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Prediction of Suicide Based on Executive Functions with the Mediating Role of Depression Symptoms

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A B S T R A C T

Objective: The present study aimed to predict suicide based on executive functions with the mediating role of depression symptoms.

Methods and Materials: This study employed a descriptive-correlational design and was applied in terms of its objective. Additionally, it falls within the category of quantitative research. The statistical population consisted of all adolescents in Tehran. Based on Krejcie and Morgan's table and using convenience sampling, 300 male and female adolescents were selected as the sample from the statistical population of male and female adolescents. The data collection instruments included Beck's Suicide Ideation Scale (Beck, 1961), the Executive Function Questionnaire (1989), and Beck's Depression Inventory-II (BDI-II). Given that this study aimed to determine the predictive power of the independent variables, the descriptive analysis included tables, charts, measures of central tendency, measures of dispersion, and correlation indices. The inferential analysis involved significance tests for correlation coefficients and stepwise regression analysis. Data analysis was conducted using SPSS 24.

Findings: The study's findings indicated that the relationships between the research variables were statistically significant at the 95% and 99% confidence levels.

Conclusion: This study highlights the predictive role of executive functions in adolescent suicide risk, mediated by depression symptoms. Early interventions targeting executive function deficits and depression may help prevent suicide and improve mental health outcomes.

Keywords: *Suicide, Executive Functions, Depression Symptoms*

1. Introduction

Suicide is a multifactorial phenomenon resulting from the interaction of biological, genetic, social, and environmental factors. It is the most prevalent phenomenon among psychiatric disorders and has a significant association with depression. During a typical depressive episode, an individual experiences sadness, low mood, loss of pleasure, and reduced energy for daily activities, which increase their susceptibility to suicidal thoughts and behaviors. Suicide is one of the major mental health challenges among adolescents, making the understanding of suicidal behaviors,

their prediction, and prevention a critical issue in mental health. The prevalence of suicide attempts peaks during adolescence, with global statistics indicating that the suicide rate among adolescents ranges from 12% to 29% (Brådvik, 2018).

Despite recent advancements in available treatment options for mental health disorders, such as cognitive-behavioral therapies and new psychotropic medications, suicide rates (i.e., intentional deaths) have not significantly declined. This underscores the need for a deeper understanding of the predisposing factors for suicidal ideation. Experts and theorists have suggested that individuals with suicidal thoughts or those who attempt suicide exhibit cognitive rigidity. According to neuropsychological and cognitive theories, this cognitive rigidity is indicative of deficits in executive functions. Indeed, cognitive impairments in the domain of executive functions are linked to cognitive rigidity (Adan et al., 2017; Riera-Serra et al., 2023; Rogerson et al., 2022).

More broadly, executive functions involve the conscious regulation of behavior toward goal-directed actions. However, goal pursuit is a complex process. Research and theories in the field of executive functions emphasize that executive functioning is a multidimensional construct. According to Miyake's proposed model, goal-directed behavior relies on three distinct executive abilities: (1) inhibition/suppression of habitual or dominant responses, (2) task-switching or mental set shifting, and (3) monitoring/control of working memory content (i.e., updating memory). These abilities regulate lower-level cognitive processes, such as perception and motor responses, which are particularly crucial in non-routine situations (Mueller et al., 2021).

Additionally, existing evidence suggests that individual differences in these abilities are significant and have behavioral and psychological consequences. Several reasons explain why deficits in executive functions contribute to suicide risk. First, impairments in executive functions can lead to difficulties in regulating emotions, thoughts, and behaviors, which, in turn, foster suicidal ideation or behavior (Lim et al., 2018). For example, individuals with deficits in executive functions struggle to control thoughts related to self-harm or to shift from negative coping strategies to positive or adaptive stress-coping mechanisms. In this regard, suicide has been linked to rumination and problem-solving deficits, which are associated with impairments in executive functions (Riera-Serra et al., 2023).

Furthermore, deficits in executive functions lead to difficulties in retrieving past event memories, resulting in a sense of helplessness. Individuals with response inhibition deficits struggle to resist impulsive thoughts of self-harm. Moreover, impairments in executive functions are linked to risky decision-making, which is also a contributing factor to suicidal ideation or behavior (Adan et al., 2017; Riera-Serra et al., 2023; Rogerson et al., 2022).

In summary, deficits in executive functions are associated with suicidal thoughts and behaviors because (1) executive function deficits are linked to various psychological disorders, including depression, and (2) functional and structural abnormalities in the prefrontal cortex (the brain region responsible for executive functions) are related to suicide. Given the existing body of research, no study has yet examined the prediction of suicidal thoughts and suicide risk in adolescents based on executive functions, with the mediating role of depression symptoms. This study aims to address the question: Can suicide risk be predicted based on executive functions with the mediating role of depression?

2. Methods and Materials

2.1. Study Design and Participants

The present study employed a descriptive-correlational design and was applied in terms of its objective. The statistical population comprised all adolescents in Tehran. Based on Krejcie and Morgan's table and using stratified random sampling, 387 male and female adolescents were selected as the sample. The sample size was determined using Morgan's formula. However, in multiple regression analysis, the ratio of the sample size (observations) to independent variables should not be less than 5; otherwise, the results of the regression equation will not be generalizable. A more conservative ratio of 10 observations per independent variable has been recommended by Halinski and Feldt (1970) and Miller and Kunce (1973). Given that the total population was 300, the Morgan formula estimated the sample size as 387 participants. Considering the possibility of participant attrition, 285 individuals were ultimately selected for the study.

Inclusion criteria included willingness to respond, being in the age range of 12–18 years, and having at least a sixth-grade education level. Exclusion criteria included lack of sufficient time, incomplete responses to the research questionnaires, and lack of interest in participating in the study.

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Following necessary coordination with the university's research department and obtaining ethical approval, the questionnaires were designed and distributed. The questionnaire link was shared with university students via online social networks. Participants were provided with explanations regarding the study's objectives and the importance of dedicating sufficient time to answering the questions. They were instructed to respond with complete honesty. After completing the questionnaires, participants submitted their responses via email to the researcher.

Ethical considerations included providing written information about the study to participants, ensuring confidentiality of the collected data, using the information solely for research purposes, emphasizing the voluntary nature of participation, and not recording participants' names to protect their privacy.

2.2. Measures

2.2.1. Suicide Ideation

Beck's Suicide Ideation Scale, developed by Beck in 1961, was used in this study. This questionnaire consists of 19 items, with five screening questions that assess active or passive suicidal tendencies. It measures three factors: desire for death, preparedness for suicide, and actual suicidal intent (Beck, 1991). Scoring involves assigning values from 0 to 2 to each item. The final score for each factor is obtained by summing the corresponding item scores and dividing by the number of items in that factor. Scores of 0–5 indicate a desire for death, 6–19 reflect preparedness for suicide, and 20–38 indicate actual suicidal intent. Anisi et al. (2005) validated this questionnaire in their research and confirmed its reliability with a Cronbach's alpha coefficient of 0.87 (Abdollahi, 2015).

2.2.2. Executive Function

The Executive Functioning Self-Report Scale was designed by Holst and Troll to assess executive functioning in both neurotypical and clinical adult populations and is widely used in research and clinical settings. The scale consists of 14 items rated on a 5-point Likert scale, ranging from 1 (completely false) to 5 (completely true). The memory subscale consists of nine items, with a score range of 9–45, while the inhibition subscale contains five items, ranging from 5 to 25. The total executive function score ranges from 14 to 70. In the original study, test-retest reliability ranged from 0.68 to 0.72, and internal consistency was reported as 0.90 for memory, 0.77 for inhibition, and 0.91 for total executive function (Babaei et al., 2024; Baniasadi, 2024).

2.2.3. Depression

The Beck Depression Inventory-II (BDI-II) is a revised version of the original Beck Depression Inventory, developed to assess depression severity and aligned with DSM-IV criteria. It consists of 21 statements, each containing four response options. The total score ranges from 0 to 63, with scores below 10 indicating a non-depressed state and scores above 10 suggesting varying degrees of depression severity. Cronbach's alpha reliability was reported as 0.87, and test-retest reliability was 0.74 for this questionnaire (Akhondi Yazdi et al., 2024).

2.3. Data Analysis

Given that this study aimed to determine the predictive power of the independent variables, the descriptive analysis included tables, charts, measures of central tendency, measures of dispersion, and correlation indices. The inferential analysis involved significance tests for correlation coefficients and stepwise regression analysis. Data analysis was conducted using SPSS 24.

3. Findings and Results

The highest number of participants in terms of gender was female. Additionally, the highest frequency for the parental education variable was in the diploma group. Moreover, the most common age group was 16 to 17 years old.

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Table 1

Descriptive Statistics of Research Variables

Variable	N	Minimum	Maximum	Mean	Standard Deviation
Suicide	223	2	33	8.70	5.38
Depression	223	0	41	15.24	11.06
Executive Functioning	223	14	63	30.65	9.74
Inhibition	223	4	20	9.12	3.46
Memory	223	9	43	21.52	6.64

Table 1 presents descriptive statistics and central tendency indicators, including the mean and standard deviation. Higher mean values for variables with positive semantic loadings indicate that the variable is in a desirable and satisfactory state. Conversely, higher mean values for variables with negative semantic loadings suggest that the variable is in an undesirable condition. Since the skewness and kurtosis values divided by the standard error for the suicide variable do not fall within the range of -2 to +2, it is concluded that the distribution of scores for this variable is not normal.

The correlation coefficient ranges from -1 to 1. A correlation coefficient of 1 indicates a perfect positive relationship between two variables, meaning that as one variable increases (or decreases), the other also increases (or decreases). A correlation coefficient of -1 indicates a perfect negative relationship, meaning that as one variable increases, the other decreases, and vice versa.

Table 2

Correlation Matrix of Research Variables

Variable	1	2	3
Suicide	1		
Depression	0.504**	1	
Executive Functioning	0.406**	0.524**	1

*p<0.05, **p<0.01

As shown in the correlation matrix (Table 2), the relationships between the research variables are significant at the 95% and 99% confidence levels. A significant positive relationship exists between all research variables. The strongest relationship is between depression and executive functions (r = 0.524), while the weakest relationship is between executive functions and suicide (r = 0.406).

Several criteria are used to evaluate the fit of the structural model in the research, with the first and most fundamental being the significance coefficients, or t-values. If the t value exceeds 1.96, it confirms the validity of the relationships between constructs and, consequently, supports the research hypotheses at a 95% confidence level.

Table 3

Direct and Indirect Effects

Pathway	Beta	M	SD	T	P	Conclusion
Executive Functions → Depression Symptoms → Suicide	0.358	0.373	0.048	7.471	0.000	Accepted
Executive Functions → Suicide	0.139	0.127	0.066	2.112	0.035	Accepted
Depression Symptoms → Suicide	0.571	0.588	0.060	9.436	0.000	Accepted
Executive Functions → Depression Symptoms	0.628	0.634	0.046	13.601	0.000	Accepted

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As observed in Table 3, the obtained test statistic must exceed the critical value of 1.96 to indicate that the null hypothesis (stating that the mediating variable plays no role in the relationship between the exogenous and endogenous variable) can be rejected at a 0.05 significance level, confirming the mediating effect in the relationships between the variables. The mediation effect was confirmed based on the results. Path coefficients (*β values*) were reported for all pathways in the model. If the *t-values* for these pathways exceed the critical value of 1.96, the research pathways are confirmed with 95% confidence. The results indicate whether the pathway or hypothesis is accepted or rejected, as specified in the conclusion column.

Another criterion for evaluating the structural model in PLS is the (Q^2) index, introduced by Stone and Geisser (1975), which assesses the model's predictive power for endogenous constructs. They argue that well-fitting structural models should be capable of predicting endogenous variables. In other words, if the relationships between constructs in a model are correctly defined, they should exert sufficient influence on one another, leading to the proper confirmation of hypotheses.

In the (Q^2) index, SSO represents the sum of squared observations for each latent variable block, and SSE represents the sum of squared prediction errors for each latent variable block. If the (Q^2) index value is positive and greater than zero, it indicates that the model fit is satisfactory and possesses strong predictive capability. As observed, the positive values confirm the model's adequate fit.

Another criterion for assessing model fit is the determination coefficient (R^2), which pertains to endogenous (dependent) latent variables. This metric links the measurement and structural components in structural equation modeling and reflects the influence of an exogenous variable on an endogenous variable. It is important to note that R^2 values are only calculated for endogenous (dependent) constructs, and for exogenous constructs, this value is always zero. The higher the R^2 value for an endogenous construct, the better the model fit. The three values 0.19, 0.33, and 0.67 are considered weak, moderate, and strong R^2 values, respectively.

Table 4

Cumulative Determination Coefficients for the Research Model

Variable Type	Variable Name	Determination Coefficient (R^2)	Adjusted Determination Coefficient (R^2 Adjusted)
Mediator	Depression Symptoms	0.394	0.390
Dependent	Suicide	0.444	0.440

The most important model fit index in the partial least squares (PLS) technique is the Goodness-of-Fit (GOF) index. This index is calculated using the geometric mean of the R^2 index and the mean of communalities. The GOF criterion was introduced by Tenenhaus et al. (2004). Although fit statistics such as the Bentler-Bonett normed fit index are reported in software outputs like LISREL, these indices are based on the assumption that model parameters are estimated to minimize the difference between observed and reproduced covariance matrices. This assumption does not hold in PLS modeling.

Tenenhaus et al. (2004) argue that the GOF index provides a practical solution for assessing the overall model fit in PLS models. This index operates similarly to covariance-based fit indices and can be used to evaluate the validity or quality of a PLS model holistically. Like LISREL fit indices, the GOF index ranges from 0 to 1, with values closer to 1 indicating better model quality.

Table 5

Overall Model Fit

Index	Critical Value	Estimated Model Value
GOF	0.25	0.372
Q^2	Above 0	0.137
RMS Theta	Less than 0.12	0.11

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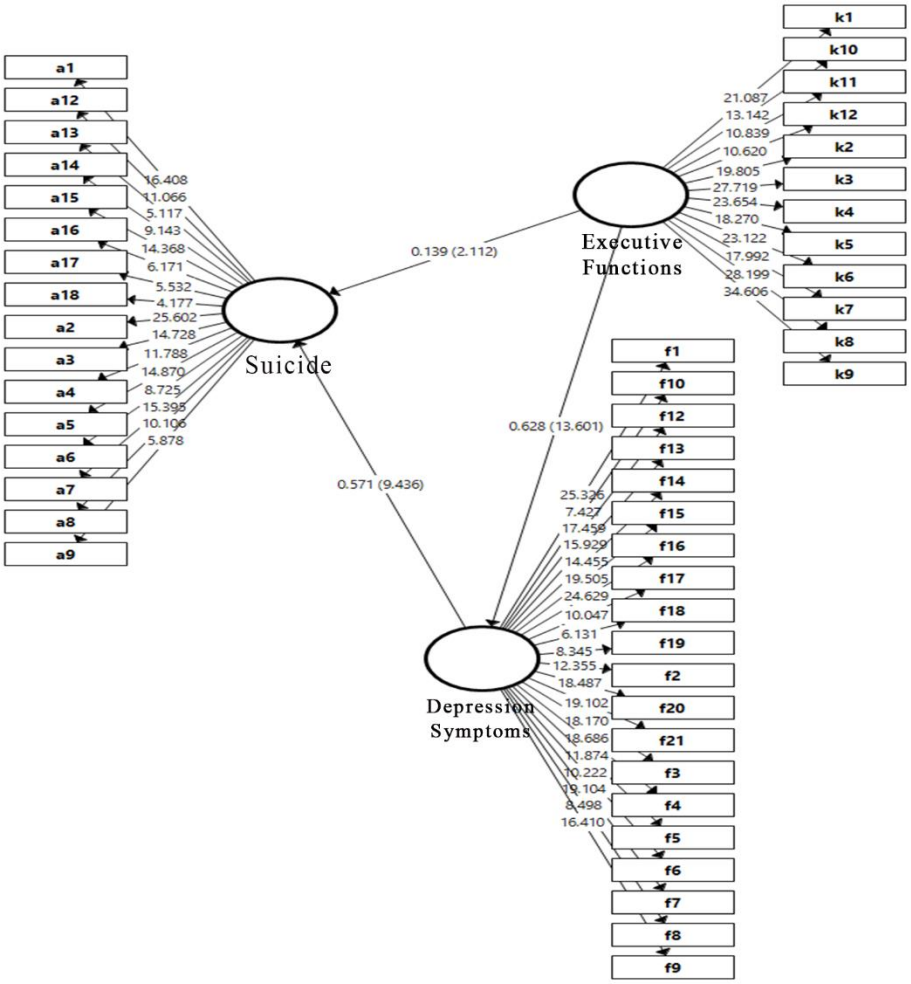
Figure 1

Final Model of the Study



As observed, the obtained GOF index is 0.372, which is above the threshold of 0.25 for moderate fit, indicating an acceptable overall model fit.

4. Discussion and Conclusion

The general hypothesis stated that suicide risk in adolescents can be predicted based on executive functions, with depression symptoms playing a mediating role. These findings align with the prior studies (Adan et al., 2017; Li et al., 2023; Mozafari et al., 2022; Pourjaberi et al., 2023; Riera-Serra et al., 2023; Rogerson et al., 2022; Zhang et al., 2022).

To explain this hypothesis, the relationship between adolescent suicide risk and executive functions, with depression symptoms as a mediator, is a critical issue in psychology and mental health. Executive functions encompass a set of cognitive abilities that enable individuals to plan, make decisions, and regulate their behaviors. Impairments in these functions can lead to behavioral and psychological difficulties.

Adolescence is a transitional period from childhood to adulthood, characterized by significant changes in brain development, hormonal fluctuations, and social environmental shifts. These changes may affect executive functions, and if dysfunction occurs in this domain, the likelihood of psychological disorders, including depression, increases.

The link between suicide, executive functions, and depression symptoms has been a focus in psychological research. Executive functions include cognitive processes such as planning, decision-making, impulse control, and cognitive flexibility, which play a crucial role in behavioral regulation and adaptation to environmental challenges. Studies have shown that executive dysfunction is associated with an increased risk of suicide.

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Depression is a major risk factor for suicide. The mediating role of depression symptoms suggests that impairments in executive functions may elevate suicide risk by inducing or exacerbating depressive symptoms. For example, adolescents who struggle with emotional regulation or problem-solving may experience heightened feelings of frustration or hopelessness, which can contribute to depressive symptoms. Ultimately, these symptoms increase the likelihood of suicidal thoughts or behaviors.

Specifically, individuals with deficits in impulse control and decision-making may be more vulnerable to high-risk behaviors, including suicide. Such impairments may reduce an individual's ability to cope with life stressors and increase feelings of helplessness and despair. Depression symptoms also serve as a critical mediator in this relationship. Depression can negatively impact executive functioning by reducing cognitive energy, impairing attention and concentration, and fostering negative thought patterns. On the other hand, depression is a strong predictor of suicide. Thus, depression not only directly increases suicide risk but also reinforces the connection through its impact on executive functioning.

Overall, examining the relationship between executive functions, depression, and suicide can enhance our understanding of the factors influencing suicidal behaviors and inform prevention strategies. Early identification of executive function deficits and depressive symptoms may help prevent adolescent suicide. Psychological interventions such as cognitive-behavioral therapy (CBT) and emotional regulation skills training can improve executive functions, reduce depressive symptoms, and subsequently lower suicide risk.

5. Limitations & Suggestions

The study's population was limited to adolescents in Tehran, and cultural and social factors may affect the generalizability of the results to a national level or other demographic groups. Due to practical constraints, random sampling was not feasible. Uncontrolled variables such as parental education level, social class, economic status, and number of siblings may have influenced the outcomes, representing a limitation of the study.

Based on the study's findings, the following recommendations are proposed:

- Organizing workshops and training sessions to teach stress management techniques and enhance psychological resilience.
- Providing individual and group counseling services to identify and treat depressive symptoms and improve executive functions.
- Encouraging regular physical exercise, which can reduce depressive symptoms and promote mental well-being.
- Teaching problem-solving, decision-making, and time management skills to enhance executive functioning.
- Facilitating access to psychiatric and psychotherapeutic services for individuals at risk of suicide.

Future research should consider studying other populations in different cities and using random sampling methods if possible. Additionally, future studies should examine the influence of variables such as parental education level, social class, economic status, and number of siblings.

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Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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Authors' Contributions

This article is derived from the first author's doctoral dissertation. All authors equally contributed to this article.

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