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Executive functioning in college students with anxiety and depression: a multivariate analysis

Juan Francisco Palomares Gómez [1], Andrés Mauricio Grisales [1], Luisa María Hurtado Gallego [1], Juan José Daza Lince [1]*

Abstract

Background: Executive functioning regulates, integrates and coordinates cognitive processes allowing the achievement of goals. Several research studies determined that anxiety and depression in College students interconnect bidirectionally with executive functions.

Objective: The aim of this study is to determine the relationship between anxiety, depression and executive functioning in a sample of college students from the city of Manizales-Colombia.

Method: This study used a simple probabilistic cluster sampling, a sample of 224 students from different universities in the city of Manizales was formed, the average age was 21 years, 75.9% of the sample was female. Updating (WAIS IV Wechsler Adult Intelligence Scale), shifting (Wisconsin Card Sorting Test - WCST), inhibitory control (Colors and Words Test - STROOP), anxiety (State-Trait Anxiety Inventory - STAI) and depression (Beck Depression Inventory II), were measured.

Results: Using multivariate analysis, specific differences were found between executive domains and some emotional variables.

Discussion: Trait anxiety correlates negatively with working memory and increases the probability of presenting a high level of shifting, as well as depression increases the probability of inhibition was above average.

[1] Universidad Católica Luis Amigo, Colombia

E-mail corresponding author: juan.palomaresgo@amigo.edu.co

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1. Introduction

Executive functions are high-level cognitive strategies that filter goal-oriented information by determining the capacity of the subject to respond to the demands of the environment. These have a phylogenetic origin characterized by the evolution of the prefrontal cortex and their

function is to integrate processes and functions of other areas of the brain to accomplish a task (Ardila, Rosselli., 2019).

They include processes such as the inhibition of emotions, thoughts and behaviours, monitoring, manipulation and modification of information related to working memory and the ability to shift attentional control, making mental operations, thought schemes and more flexibility in task execution (Friedman & Miyake., 2017)

Therefore, the integrated functioning of these constructs influences different aspects of cognitive control, including the management of emotions due to its relationship with the cingulate cortex (Friedman & Robbins, 2022; Hu & Dolcos, 2017). This allows us to consider that alterations in executive functioning and cognitive control are related to disorders such as depression and anxiety (Ajilchi & Nejati, 2017; Dickson et al., 2017; Friedman & Robbins, 2022; Leonard & Abramovitch, 2019; Mou, 2022; Warren et al., 2021)

Depression is an affective state characterized by unhappiness, pessimism and discouragement, which can reach a state of extreme sadness where self-care, the ability to make decisions and the quality of life of the individual are affected (American Psychological Association, 2022). Anxiety, on the other hand, is divided in anxious arousal and anxious apprehension, the first one is a feeling of physiological agitation or stress, while the latter is a cognitive component related to catastrophic anticipation of the future (Härpfer et al., 2021). Other authors differentiate it between trait anxiety understood as a personality constant in the subject and state anxiety, which refers to transient feelings of insecurity in situations perceived as threatening (Forrest et al., 2021).

Both anxiety and depression present different degrees of psychopathology and often occur together in three quarters of the population who suffer from either disorder (ter Meulen et al., 2021), although the underlying processes that support this comorbidity are still unknown. (Coussement et al., 2022; König et al., 2021; ter Meulen et al., 2021), some approaches show a possible genetic relationship (Gustavson et al., 2019)

These emotional pathologies are more frequent in women than in men (Deng et al., 2021; Kim et al., 2022; Oh et al., 2021), since they have higher scores on anxiety tests than their male counterparts (Gao et al., 2020) as well as twice the probability to be diagnosed with depression starting in adolescence and throughout adulthood (Eid et al., 2019). Although specifically in college students, men might show higher scores in depression tests (Gao et al., 2020).

These emotions influence executive functioning and cognitive control, for example, the deficits of attentional control and cognitive processes increase during periods of high stress, or high levels of anxiety (Huang t al., 2022; König et al., 2021; Morales et al., 2022; Mou, et al., 2022;

Zainal & Newman, 2021). Explaining that the physiological activation of anxiety, as well as the highest scores in depression, are the determining components in the affectation on cognition and efficiency of thought (Warren et al., 2021). Arguing that trait anxiety is related to the specific deficits of the shifting factor and that subjects who present high levels of concern are also affected by the ability to make thought schemes more flexible, besides the adequate selection of contents of working memory (Valenti et al., 2021; Warren et al., 2021). Other authors relate the anticipatory component of anxiety to specific alterations in inhibition and shifting (Sluis et al., 2017)

In turn, executive dysfunction may have consequences for emotional regulation, rather than simply being a response to anxiety and depression, suggesting a bidirectional relationship (Warren et al., 2021) where major depressive disorders predict alterations in executive functioning and these, consequently, predict the development of signs of generalized anxiety (Zainal & Newman, 2021).

Coussement et al. (2022) and Ajilchi & Nejati (2017) confirm the finding by discovering a direct and mutual relationship between executive functioning impairment and the severity of emotional impairments. Being depression, more than anxiety, the variable that best explains the affectation of executive functioning (Ajilchi & Nejati, 2017; Wen et al., 2021) where the rumination of ideas is a trigger of alterations in executive functioning and not the other way around, especially for the updating (Dickson et al., 2017) and shifting functions (Dickson et al., 2017; Gilbert et al., 2019), both being a predictor of psychopathology (du Pont et al., 2019).

In regard to this approach, it was found that the maturation of the dorsolateral, ventromedial and orbitofrontal prefrontal cortices are protective factors that allow the development of emotional regulation strategies (Kaya & McCabe, 2019) additionally, shifting, updating and especially inhibition dysfunctions, can predict the appearance of signs of generalized anxiety (Zainal & Newman, 2018) an aspect also found for trait anxiety where a predictive factor is the decrease in grey matter in the opercular segment of the lower left frontal cortex, while cortical decrease in the anterior portion of the cingulate gyrus, amygdala, ventromedial prefrontal cortex and insula are associated with depression (Hu & Dolcos, 2017)

In contrast, some authors found no alteration in attentional control test in people with anxiety. (Liang 2021) On the other hand other authors found that trait anxiety predicts higher performance in some executive functioning tests, specifically in working memory, although they confirm that in high-stress situations such as those present in state anxiety, the domains of shifting, inhibitory control and working memory are affected (Alfonso & Lonigan, 2021), an aspect also found by (Sluis et al., 2017), who suggest that low levels of anxiety are related to a

better performance of the shifting function. Therefore, the impairment of executive functioning caused by anxiety depends on the intensity of the emotion (Alfonso & Lonigan, 2021).

The results of the relationship between executive functioning and anxiety and depression variables are mixed, for example Leonard & Abramovitch. (2019) compared two groups of college students, one group with generalized anxiety disorder, and the control group, finding that the group with generalized anxiety had better executive functioning than the control group, which they explain from the use of compensatory attentional strategies by the subjects with anxiety.

Besides, are other mediating factors in the environment, for example Zhang et al. (2021) explain that quality of life prevents depression from affecting executive functioning.

This was confirmed by research conducted with more than 1400000 college students from all over the world, where it was found that depression has a prevalence of 34%, while anxiety in 32% of this population (Deng et al., 2021) with the socioeconomic variable being a protective factor in the presence of these disorders (Deng et al., 2021; Mance et al., 2019; Morales et al., 2022; Oh et al., 2021).

Moreover, the socioeconomic level also influences executive functioning as it is positively related to the development of updating, shifting and inhibitory control in children (Ming et al., 2021; Ivanovic, et al., 2022) and adolescents (Mance et al., 2019), in which better scores are also found on tests that measure theory of mind (Pluck et al., 2021), since socioeconomic status is related to better verbal and vocabulary skills (Chung et al., 2017; Pluck et al., 2021) which stimulates the development of executive functioning and consequent cognitive control.

This relationship between the socioeconomic status and executive functioning was found in other investigations, where socioeconomic status is related to the level of stress in parents and their children, where economic deprivation is related to social and environmental variables that predispose this affectation (Mance et al., 2019)

A current example is the COVID-19 pandemic since 2020, which, consistent with research, has presented an increase in cases of anxiety, especially in young adults (Morales et al., 2022). In Colombia, according to figures of the Departamento Administrativo Nacional de Estadísticas (2021), it was found that 28.2% of the population between 25 and 54 years old and 16.4% of the population between 10 and 24 years old have presented feelings of loneliness, stress, worry and depression, consistent with the pandemic, however, when investigating specifically due to symptoms of worry and nervousness in the last week prior to the survey, the population aged 10 to 24 years reports these symptoms in 41.2% of cases.

Owing to the prevalence of these emotions, this research seeks to determinate the relationship between anxiety, depression and executive functioning in a sample of college students from the city of Manizales. Since, different researches propose a complex interaction between these emotions and executive functioning, allowing to hypothesize that anxiety and depression affect different domains of executive functioning.

2. Methods

2.1 Design

The current study was an empirical analytical approach, of a quantitative type, with a correlational scope through multivariate analysis, which according to Hernández et, al (2006) seeks to explain the behavior of two or more variables in a study. For the present investigation, the variables are: trait-state anxiety, depression and those that conform executive functioning such as updating, shifting and inhibitory control.

2.2 Participants

The sample consisted of a total of 224 people, college students from different universities in the city of Manizales, of which 75.9% (170) correspond to the female gender. The average age of the participants was 21 years (SD = 2.83 years), with a range of 12 years between the minimum age (18 years) and the maximum age (30 years). When comparing by gender, it was observed that the average age of the women was 20.96 years (SD = 2.73 years), while the average age of the men was 21.51 years (SD = 3.11 years). This age variable was grouped into two intervals, from 18 to 23 years old, where 83% of the sample (186 people) were classified, and from 24 to 30 years old. The participants were selected through probabilistic cluster sampling, taken from different universities in the city of Manizales-Colombia.

2.3 Instruments

Working Memory Index WAIS IV: The Wechsler Adult Intelligence Scale – IV assesses intelligence in subjects aged 16 years to 90 years and 11 months. This test has a working memory index made up of the digit retention, arithmetic and sequence of numbers and letters sub-tests, which together, allow measuring the capacity of the evaluated person to temporarily retain information in his consciousness by performing operations with it to obtain a result, thus revealing the state of functions such as attention, concentration, mental control and reasoning, becoming an aspect of great relevance in higher order cognitive processes. Its validity is .92 measured by Alpha of Cronbach and the reliability of this index is .94 also calculated by the Alpha of Cronbach coefficient and by comparison by halves (Wechsler, 2014).

Wisconsin Card Sorting Test (WSCT): Assesses the ability to generate and change sorting criteria, providing an indicator of shiftng or mental flexibility, based on sudden changes in test

conditions. It helps to establish an indicator of the executive attention control tasks, as well as the ability to plan a series of actions that only together and in sequence lead to a specific goal; the reliability index calculated using Alpha of Cronbach is higher than 0.9 (Heaton, Chelune, Talley, Kay & Curtiss, 1997).

Colors and Words Test (STROOP): Evaluates the ability of the subject to inhibit an automatic response, these show a reliability higher than .79 in Alpha of Cronbach (Golden, 2010).

State-Trait Anxiety Inventory (STAI) was constituted his test for the investigation of two different dimensions of anxiety: the anxiety as a trait and the anxiety as a state, in normal adult subjects, that means, without psychiatric symptoms, although it later proved to be useful in measuring anxiety in secondary and high school students, as well as in neuropsychiatric, medical and surgical patients (Spielberger & Gorsuch, 1983). The reliability of the data determined by Alpha of Cronbach for the present investigation is .94 for state anxiety and .93 for trait anxiety.

Depression Inventory Beck II: It is a 21-item instrument to measure the severity of depression in people from 13 years and older, according to the DSM-IV criteria for depressive disorders. It has a reliability of .93 using Alpha of Cronbach and test-retest correlation; its construct validity is .93. (Beck. *Et al.,* 2003) For the present investigation, the reliability of these data determined by Alpha of Cronbach is .92.

2.4 Procedure

Phase 1. The sample was selected, the instruments to be used were determined and the informed consent forms were signed by each of the participants.

Phase 2. The collection of information and its subsequent analysis was established.

Phase 3. The report is elaborated by constructing tables of all the tests used, as well as the specific ones for each of the variables to be investigated, as part of the results, then these are contrasted with the theory to establish the discussion and conclusions.

3. Results

3.1 Descriptive and comparative statistics of the variables considered

Table 1 presents the descriptive statistics of the variables studied. In general, it is observed that, within the variables related to some emotional condition, Anxiety - Trait is the one that reaches a higher average value with a mean of 45.90 (S.D. = 12.47), while the one with the lowest value mean was Depression with a mean of 17.37 (S.D. = 10.77).

Similarly, it is observed that, of the executive functions, working Memory reached an average of 90.73 (S.D. = 11.05), while shifting and inhibition average values of 69.42 (S.D. = 16.18) and

49.88 (S.D. = 9.43) respectively. This same trend was maintained in each of the categories of the variables of sex and age ranges (Tables 2 and 3).

Table 1. Descriptive statistics of the given variables

Measured variable	Minimum	Maximum	Mean	S.D.	Median	Mode
Anxiety - Trait	21	72	45.90	12.47	45	55
Anxiety - State	20	73	41.90	11.77	42	38
Depression	0	47	17.37	10.77	16	20
Shifting	19	88	69.42	16.18	80	80
Working memory	66	133	90.73	11.05	89	88
Inhibition	20	80	49.88	9.429	49	50

When observing the scores obtained in the categories of the sex variable, it is observed that the emotional variables obtained a higher average value in the female gender than in the male gender. By contrast, the average values obtained in executive functions were higher for males than females, except in the Inhibition variable where the average value is slightly higher in males. When applying the non-parametric Mann-Whitney U test, it was found that there were statistically significant differences in the categories of the gender variable, the emotional variables, but not on the variables that measured executive functions. These results are shown in Table 2.

Table 2. Descriptive and comparative statistics with respect to the genre of the variables considered

Variables		Minimum	Maximum	Mean	S.D.	Median	Mode	Average range	Mann-Whitney U	Z	Sig.
Anxiety - Trait	Female	21	72	47.59	12.24	48	55	121.63	3038.5	-3.741	.000
	Male	25	70	40.57	11.77	37.5.	28	83.77			
Anxiety - State	Female	21	73	43.72	11.89	43	38	122.44	2900	-4.075	.000
	Male	20	57	36.19	9.39	34.5	30	81.2			
Depression	Female	.00	47	18.23	10.69	18	20	118.1	3637.5	-2.297	.022
	Male	1	41	14.67	10.64	9.5	7	94.86			
Shifting	Female	19	88	69.11	16.24	80	80	110.42	4236.5	-.940	.347
	Male	33	80	70.39	16.10	80	80	119.05			
Working memory	Female	66	124	90.76	10.81	89	88	114.66	4222	-.890	.374
	Male	73	133	90.09	12.13	88	85	105.69			
Inhibition	Female	20	80	49.98	9.76	49	50	113.10	4488	-.246	.805
	Male	28	71	49.59	8.37	49	44	110.61			

In relation to the age range, it was observed that the emotional variables reached higher average values in the first age range than in the second. The same was observed in the shifting variable, where the mean score was higher in the first age range. However, the working memory variable was higher in the range of 24 to 30 years, as was inhibition. The Mann-Whitney U test shows

that there are statistical differences between the age ranges for the variables trait anxiety and depression. These results are shown in Table 3.

Table 3. Descriptive and comparative statistics with respect to the age range of the variables considered

Variables		Minimum	Maximum	Mean	S.D.	Median	Mode	Average range	Mann-Whitney U	Z	Sig.
Anxiety - Trait	18 to 23	21	72	46.71	12.21	47	43	116.85	2725	-2.223	.026
	24 to 30	24	70	41.92	13.14	38	32	91.21			
Anxiety - State	18 to 23	20	73	42.33	11.48	42	43	114.97	3074	-1.264	.206
	24 to 30	21	71	39.79	13.04	38	35	100.39			
Depression	18 to 23	1	47	18.15	10.81	17	20	117.26	2648.50	-2.434	.015
	24 to 30	.00	39	13.55	9.81	11	2	89.20			
Shifting	18 to 23	23	88	70	15.36	80	80	113.50	3347.50	-.565	.572
	24 to 30	19	80	66.55	19.70	80	80	107.59			
Working memory	18 to 23	66	133	90.63	11.53	89	88	112.42	3518.50	-.043	.966
	24 to 30	76	115	90.42	8.99	88	85	112.91			
Inhibition	18 to 23	20	80	49.87	9.02	49	50	112.94	3452	-.226	.821
	24 to 30	28	80	49.95	11.34	49	48	110.34			

When evaluating the correlation between the executive functioning variables and the emotional variables, the nonparametric Spearman's Rho correlation coefficient was calculated, given that the variables considered are not normally distributed. In this case, it was observed that the only variable that correlated significantly with any emotional variable was working memory, which correlated with Anxiety - Trait ($r = -.139$; sig. $< .001$).

3.2 Multinomial logistic regression

In order to evaluate the predictive value that the emotional variables had on the variables related to executive functions, a multinomial logistic regression model was applied, where shifting and Inhibition were considered as dependent variables, categorized into three levels: Low (typical score equal to or lower than 39), average (typical score between 40 and 60) and high (direct score higher than 60), different from working memory with a mean of 100 and a standard deviation of 10 points, with the low range being below 90 and high when above 110.

In the first model, shifting is considered as a dependent variable and is contrasted with the trait anxiety, state anxiety and depression scales. In this contrast, it was observed that 8% of the cases are at the low level of shifting, 82.6% at the average level and 9.4% at the high level. The goodness of fit of the model was significant with respect to the final model (Chi-square = 153.878; df = 6; p = .286).

Table 4. Adjustment of the Shifting model

Model adjustment information				
Model	Model adjustment criteria	Plausibility ratio tests		
	Logarithm of the probability -2	Chi- square	Df	Sig.
Null	490.792	153.878	6	.000
Final	336.914			
Goodness of adjustment				
Pearson	--	454.227	438	.286
Deviation	--	335.527	438	1
Plausibility ratio				
Anxiety – Trait	343.479	6.565	2	.038
Anxiety – State	338.066	1.152	2	.562
Depression	341.689	4.776	2	.092

$R^2_{Cox\ y\ Snell}$ = .497; $R^2_{Nagelkerke}$ = .559; $R^2_{McFadden}$ = .313.

From the results in Table 4 it can be observed that the final model achieves a significant adjustment, that trait anxiety is the variable that manages to significantly explain the behavior of the dependent variable, which is established at 49.7% of the variance explained. Table 5 shows the estimated coefficients of the multinomial regression model.

Table 5. Parameter estimation of the shifting model

Shifting [to]		B.	S.D.	Wald	gl	Sig.	OR	95% confidence interval for Exp(B)	
								Lower limit	Upper limit
Average	Anxiety - Trait	.040	.033	1.491	1	.222	1.041	.976	1.110
	Anxiety - State	-.024	.031	.605	1	.437	.976	.919	1.037
	Depression	-.010	.035	.073	1	.787	.990	.924	1.062
High	Anxiety - Trait	.067	.029	5.519	1	.019	1.070	1.011	1.131
	Anxiety - State	-.003	.027	.015	1	.903	.997	.946	1.051
	Depression	-.051	.031	2.692	1	.101	.951	.895	1.010

a. The reference category is: Low. R^2 Cox and Snell = .497; R^2 Nagelkerke = .559; R^2McFadden = .313.

Table 5 shows that Anxiety - Trait significantly increases 1.070 times the probability of being in the high level of shifting with respect to the low level. The other variables fail to significantly explain the levels of shifting as a dependent variable.

Table 6. Adjustment of the Inhibition model

Model adjustment information				
Model	Model adjustment criteria	Plausibility ratio tests		
	Logarithm of the probability -2	Chi- square	df	Sig.
Null	490.792	233.102	6	.000
Final	257.690			
Goodness of adjustment				
Pearson	--	503.167	438	.017
Deviation	--	256.303	438	1
Plausibility ratio				
Anxiety – Trait	258.295	.605	2	.739
Anxiety – State	261.899	4.209	2	.122
Depression	259.260	1.571	2	.456

$R^2_{Cox\ y\ Snell}$ = 0,647; $R^2_{Nagelkerke}$ = 0,728; $R^2_{McFadden}$ = 0,474.

Alternatively, the model associated with the dependent variable of Inhibition, shows that the final model reaches a significance level at the 1% level. It was also observed that the Chi-square value decreases from 503.167 to 256.303, increasing the significance level in goodness of adjustment. The plausibility ratio test does not show statistically significant values in the independent variables. It was also observed that the independent variables manage to explain between 64.7% and 72.8% of the variance of the dependent variables.

Table 7. Parameter estimation for the Inhibition model

Inhibition[a]		B	S.D.	Wald	gl	Sig.	OR	95% confidence interval for Exp(B)	
								Lower limit	Upper limit
Low	Anxiety - Trait	-.026	.034	.593	1	.441	.974	.912	1.041
	Anxiety - State	-.014	.033	.195	1	.659	.986	.925	1.051
	Depression	-.041	.040	1.058	1	.304	.959	.887	1.038
High	Anxiety - Trait	-.005	.027	.029	1	.864	.995	.944	1.050
	Anxiety - State	-.054	.027	4.077	1	.043	.948	.900	.998
	Depression	.017	.031	.304	1	.581	1.017	.957	1.081

a. The reference category is: Average. R^2 Cox and Snell = .647; R^2 Nagelkerke = .728; R^2 McFadden = .474.

From the results of Table 7 it can be observed that Anxiety-State significantly decreases the probability of having a high level of Inhibition by .948 times with respect to the average level. The other dependent variables have no significant effect on the behavior of Inhibition levels.

In this analysis, the effect of the social stratum (categorized as low, medium and high) on the observed variables was also evaluated and the effects of the change of stratum on the definition of the categories of trait anxiety, state anxiety, depression, shifting and inhibition were

established from the logistic regression model. For the emotional variables, the variable was dichotomized into the minimal presence of the respective emotion and presence of the emotion. The executive variables were taken at the same three levels of the previous models.

Table 8 shows how the change in socioeconomic levels significantly increases the probability of moving from the minimum level of Trait Anxiety to the presence of anxiety in the participants. These changes are significant and more probable for the three levels of socioeconomic stratum being more probable for the high stratum.

Table 8. Parameter estimation for the Trait Anxiety model

Trait Anxiety[a]		B	S.D.	Wald	gl	Sig.	OR	95% confidence interval for Exp(B)	
								Lower limit	Upper limit
Presence Trait Anxiety	Low stratum	2.048	.376	29.711	1	.000	7.750	3.711	16.184
	Medium stratum	1.868	.246	57.412	1	.000	6.474	3.993	10.495
	High stratum	2.398	1.044	5.271	1	.022	11	1.420	85.201

a. The reference category is: minimal trait anxiety. R^2 Cox and Snell = .470; R^2 Nagelkerke = .626; R^2 McFadden = .458.

This model presents a significant adjustment from the goodness of adjustment indicators (Chi-square = 142.123, gl = 3; p = .076). This model classifies 12.5% of the participants (28) in the level of minimal trait anxiety and the remaining (87.5%) in the level of presence of trait anxiety.

Table 9 shows the effect of the change in socioeconomic level on the state anxiety variable. This table shows that it is more likely to significantly increase from the level of minimal state anxiety to the presence of state anxiety only in the low and middle stratum, with this relationship being more important in the low stratum.

Table 9. Parameter estimation for the State Anxiety model

State Anxiety[a]		B	S.D.	Wald	gl	Sig.	OR	95% confidence interval for Exp(B)	
								Lower limit	Upper limit
Presence State Anxiety	Low stratum	2.197	.398	30.415	1	.000	9	4.122	19.650
	Medium stratum	1.276	.203	39.426	1	.000	3.581	2.405	5.332
	High stratum	.693	.612	1.281	1	.258	2	.602	6.642

a. The reference category is: minimal state anxiety. R^2 Cox and Snell = .362; R^2 Nagelkerke .483; R^2 McFadden = .324.

This model presents a significant adjustment to the data from the goodness of adjustment indicators (Chi-square = 100.710, gl = 3; p = .123). This model evaluates the classification of 18.8% of the participants in the level of minimal State Anxiety and 81.3% in the level of presence of State Anxiety.

Finally, the socioeconomic stratum effect on the depression levels is evaluated. In this case it is observed that it is more likely to change from the level of minimal depression to the presence of depression only in the middle stratum. This result is shown in Table 10.

Table 10. Parameter estimation for the Depression model

Depression [a]		B	S.D.	Wald	gl	Sig.	O.R.	95% confidence interval for Exp(B)	
								Lower limit	Upper limit
Presence Depression	Low stratum	.346	.243	2.037	1	.154	1.414	.879	2.275
	Medium stratum	.370	.171	4.707	1	.030	1.448	1.036	2.024
	High stratum	.000	.577	.000	1	1	1	.323	3.101

a. The reference category is: minimal depression. R^2 Cox and Snell = .03; R^2 Nagelkerke .04; R^2 McFadden = .02.

This model presents a significant adjustment to the data based on the goodness of adjustment indicators (Chi-square = 6.855, gl = 3; p = .077). This model evaluates the classification of 41.5% of the participants in the level of minimal depression and 58.5% in the level of presence of depression.

4. Discussion

The depression and anxiety tests applied place the sample in a range of mild depression, medium state anxiety and high trait anxiety. Although this also means that at least 17 out of every 100 students in Manizales have severe depression, 4 out of 10 have high state anxiety and 1 out of two has high trait anxiety. This allows us to confirm the national results issued by DANE (National Administrative Department of Statistics, 2021), but it also reflects the great incidence that emotions such as anxiety and depression have on college students in the city of Manizales. Regarding executive functions, working memory and inhibition are in average ranges, except for shifting, which is in high ranges.

With respect to the interaction of these factors, some relationships were found between the emotional variables and executive functioning, however, there was no evidence of a direct and clear affectation between high or severe levels of the emotional variables and all the domains of executive functioning. The evidence points to a bidirectional relationship between emotions and

the different executive variables, for example it was shown that high state anxiety decreases the probability that inhibition is at high levels as explained (Alfonso & Lonigan, 2021; Cao et al., 2022; Liang 2021). And that confirms for this executive domain the relationship proposed by (Morales et al., 2022; Zainal & Newman, 2021; König et al., 2021) confirming that the cognitive component of inhibition can regulate anxiety, just as anxiety can affect this regulatory capacity (Cao et al., 2022; Sluis et al., 2017).

For the working memory variable, a negative correlation was identified with the trait anxiety variable, finding that the higher trait anxiety levels, the lower working memory performance, which confirms the relationship between these variables described by (Warren et al., 2021; Valenti et al., 2021) and also that of (Culot et al., 2021; Minihan et al., 2021; Zainal & Newman, 2018) in finding that low scores in working memory can be a predictor of anxiety.

As for the shifting variable, trait anxiety was not found to be inversely related to this function as proposed by (Valenti et al., 2021; Warren et al., 2021). On the contrary, it was confirmed that when the trait anxiety scores are higher, there is a higher probability that the executive function of shifting is in high ranges, confirming some of the proposals of (Atabek, et al., 2022; Alfonso & Lonigan, 2021; Sluis et al., 2017), finding that low anxiety scores improve the performance of some executive functions and high levels of anxiety related to impairments (Culot et al., 2021)

Regarding the relationship with the depression variable, the present research did not find a statistically significant relationship between depression as an independent variable and the affectation of the domains of executive functioning, this controverts the findings made by Ajilchi & Nejati. (2017) who found affectation of the domains of executive functioning in the presence of depression in college students. As well as the results of (Warren et al., 2021) who also relate depression to lower scores on executive function tests or (Kryza-Lacombe et al., 2021) who explain that executive deficiency is associated with the most severe cases of depression by the presence of signs such as marked lack of motivation and apathy. However, our investigation not having found a direct relationship between depression and executive functioning may be due to the fact that the sample is not a psychiatric population where these pathologies are accentuated, since the depression scores obtained in the present investigation place the sample in the range of mild depression.

It was confirmed that trait and state anxiety tend to occur together, a relationship widely studied by different authors between anxiety and depression was also confirmed, explaining that these disorders tend to occur together (Coussement et al., 2022; ter Meulen et al., 2021 ; König et al., 2021; König et al., 2021; Gustavson et al., 2019) and that they are more accentuated in women than in men (Deng et al., 2021; Eid et al. 2019; Kim et al., 2022; Oh et al., 2021) contrary to

what was found (Gao et al., 2020) who indicated that depression was more accentuated in male than female college students. On the other hand, in terms of executive functioning, there was no significant difference between women and men.

Another aspect that was taken into account was the comparison by age, compared to this, higher scores were presented in both depression and trait and state anxiety in the sample of 18 to 23 years old. Regarding executive functioning by age, there is evidence of a higher average performance in working memory and inhibitory control in subjects aged 24 to 30 than in those aged 18 to 23, which is related to the maturation of these processes explained by (Friedman & Robbins, 2022). This confirms that executive maturation supports cognitive control over emotional variables (Kryza-Lacombe et al., 2022; Dobson et al., 2021; Bardeen et al., 2022; Rifkin et al., 2021; Kaya et al., 2019)

Additionally, a variable that better explains the change in emotional variables is the socioeconomic level, because although trait anxiety is transversal to the sample, state anxiety is more likely in low socioeconomic levels, while depression, by contrast, is more likely when the socioeconomic level is medium, confirming that the socioeconomic variable is a protective factor in the presence of these disorders (Ivanovic et al., 2022; Mou et al., 2022; Deng et al., 2021; Morales et al., 2022; Oh et al., 2021; Mance et al., 2019). Additionally, the socioeconomic stratum was not found to be related to any change in the executive functioning of college students, which suggests that this relationship may be more frequent in children (Ming et al., 2021) and adolescents (Mance et al., 2019), but not in adults as evidenced by this research.

In conclusion, executive functioning can be affected by severe anxiety and depression, (Crandall et al., 2019; Kryza-Lacombe et al., 2021; Alfonso & Lonigan, 2021; Cao et al., 2022; Liang 2021) however, the maturity of executive functioning can regulate emotional responses (Kryza-Lacombe et al., 2022; Bardeen et al., 2022; Dobson et al., 2021; Rifkin et al., 2021; Kaya et al., 2019) suggesting a bidirectional relationship between emotions and executive functioning mediated by protector factors like socioeconomic status Ivanovic et al., 2022; Mou et al., 2022; Deng et al., 2021; Morales et al., 2022; Oh et al., 2021; Mance et al., 2019) and quality of life (Zang et al., 2021).

These results are similar to those found by Majeed et al., (2023) the author explain that higher anxiety levels influence the effectiveness of updating and inhibitory control performance but not for shifting. As a limitation, it was not measured in this research whether the socioeconomic level is related to quality of life, since according to the research by Zhang et al. (2021) quality of life prevents executive impairment caused by depression, so future research is suggested to study quality of life as a mediating factor between anxiety and executive functioning. Also, is important

to consider in these studies of the relation between anxiety and executive functions that they are due to external variables, such as the use of psychiatric medication, or to situational factors at the time of assessment or social desirability that should be considered a bias (Majeed et al., 2023).

Conflict of Interest Statement

The authors declare that the research was conducted in the absence of any potential conflict of interest.

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