Ecological EF in alcohol-dependent patients

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Abstract: Objective: To investigate the characteristics of ecological executive functioning in alcohol-dependent patients. Methods: The Behavior Rating Inventory of Executive Function-Adult Version (BRIEF-A) was used to assess 103 alcohol-dependent patients and 106 healthy volunteers. Results: The total score and all factor scores of the alcohol-dependent patients were significantly higher than those of the healthy volunteers (all $P<0.01$). The daily alcohol consumption of alcohol-dependent patients was significantly positively correlated with working memory and emotional control of executive functioning (both $P<0.05$). Emotional control of executive functioning was identified as a risk factor for alcohol dependence ($OR=1.375, P<0.05$). Conclusion: Alcohol-dependent patients exhibited significant impairment in ecological executive functioning, with greater impairment observed in those with higher alcohol consumption. Poor emotional control was identified as a risk factor for alcohol dependence.

Keywords: Alcohol Dependence, Ecological Executive Functioning, Risk Factors, Case-Control Study

1. Introduction

Alcohol is a relatively common addictive substance and an anesthetic with neurotropic properties. It has direct neurotoxic effects on the human brain and exhibits a variety of behavioral and neurobiological effects. In recent years, the number of patients with chronic alcohol dependence has increased annually. Poor treatment outcomes and high relapse rates have made this issue a significant social concern. The socio-psychological status of individuals with alcohol dependence has garnered substantial attention in the fields of psychiatry and psychology both domestically and internationally. Numerous studies have been conducted on the neuropsychological changes associated with alcohol dependence [1].Generally, the decline in executive function is considered the most prominent feature of cognitive impairment in patients with alcohol dependence[2-3].In recent years, some domestic studies have begun to focus on the neurological, physiological, and psychological changes in patients with alcohol dependence, but research on the ecological executive function of these patients remains limited.

Executive function refers to the complex cognitive process by which an individual dynamically and flexibly coordinates the activities of multiple cognitive subsystems during goal-directed behavior. It is a higher-order cognitive process that regulates individual behavior to adapt to changing environments. Executive function is controlled by neural circuits in brain regions such as the prefrontal cortex, thalamus, and basal ganglia. The ecological dimension of executive function was first proposed by Gioia et al. [4] with the aim of effectively applying the results of executive function measurements to real-life situations. This study investigates the executive function of patients with alcohol dependence through a case-control design and explores its relationship with alcohol dependence, providing a reference for the treatment and prevention of excessive drinking and effective interventions.

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2. Subjects and methods

2.1. Subjects

2.1.1. Patient group

Patients admitted to the Shandong Provincial Mental Health Center for alcohol withdrawal treatment from November 2010 to August 2013.These patients met the diagnostic criteria for alcohol dependence according to the International Statistical Classification of Diseases and Related Health Problems,10th Revision(ICD-10)[5].They were diagnosed by senior psychiatrists and had undergone at least 2 weeks of alcohol detoxification treatment(those with severe withdrawal symptoms were included after their condition improved).They were able to complete the questionnaires independently. Patients with severe somatic diseases, severe mental disorders, or other organic brain disorders were excluded. A total of 103 male patients were enrolled, aged between 27 and 61 years.

2.1.2. Control group

Healthy volunteers were recruited through convenience sampling from October 2012 to May 2013, totaling 106 individuals. Among them,72 were community volunteers from Jinan, and 34 were staff members of our hospital. All were male, with no history of severe somatic diseases, severe mental disorders, or other organic brain disorders, and no alcohol preference. There were no significant differences between the patient and control groups in terms of age, marital status, and living arrangements. However, the patient group had a lower educational level and more individuals from rural areas compared to the control group (both $P<0.05$). See Table 1.This study was approved by the Ethics Committee of the Shandong Provincial Mental Health Center.

Table 1 Comparison of General Information Between the Two Groups

Group	Number of Cases	Age	Marital Status (Number of Cases)		Place of Birth (Number of Cases)		Living Arrangement (Number of Cases)			Education Level (Number of Cases)	
		(years, $\bar{x} \pm s$)	Married	Unmarried	Rural	Urban	Living Alone	Living in a Group	Living with Family	High School or Below	Associate Degree or Above
Control Group	106	42.4 ±9.1	99	7	61	45	11	3	92	39	67
Patient Group	103	44.5 ±8.0	90	13	73	30	14	7	82	77	26
t/x^2		1.809	2.186		4.032			2.492		30.487	
P		0.071	0.139		0.045			0.288		0.000	

2.2. Methods

2.2.1. Survey tools

The Behavior Rating Inventory of Executive Function-Adult Version (BRIEF-A) was used to assess the executive function of adults aged 18 years or older. The scale includes two indices with a total of 75 items: the Behavioral Regulation Index (BRI)and the Metacognition Index (MI). The BRI comprises four factors, namely Inhibition, Shifting, Emotional Control, and Self-Monitoring. The MI includes five factors: Initiation, Working Memory, Planning, Task Monitoring, and Organization of Materials. Each item is scored on a scale from 1 to 3: “Never” (1 point), “Sometimes” (2 points), and “Often” (3 points). Higher total scores indicate greater impairment in executive function.

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To ensure the objectivity of the scoring, strict quality control measures were implemented, including three validity subscales: the Low Frequency Event Rate, the Negative Evaluation Rate, and the Inconsistency Rate. These measures were designed to prevent rater errors, such as overly harsh scoring, careless completion of the questionnaire, or inconsistencies in responses. The BRIEF-A has demonstrated good reliability and validity in China [6].

2.2.2. Survey methods

Both groups were guided through the questionnaire completion by two specially trained psychiatrists, and informed consent was obtained from all participants. A total of 253 questionnaires were distributed, with 209 being effectively returned, resulting in an effective response rate of 82.6%.

2.2.3. Statistical methods

The data were analyzed using SPSS 20.0 software. Statistical analyses included chi-square(χ^2)tests, t-tests, Spearman correlation analysis, and logistic regression analysis, with a significance level(α)set at 0.05.

3. Results

3.1. Comparison of total scores and factor scores of BRIEF-A between the two groups

See Table 2.

Table 2 Comparison of Total Scores and Factor Scores of BRIEF-A Between the Two Groups

Group	Number of Cases	Total Score	Behavioral Regulation Index (BRI)	Inhibition	Shifting	Emotional Control	Self-Monitoring
Control Group	106	91.74±19.97	40.02±9.10	10.77±2.57	8.09±2.01	13.14±3.32	8.02±2.14
Patient Group	103	118.02±24.31	53.23±11.01	13.64±3.04	10.59±2.51	18.55±4.54	10.45±2.66
t		8.53	9.47	7.37	7.95	9.81	7.25
P		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Group	Number of Cases	Metacognition Index (MI)	Initiation	Working Memory	Planning	Task Monitoring	Organization of Materials
Control Group	106	51.72±11.52	10.19±2.66	10.45±2.46	12.62±2.97	8.07±2.09	10.38±2.79
Patient Group	103	64.80±14.79	13.26±3.60	13.17±3.39	16.09±3.90	9.68±2.25	12.60±3.78
t		7.12	7.00	6.61	7.21	5.38	4.81
P		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

3.2. Correlation analysis between alcohol consumption and nine factors of BRIEF-A

Patients were divided into two groups based on their alcohol consumption: high alcohol consumption (daily consumption of 500 mL or more of 38%alcohol by volume [ABV]white liquor) and low alcohol consumption. Spearman correlation analysis was conducted between these two groups and the nine factors of BRIEF-A. The results showed that alcohol consumption was significantly correlated with emotional control($r=0.21$,$P=0.04$)and working memory($r=0.22$,$P=0.03$).

3.3. Logistic regression analysis of factors associated with alcohol dependence

Logistic regression analysis (forward method) was used to explore the risk factors for alcohol dependence. The presence or absence of alcohol dependence was used as the dependent variable, while education level and place of birth (which were statistically significant) were included as control variables. The nine factors of BRIEF-A were used as independent variables. The results indicated that emotional control of executive function is a risk factor for alcohol dependence. For every one-point increase in emotional control, the risk of alcohol dependence increased by 37.5%. See Table 3 for details.

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Table 3 Logistic Regression Analysis of Factors Associated with Alcohol Dependence

Variable	β	SE	Wald x^2	P	OR	95%CI
Control Variable: Degree+	-1.02	0.39	6.78	0.009	0.362	0.168~0.778
Control Variable: Place of Birth (Urban)	-0.28	0.39	0.50	0.482	0.759	0.353~1.634
Independent Variable: Emotional Control	0.32	0.09	12.94	0.010	1.375	1.156~1.635

4. Discussion

The results of this study indicate that the total scores and factor scores of behavior management and metacognition on the BRIEF-A in the patient group were significantly higher than those in the control group (all $P<0.01$). The greater the alcohol consumption, the more severe the impairment in working memory function. Poor emotional control was identified as a risk factor for alcohol dependence($P<0.05$). These findings are consistent with the view that long-term alcohol consumption leads to biological changes in the human body. From a biological perspective, heavy alcohol consumption often results in abnormalities in prefrontal cortex function or cortical damage, which prevents the effective execution of complex, goal-oriented activities over extended periods. It also impairs the ability to adjust behavior appropriately based on feedback from outcomes. Therefore, executive function is reduced in patients with alcohol dependence [7]. Previous psychological studies have also shown that significant differences in reaction times and error rates in stop-signal tasks between individuals with alcohol dependence and healthy volunteers confirm the reduced executive function in alcohol-dependent individuals [8].

Our study demonstrates a significant correlation between the severity of alcohol dependence and executive function. The greater the daily alcohol consumption in patients with alcohol dependence, the worse their working memory and emotional control. This is consistent with the findings of basic experimental research on alcohol dependence. Animal experiments have shown that during working memory tasks in rats, acetylcholine transmission is activated, and alcohol affects the excitatory effects on working memory by increasing acetylcholine transmission [9]. Other studies have shown that different doses of alcohol administered to rats produce varying effects on acetylcholine release in the hippocampus. Low doses of alcohol (0.5 g/kg) increase acetylcholine transmission and release in the prefrontal cortex of rats, while high doses (1 g/kg) inhibit this transmission and release. Therefore, the impact of alcohol on working memory is dose-dependent, which is also confirmed by our study. The increase in acetylcholine transmission is due to the effects of alcohol on the axons and cell bodies of cholinergic neurons, although the exact mechanism remains unclear. It may be that alcohol indirectly activates the transmission of excitatory amino acid neurotransmitters in the nucleus basalis (the origin of the cortical cholinergic system)[10].

Our study indicates that impaired ecological executive function, particularly emotional control, is a risk factor for alcohol dependence($P<0.05$). This suggests that individuals with poor emotional regulation are more prone to alcohol dependence and more likely to use alcohol as a coping mechanism for daily stress. Studies have found that individuals with alcohol dependence exhibit significant deficits in coping strategies when facing difficulties, often relying on immature defense mechanisms [11]. They also show lower problem-solving abilities and a tendency to use rationalization, self-blame, fantasy, and avoidance [12].

Currently, in China, the treatment of chronic alcohol dependence focuses primarily on the inpatient detoxification phase, with little emphasis on comprehensive psychological interventions for patients with addiction [13-14]. Therefore, it is essential to strengthen research on the socio-psychological characteristics of alcohol-dependent patients and provide targeted psychological interventions early on to improve their psychological resilience and social adaptability. This is crucial for the prevention and treatment of alcohol dependence.

5. Conclusion

This study, through the assessment of executive functioning using the Behavior Rating Inventory of Executive Function-Adult Version (BRIEF-A) in alcohol-dependent patients and healthy volunteers, revealed significant impairments in ecological executive function among alcohol-dependent individuals.

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The results showed that the total scores and factor scores of executive function in alcohol-dependent patients were significantly higher than those in the healthy control group. Moreover, the greater the alcohol consumption, the more severe the impairment in executive function, particularly in working memory and emotional control. Poor emotional control was identified as a risk factor for alcohol dependence, highlighting the need to emphasize the development of emotional regulation skills in clinical interventions.

This study provides a new perspective for understanding the neuropsychological mechanisms of alcohol dependence and offers a theoretical basis for clinical interventions. However, limitations remain, such as the limited sample size and cross-sectional design. Future research should expand the sample size and conduct longitudinal studies to further explore the dynamic relationship between alcohol dependence and executive function. Additionally, integrating neuroimaging and biomarker studies could help reveal the neurobiological basis of alcohol dependence more comprehensively. In summary, this study underscores the importance of strengthening psychological interventions in the treatment of alcohol dependence to improve patients' psychological resilience and social adaptability, reduce relapse rates, and enhance their quality of life.

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