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Working Memory, Attention, and Inhibitory Control in Adolescents with Suicidal Behavior: A Pilot Study

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ABSTRACT

Suicide in people between the ages of 15 and 24 is one of the top three causes of death. The aim of this research is to compare and associate performance in working memory, attention, and inhibitory control with the presence of suicidal behavior in adolescents. Research design was cross-sectional and the convenience sample consisted of 65 adolescents from the city of Temuco, Chile. The instruments used for data collection were: 1) the Okasha Suicidality Scale, 2) span of direct and indirect digits, and 3) the Stroop test. The results show that 49.3% of the adolescents had suicidal ideation. In terms of the groups, an association and significant differences were found in the Stroop test; this occurred specifically in the female sex ($p < .05$). In the rest of the tasks that measured memory and attention, no differences were observed ($p > .05$). It is concluded that suicidal behavior is associated with a lower performance in inhibitory control tasks for females.

La memoria de trabajo, la atención y el control inhibitorio en los adolescentes con conducta suicida: un estudio piloto

RESUMEN

El suicidio en personas entre 15 y 24 años es una de las tres primeras causas de muerte. El objetivo de este trabajo ha sido determinar la asociación de la memoria de trabajo, la atención y el control inhibitorio con la presencia de conducta suicida en adolescentes. Se ha utilizado un diseño de investigación transversal y una muestra por conveniencia compuesta por 65 adolescentes de la ciudad de Temuco, Chile. En la recolección de datos se utilizaron: 1) la Escala de Suicidalidad Okasha, 2) la amplitud de dígitos directos e indirectos y 3) el test de Stroop. En el 49.3% de los adolescentes se presentó ideación suicida, encontrando diferencias significativas en el test de Stroop, esto ocurre específicamente en el sexo femenino ($p < .05$). Se concluye que la conducta suicida está asociada a un desempeño más bajo en tareas de control inhibitorio para el sexo femenino.

According to the World Health Organization, suicide is defined as “any act by which an individual causes injury or harm to himself or herself, with varying degrees of intent to die and knowledge of the true motivation” (WHO, 2016).

There are different researchers whose theories stand out in explaining suicidal behavior. Emile Durkheim analyzed suicide as a social phenomenon, discarding the hereditary component and associating it with the temperament of its executors, indicating that there must be a favorable environment for its development, where society, family, school, and the groups in which each person participates are fundamental and act by influencing the suicidal episode itself (Kołodziej-Sarzyńska et al., 2019). Aaron Beck, proposed a cognitive model for the study of suicide, associating it mainly to depression and hopelessness, contributing to the knowledge of suicide

through the generation of scales for the evaluation of its dimensions (Beck et al., 1996). Thomas Joiner proposed the Interpersonal Theory of Suicide, suggesting therapeutic targets to work on with people at risk of suicide. The interpersonal theory links suicidal desire to the presence of interpersonal factors: lack of belonging, feeling of being a significant burden to others, and the acquired capacity to carry out the suicide; in this sense, he states that people who feel a desire to commit suicide and have also developed the capacity to do so will be the ones who carry out suicide attempts with greater lethality and are more likely to die of it (Chu et al., 2017). On the other hand, it is proposed that suicidal behavior is composed of stages. These stages range from suicidal ideation to suicide death (Carrasco-Barrios et al., 2020). The first stage corresponds to suicidal ideation, defined as ideas or thoughts about dying or taking one's own life. The second stage is

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suicide attempt, which corresponds to a self-inflicted destructive act with explicit or inferred intent to die. The final stage is suicide death, which is a fatal destructive self-inflicted act with explicit intent to die (O'Connor & Nock, 2014).

Globally, it is estimated that one million people commit suicide each year. Besides, this figure is expected to increase as a result of COVID-19 pandemic (Niederkröth et al., 2020). As for pre-pandemic figures, worldwide, 3,000 suicides per day were reported—approximately two people per minute—establishing a 20:1 ratio between suicide attempts and suicide deaths (WHO, 2016). In South America, there are differences regarding suicide rates, with Chile being one of the countries with the highest suicide rates. This phenomenon is on the rise and can be explained by various religious, cultural, environmental, etc. factors (Bustamante et al., 2016). At national level, the overall suicide rate is 10.2 per 100,000 inhabitants, while in the Araucanía region this rate rises to 13.6 per 100,000 inhabitants (DEIS, 2016). Among people between ages of 15 and 44, suicide is one of the three leading causes of death, and it is the second leading cause in the 10 to 24 age (Echávarri et al., 2015).

Regarding suicidal ideation in school children, studies in Chile report figures ranging from 30.7% to 57%, and from 14.2% to 19% in the case of suicide attempts (Valdivia et al., 2015).

In Latin America, there are few bibliographic references in Spanish on the association between executive functions and suicidal ideation. Therefore, it becomes essential to promote research on this topic of interest, especially in adolescents, since this is a crucial period in which young people are affected by multiple physical and emotional changes, often causing anxiety and depression and, as a result, leading to suicidal ideation (Shain, 2016). Additionally, during this stage of development, adolescents become more competent in the control of their thoughts, actions, and regulation of their own behaviors. These changes are associated and linked to the development of executive functions (Walshe et al., 2017).

Suicidal Behavior and Executive Functions

Executive functions correspond to complex cognitive abilities, such as selective attention, inhibitory control, and working memory, being responsible for the control and regulation of behaviors and emotions (Waller et al., 2017). These functions are particularly susceptible in psychiatric populations, especially among individuals with bipolar disorder, borderline personality disorder, depression, and psychotic disorder (Walshe et al., 2017).

As mentioned above, suicidal behavior comprises stages ranging from suicidal thinking to suicide death (Carrasco-Barrios et al., 2020). Suicides are estimated to be 10 times higher in people with mental disorders than in the general population (Bachmann, 2018).

Among some of the neuropsychological functions reported, impaired attention has been found to be related to suicidal behavior (Kim & Kong, 2020). Thus, the evidence suggests that the impairment of neurocognitive functioning is compromised in patients with suicide attempts (Interian et al., 2020). In this sense, executive functioning would be affected in people with current suicidal ideation (Interian et al., 2020), being inhibitory control the most affected, which, in addition, has been considered a risk factor (Lin et al., 2020). Furthermore, the ability to inappropriately inhibit responses represents a key component of executive function (Hu et al., 2018).

Along these lines, impaired inhibition can be considered a specific risk factor for suicidal behavior (McHugh et al., 2019). The explanation for this lies in the prefrontal cortex, which fulfills the role of executive control, mainly of information processing and behavioral expression, the ability to selectively hold information, inhibit irrelevant stimuli, and evaluating and selecting the appropriate response. Therefore, the presence of suicidal behavior could reflect or be a reflection of cognitive rigidity within the executive domain (Ram et al., 2019).

For this reason, the aim of this research was to compare and associate performance in working memory, attention, and inhibitory control with the presence of suicidal behavior in adolescents.

Method

This study was based on a cross-sectional design. The sample was composed of adolescents from the city of Temuco, aged 14 to 19 years. Non-probability convenience sampling was considered. The sample consisted of 65 adolescents, 24 females and 41 males.

Instruments

The following three instruments were used for this research.

Okasha's Suicidality Scale (Okasha et al., 1981). Self-administered, 4-point Likert-type response format, with a cut-off score of 5 points for suicidal ideation and adequate levels of reliability and validity (Salvo et al., 2009).

Digit span. It is part of the Wechsler scale, and is used to assess components of executive functions such as attentional capacity and working memory. It consists of two parts, which are applied separately: first in order to assess attention and then in reverse order to assess working memory. In both cases, the examiner must read aloud a series of numbers to the subject. The reliability of the test is .78 for digits forward and .73 for digits backward (Rosas et al., 2014).

Stroop test (Stroop, 1935). It is used to assess inhibitory control, attention, and cognitive flexibility. This is assessed through the ability to inhibit interference and the ability to control the interference produced by previously automated and unintentional responses in favor of other controlled and voluntary responses demanded by the test (Naber et al., 2016). It is composed of 3 cards: 1) words card, 2) colors card, and 3) interference card, plus a conjugate measure called interference index. Validated in Chile, it presents adequate levels of reliability and validity (Maureira et al., 2014).

Regarding data collection procedures, firstly, educational establishments in Temuco were selected, sending a presentation letter that disclosed the research objective and required procedures to obtain information of interest to each institution. After getting their approval, the research objective was presented to the students. The students that willingly agreed to engage in the evaluation signed two copies of an informed consent. Subsequently, in a room free of environmental noise, instructions for the evaluation were explained in detail and the battery of instruments was applied randomly. These instruments were: a) Okasha's Suicidality Scale, b) direct and inverse digit span, and c) the Stroop test (cards 1, 2, and 3). After the assessment, they were thanked for their participation and were assigned to the suicide risk group when their score on the Okasha's scale was equal to or greater than 5 points. At this point, it is important to mention that those adolescents who obtained a high suicide risk were referred to the psychologist of the establishment. To perform the statistical analysis, data were entered into the SPSS v23 software, after which an exploratory analysis was conducted through the Shapiro-Wilk test to determine the type of distribution. A descriptive analysis was then used to obtain means, standard deviations, medians, and ranges. Afterwards, the Student's *t*-test was used for the comparison of parametric data and the Mann-Whitney *U* test for the comparison of non-parametric data. At the same time, Pearson was used for the correlation of parametric data and Spearman for the correlation of non-parametric data, accepting the hypothesis when the significance level was less than .05.

As far as ethical aspects are concerned, the research subscribed to the principles of the 2013 Helsinki treaty, and the research protocol was approved by the ethical committee of Phonaudiology from the Autonomous University of Chile, Temuco campus, which gave its approval to proceed with the sampling through a record, code FONOAU0025.

Table 1. Comparison of Working Memory, Attention, and Inhibitory Control in Adolescents with and without Suicidal Ideation

		Without ideation (<i>n</i> = 33)		With ideation (<i>n</i> = 32)		<i>t</i> -test	<i>p</i>
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Stroop test	CW card	34.15	12.311	30.81	11.563	1.126	.26
	Interference	-2.12	10.11	-4.99	10.513	1.119	.267
		<i>Me</i>	<i>IQR</i>	<i>Me</i>	<i>IQR</i>	Mann-Whitney <i>U</i>	<i>p</i>
Stroop test	W card	94.82	18	91.00	24	449.00	.30
	C card	59.45	12	59.47	8.20	510.00	.81
	CW'	36.28	7.269	35.805	5.077	476.00	.49
Working memory	Direct span	5.39	1.059	5.16	0.954	466.00	.39
	Inverse span	3.45	0.905	3.31	0.821	500.00	.69

Note. Me = Median; IQR = Interquartile range.

Results

Overall Performance

Regarding age, the median was 17 years and the range was 4 years in both groups. Of these, 49.3% presented suicidal ideation while 50.7% did not.

In the first analysis, group performance was compared without considering sex. To this end, the Shapiro-Wilk test was applied, which showed normality for the scores of Stroop test's card 3 (CW) and interference, while the rest of the tasks showed a non-parametric distribution. When evaluating differences concerning attention, working memory, and inhibitory control between adolescents with and without suicidal ideation, no significant differences were observed, showing a value of $p > .05$ (Table 1).

Comparison of Working Memory, Attention, and Inhibitory Control in Adolescents with and without Suicidal Ideation by Sex

Concerning women, 70.8% presented suicidal ideation. The Shapiro-Wilk test showed normality for Stroop test's card 2 (C), card 3 (CW), CW', and interference subtests. On the other hand,

Stroop test's card 1 (W) subtest and the direct and inverse digit span behaved nonparametrically. Thus, it was possible to observe that only the Stroop test's interference value was significant ($p < .05$), where subjects with suicidal ideation showed higher scores than subjects without such ideation. No significant differences were observed for the rest of the variables (Table 2).

As to the group composed of men, 36.5% presented suicidal ideation. The Shapiro-Wilk test showed normality for Stroop test's card 2 (C), while Stroop test's card 1 (W), card 3 (CW), CW', and interference and direct and inverse digit span behaved nonparametrically. Thus, it is possible to observe that, with respect to the significance level ($p < .05$), none of the tests showed significant differences (Table 3).

Comparison of Working Memory, Attention, and Inhibitory Control in Adolescents with suicide Attempts, Considering Sex

Regarding women, 45.8% presented suicide attempts. The Shapiro-Wilk test showed normality for Stroop test's card 3 (CW) and interference. In contrast, Stroop test's card 1 (W), card 2, CW', and direct and inverse digit span behaved nonparametrically.

Table 2. Comparison of Working Memory, Attention, and Inhibitory Control in Females with and without Suicidal Ideation

		Females					
		Without ideation (<i>n</i> = 7)		With ideation (<i>n</i> = 17)		<i>t</i> -test	<i>p</i>
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Stroop test	C card	48.49	19.191	58.24	8.635	-1.730	.098
	CW card	32.57	12.286	27.59	8.132	0.988	.351
	CW'	31.039	11.203	34.986	5.345	-1.185	.249
	Interference	1.531	4.820	-7.398	7	3.584	.002**
		<i>Me</i>	<i>IQR</i>	<i>Me</i>	<i>IQR</i>		
Stroop test	W card	101	19	84	23	44.0	.324
Working memory	Direct span	6	2	5	2	32.5	.073
	Inverse span	3	1	3	2	58.0	.919

Note. Me = Median; IQR = Interquartile range.

** $p < .01$.

Table 3. Comparison of Working Memory, Attention, and Inhibitory Control in Males with and without Suicidal Ideation

		Males				<i>t</i> -test	<i>p</i>
		Without ideation (<i>n</i> = 26)		With ideation (<i>n</i> = 15)			
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Stroop test	C card	48.49	19.191	62.38	9.992	0.542	.591
		Me	IQR	Me	IQR	Mann-Whitney <i>U</i>	
Stroop test	W card	101	18	96	22	193.0	.957
	CW card	38	14	36.50	17	189.5	.881
	CW'	37.894	5.887	37.36	2.149	181.0	.705
	Interference	1.208	11.230	-0.927	7.1548	168.0	.465
Working memory	Direct span	6	1	5	1	183.0	.725
	Inverse span	3	1	3.50	1	186.5	.805

Note. Me = Median; IQR = Interquartile range.

Table 4. Comparison of Executive Functions in Females with and Without Suicidal Attempts

		Females				<i>t</i> -test	<i>p</i>
		Without attempt (<i>n</i> = 13)		With attempt (<i>n</i> = 11)			
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Stroop test	CW card	29.4	12	28.6	7.2	0.1	.85
	Interference	-1.1	7.4	-7.9	6.3	2.4	.02*
		Me	IQR	Me	IQR	Mann-Whitney <i>U</i> test	
Stroop test	W card	84	22	92	27	51	.23
	C card	53	18	62	8	33.5	.02*
	CW*	32	6.3	37.9	6.2	33	.02*
Digit span	Direct	5	2	6	2	60	.48
	Inverse	3	1	3	2	70	.92

Note. *Me* = Median; *IQR* = Interquartile range.

**p* < .05.

Table 5. Comparison of Executive Functions in Males with and without Suicidal Attempts

		Males				<i>t</i> -test	<i>p</i>
		Without attempt (<i>n</i> = 33)		With attempt (<i>n</i> = 8)			
		<i>M</i>	<i>SD</i>	<i>SD</i>	<i>SD</i>		
Stroop test	C card	62.3	8.8	8	59.8	0.5	.5
	CW card	33.7	13.9	37.6	6.7	-1.1	.27
	Interference	-3.9	12.6	1.7	3.6	-1.2	.22
		Me	IQR	Me	IQR	Mann-Whitney <i>U</i> test	
Stroop test	W card	97	22	95	19	118.5	.65
	CW*	38.1	5.5	37.1	2	114.5	.56
Digit span	Direct	5	1	5	1	122	.72
	Inverse	3	1	3.5	1	126	.85

Note. *Me* = Median; *IQR* = Interquartile range.

Concerning the test statistic, it was possible to observe that in Stroop test's interference subtest, performance differed significantly between both groups ($p < .05$), so it was concluded that female adolescents who had had suicide attempts had a lower capacity to control the interference produced by previously automated and unintentional responses than those who did not report an attempt (Table 4).

As for men, 19.5% presented suicide attempts. The Shapiro-Wilk test showed normality for Stroop test's card 2 (C), card 3 (CW), and interference subtests, while the rest of the variables behaved nonparametrically. Concerning the executive differences associated with reports of suicide attempts, it was possible to observe that there were no significant differences in any of the tests ($p > .05$) (Table 5).

Correlation between Working Memory, Attention, Inhibitory Control, and Suicidal Ideation, according to Sex

In the group composed of women, it was possible to observe a negative association in the Stroop test's interference subtest ($p < .05$). This means that adolescents with higher scores on suicidal ideation have lower performance in their ability to inhibit the interference produced by previously automated and unintentional responses (Table 6).

In the group of men no significant relationship was observed in any of the tests applied ($p > .05$), which would indicate that, in the male sex, suicidal ideation is not associated with memory, attention, and inhibitory control performance (Table 6).

Discussion

This research aimed to compare performance in working memory, attention, and inhibitory control with the presence of suicidal behavior in adolescents. At the same time, it aimed to establish the association between these functions and the level of suicidal risk.

Among the findings obtained, it was possible to observe significant differences in the interference task. Likewise, it was possible to see that as suicidal ideation increases, the capacity to inhibit automatic responses decreases. However, this only occurred in the female sex, which would indicate a different behavior between men and women (LeGris et al., 2012). It is also noteworthy that women who reported a previous suicide attempt showed a significantly higher relative processing speed of colors card, which could be due to a faster and slightly impulsive action. Besides, a greater deterioration in interference control was a striking finding concerning this group. Another study obtained similar results, indicating adequate performance for all executive functioning tasks except the Stroop test, in which individuals with suicidal ideation and attempt showed slightly impaired performance (Thompson & Ong, 2018).

Table 6. Correlation between Memory, Attention, Inhibitory Control, and Level of Suicidal Risk, according to Sex

		Suicidal Ideation			
		Females (<i>n</i> = 24)	<i>p</i> -value	Males (<i>n</i> = 41)	<i>p</i> -value
Stroop test	W card	.010	.963	.038	.813
	C card	.331	.114	.040	.804
	CW card	-.272	.198	.084	.601
	Interference	-.647	.001*	.086	.593
	CW*	.287	.173	.042	.792
Digit span	Direct	-.094	.663	-.004	.982
	Inverse	.004	.986	.058	.720

* $p < .05$.

At the same time, these findings are consistent with a subsequent study where it was found that suicidal ideation produced a greater vulnerability in inhibitory control. These results, as in the present study, were observed exclusively in the female sex (Harfmann et al., 2019).

Regarding findings related to inhibitory control performance, one study mentions that executive functions remain below the expected average, except for inhibition, which is very impaired, being considered a risk factor (Burton et al., 2011; Harfmann et al., 2019; Keilp et al., 2013; Oquendo et al., 2004). The results obtained in this research would indicate that suicidal behavior is manifested differently according to sex. For this reason, it seems prudent to continue conducting studies that incorporate a sample size calculation, with its respective effect size, in order to establish new therapeutic objectives and predictive markers.

On the other hand, this research is considered a first approach to executive function and suicidal behavior in young people in Chile, hoping to have results that can be widespread to the general population in the future. All of this with the goal of improving the current understanding of suicidal behavior. In addition, it would be interesting to control different factors, such as social context, drug use, and educational modalities, so as to be able to establish conclusions specific to the reality of each subject.

Conclusion

It is concluded that there is a link between interference tasks and suicidal ideation. In the same vein, it was also possible to find a link between performance in interference and suicide attempt. These findings were only applicable to female adolescents. No association was observed in the rest of the tasks. However, it is suggested to continue exploring the neuropsychological elements at the base of suicidal behavior in adolescents in order to establish new possibilities for therapeutic approaches and evaluation systems.

Conflict of Interest

The authors of this article declare no conflict of interest.

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