a process in which internal and environmental variables, especially the endocrine system, are involved. Depending on the increase in the ERS levels of the children included in the study, while the salivary BDNF level increased, the cortisol hormone levels decreased, while the salivary BDNF levels were decreased and the cortisol hormone levels increased in the children whose ERS levels were decreased. The same situation was determined in the results of anger, excitement, fear and sadness, which are sub-dimensions of the emotion regulation skills scale. In studies, higher BDNF levels were associated with better cognitive performance [31, 32], while higher cortisol levels were associated with lower cognitive performance among young children [33]. It is thought that the reason for the difference in BDNF and cortisol hormone levels according to ERS levels in children is shaped by the difference in the physiological development processes of the children's endocrine system and brain. According to the results of the study, training on emotion regulation results in positive outcomes [34–36]. Considering the health-related consequences of ERS in children, it is thought that it will be a guide especially for school health nursing, pediatric nursing and mental health nursing.

Limitations

This study had some limitations. First, self-report measuring instruments were used in this study, which may cause a kind of response bias. Second, the results cannot be generalized to all students in Türkiye, since this study was conducted in a province in the Eastern Black Sea Region of Türkiye. Despite these limitations, the study also had strengths. This study is valuable because it is the first study in which children's ERS and salivary BDNF and cortisol levels were investigated in terms of some variables.

Conclusion

Within the scope of the data obtained in our current study, BDNF levels were determined to be high, and cortisol hormone levels were determined to be low in children with high ERS levels. In line with these results, it is suggested that children with low ERS should be accepted as the target group whose ERS should be improved education, and counseling programs should be developed in this direction. However, further research is needed to explain the relationship between ER abilities and hormone levels.

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Author contributions
Authors' Contribution Statements: B.B. and Z.Ö.K. designed the study. B.B. enabled BDNF and cortisol analysis to be performed. Z.Ö.K. and E.O.A. collected the data and performed the statistical analysis. All authors read and approved the final manuscript.

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Data availability
The corresponding author upon reasonable request will provide data supporting the findings of this study.

Declarations

Ethics approval and consent to participate
The study was approved by the Bayburt University Research Ethics Committee (Decision no: 2023 – 139/5). Before the data were collected by the researchers, parents were informed about the study in accordance with the Declaration of Helsinki and Informed consent was obtained from the children's parents and/or legal guardians. Children who had parental permission and volunteered to participate in the study were briefly informed and included in the study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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