Mental Health: Research and Practice

ISSN: 2980-8502 2022, Vol. 1, No. 2, 28-34
DOI: 10.22034/MHRP.2022.335216.1011

Response Inhibition, Executive Planning and Working Memory among Runaway Girls Compared to Normal Controls in Tehran

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Adolescence is one of the most critical developmental stages associated with several behavioral conflicts and crises. This study was aimed at comparing the executive functions of runaway girls and normal ones. The research design was descriptive and expos facto. The target population of the present study was all the runaway girls living in the houses provided by the Welfare Organization in Tehran and normal girls that match with them. Fifty subjects (25 runways girls and 25 normal girls) were sampled out of the population through the convenience method and inclusion-exclusion criteria. The research tools included Wechsler's Digit Span Subtest, Stroop Test, Wisconsin Card Sorting Test (WSCT), and Raven's Progressive Matrices. The data was analyzed by applying MANCOVA. The results showed a significant difference between the factors of inhibition response, executive planning, and working memory functions, controlling the intelligence quotient of the runaway girls with high-risk behaviors and those of the normal ones. The deficit in adolescents' executive functions has an essential role in developing risky behaviors.

Keywords: Runaway Girls, Response Inhibition, Planning, Working Memory

Adolescence is a formative stage of development characterized by neurobiological and psychological changes in the brain and mind, which are generally associated with increased impulsivity and risky behaviors. These characteristics are associated with injuries that play an essential role in the emergence and maintenance of addictive behaviors, high-risk behaviors, and running away from home. It is worth noting that high levels of impulsivity in adolescence are accompanied by an increase in drugs abuse and Internet addiction (Cao et al., 2007), early alcohol consumption (Soloff et al., 2010), and multiple sexual relationships. Many researchers have linked the relationship between impulsivity and risky behaviors to the process of emotion and reward, while a small number of researches has linked it to components of cognitive function (Romer et al., 2009).

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High-risk behaviors are known as behaviors that are uncertainly formed without proper planning and could often lead to negative results (Balogh et al., 2013). Adolescence is characterized by an increase in the level of high-risk behaviors (Steinberg, 2008), and this period is basically associated with more reports of drugs use and mortality violation rates (Eaton et al., 2012). Neuropsychological evidence points to a dual system in the activation of high-risk behaviors in explaining why increases in high-risk behaviors are commonly seen during adolescence. The first up-down emotional control system (Casey et al., 2008; Steinberg, 2008) controls reward and social reinforcement processes and includes the amygdale, ventral Striatum, medial prefrontal cortex, Orbit-frontal cortex, and Insula. The second system controls a person's cognitive functions related to brain structures such as the prefrontal cortex and parietal region. The brain structures of these two systems undergo significant changes during adolescence (Casey et al., 2008; Nelson et al., 2005). Therefore, the increase in high-risk behaviors during adolescence can be attributed to these changes and developmental changes

associated with delays in the development of the inhibition system (Ernst & Fudge, 2009).

The ability to suppress thoughts, actions, and emotions is fundamental in inhibition theory, which is considered as a significant regulator of behavior. In other words, the general concept of behavioral inhibition is synonymous with behavioral control (Barkley, 2006; Miyake et al., 2000) and is generally defined as the inhibition of a dominant response (Nigg, 2006). Lack of inhibition or disinhibition is generally associated with attention and impulsivity. According to Barkley, inhibition is a prerequisite for realizing other executive functions (Barkley, 2005). Insufficiency of response inhibition causes children to have lower self-regulation than their peers at different stages of development (Rapport et al., 2009). Many problems in adolescence are related to problems in behavioral inhibition and low self-regulation, low self-motivation, and failure in prospective behavior (Nigg, 2006). Disinhibition leads to greater risk-seeking behaviors such as running away from home and school in both childhood and adolescence; it also increases the risk of alcohol abuse, drugs abuse, and high-risk sexual behaviors at an older age. The results of a study found that neural disinhibition is the primary source of adolescents' high-risk behaviors (Tarter et al., 2003). In addition, Nigg et al. examined executive cognitive functions concerning drugs use in boys aged 12-15, the results of which indicated no significant relationship between primary narcotics use and different indicators of executive cognitive functions (Nigg, 2006). In their subsequent study on narcotics abuse in the same sample group of boys and a smaller sample of girls aged 15-17 years, they found a weak correlation between performance in the task of inhibiting response, alcohol use, and narcotics use. However, in all cases of this sample, the subjects' parents also had a history of drugs use (Nigg et al., 2004).

Moreover, planning and organization, which are among the most important executive functions in carrying out daily life activities, have recently been taken into account by researchers (Shallice, 1982). Since these domains are the greatest functions of the frontal cortex, it is believed that damage or disruption of the prefrontal and some subcortical areas of the brain interfere with the child's ability to plan and organize (Fuster, 2013). Numerous studies suggest that deficits in planning and mental flexibility result in increased antisocial behaviors and emotional disorders. In a sample of juvenile delinquents, signs of frontal cortex dysfunction such as inability to plan, flexibility of thought, attention deficit, and impulsivity were reported (Lamm et al., 2006).

On the one hand, memory is one of the highest cognitive processes of human beings which is related to perception and attention, and on the other hand it is involved in problem-solving and thinking (Fuster, 2013). Finn (2002) demonstrated that working memory capacity is affected by the task reward process. Hence, adolescents' performance in tasks related to learning rewards is influenced by working memory. In addition, Shamosh et al. (2008) found that reducing working memory capacity increases the tendency to select immediate and small rewards, and poor working memory interferes with optimal reward processes. However, studies show that working memory has nothing to do with the rewarding process in adolescence (Tronsky, 2005). Based on research findings on running away from home and having high-risk behaviors (Tarter et al., 2003) and the results of neuropsychological studies (Casey et al., 2008; Steinberg, 2008 #5), it is assumed that components such as impulsivity (non-inhibition), sensation seeking, and inability to plan as well as short-term memory problems can play a great role in the occurrence of behaviors such as running away from home and early onset of high-risk behaviors. Accordingly, this study was intended to compare the executive functions such as response inhibition, planning, and working memory in the runaway girls with high-risk behaviors and the normal girls.

Method

Participants

The present study was a descriptive research with expos facto design. The two statistical populations in this study were all the runaway girls in Tehran living in the welfare organization care centers, and all the normal girls matched for age, and intelligence. The sample consisted of 50 participants (n = 25 runaway girls and n = 25 normal girls). With an alpha level set at 0.05, n = 50 participants were required to detect a medium effect size in 88% of cases. The comparison group (n = 25

normal girls) was matched the main group in terms of age, and was selected by the convenience sampling method. The inclusion criteria were 1) age range of 14 to 19 years and 2) IQ above 80; while the exclusion criteria included 'history of epileptic seizures in the past two years'. To carry the study and collect the required data, a written consent was obtained from all the participants.

Measurement Instruments

Wechsler Forward/ Backward Digit Span. To assess verbal memory functions of the participants, the digit span sub-tests of the Wechsler memory scale (WMS-III) were used. In this study, short-term memory was assessed by forward digit span the subjects' working memory was assessed by backward digit span. In a Persian speaking population, the reliability coefficients of the sub-tests by using the test-retest method have been reported ranging from 0.28 to 0.98 (Orangi et al., 2002).

Wisconsin Card Sorting Test (WCST). The Wisconsin test has 64 cards, on which four types of shapes (triangle, star, cross, and circle) are printed, and the number of each shape on each card varies from one to four. In addition, each card is painted in one of four colors (blue, red, yellow, and green). Thus, the test has three principles of shape (four types), number (four modes), and color (four colors). The combination of these three principles constitutes 64 states. This test can be scored in several ways where the most used scores are assigned to the number of categories obtained and preservative errors. The errors demonstrate cognitive inflexibility. The reliability of this test obtained by the test-retest method on the Iranian population has been reported to be 0.85 (Ghadiri et al., 2006).

*Stroop Test***.** This test was developed by Stroop (1935) to measure selective attention and cognitive flexibility. The Stroop test consists of two stages of practice. In the main stage the subject is asked to pay attention only to the color of the words and not to the writing itself. The response inhibition score is obtained by subtracting the number of correct answers from the incorrect ones. The reliability of this test through test-retesting has been reported to range from 0.81 to 0.92 (Gharaipoor et al., 2007).

Raven's Colored Progressive Matrices. Raven's colored progressive matrices (Raven et al., 1962) were used to assess complex non-verbal reasoning. This test is widely used for clinical and research work and has a good validity and reliability. The reliability of this test was reported to be 0.91 by the test-retest method, and its Cronbach's alpha coefficient was 0.82 (Rahmani, 2008).

Data Analysis

The MANCOVA test was applied for the comparison between the two groups. The SPSS software, version 26, were employed for the data analyses.

Results

The present study was performed on 25 runaway girls (average age=16.04, SD=1.59) living in welfare organization care centers and 25 normal controls (average age=15.8, SD=1.55), whose information on high-risk behaviors and other descriptive characteristics is presented in Table 1.

Table 1.

	Runaway girls		Normal girls	
	Frequency	%	Frequency	%
Substance Use	6	22	0	0
Alcohol Use	5	25	0	0
High-Risk Sexual Behavior	14	56	0	0
Addicted Father	15	60	4	16
Addicted Mother	9	36	0	0
Divorced Parents	14	56	3	12

Frequency of high-risk behaviors

To measure the executive functions in this study, three components such as working functions (short-term memory, working memory), response inhibition, and executive planning, were used. Therefore, considering the diversity of dependent variables and eliminating the effect of participants' IQ scores, MANCOVA was used to analyze the data. Each executive function was analyzed separately, and the IQ scores were entered as a concomitant variable.

First, to ensure MANCOVA assumptions, the M box test was used. Results of M box test indicated that this assumption was not met (p<0.05). Given the sample size of the two groups, the test seems to be resilient to this assumption violation.

To measure memory functions, two scores of forward and backward digits span were used, which according to the results of MANCOVA (Pillai's Trace=0.741, p<0.001, $F_{(5, 43)}$=24.54, Eta Squared= 0.741), there was a significant difference in the linear composite of the executive functions between runaway girls and the normal group.

As it is shown in Table 2, the separate analyses for each dependent variables indicated a significant difference between the runaway girls and the normal group in backward (P<0.001, F= 48.89) and forward (P<0.001, F=22.72) digit span, perseverative errors (F= 40.74, P<0.001) and number of completed categories (F=26.12, P<0.001) and response inhibition (F = 54.9, P<0.001). Thus, it seems that the girls in the normal group performed better in these executive function tests.

Table2.

Results of Multivariate Analysis of Covariance

	Group	Mean± SD	adjusted Mean	F	P-Value	n^2
Forward Digit Span	Runaway	5.81± 1.95	6.12±0.31	22.72	0.001	0.32
	Normal	8.72±1.24	8.39±0.31			
Backward Digit Span	Runaway	4.04±1.27	4.28±0.35	48.89	0.001	0.51
	Normal	8.24 ±2.08	7.95 ±0.35			
Perseverative Error	Runaway	6.52±2.02	6.41±0.39	40.74	0.001	0.46
	Normal	2.56±1.68	67.23±0.39			
Completed Categories	Runaway	3.88±1.09	3.85±0.19	6.12	0.001	0.35
	Normal	5.32±0.69	5.34±0.19			
Response Inhibition	Runaway	18.44±19.02	19.73±3.15	54.9	0.001	0.53
	Normal	55.76±9.31	54.49±3.15			

Discussion

The aim of this study was to investigate the executive function differences between the two groups of runaway girls with high-risk performances and normal girls. The results showed statistically significant differences on all the different components even after controlling for the intelligence effect. These results are consistent with those of some studies (Ernst & Fudge, 2009; Shamosh et al., 2008) and inconsistent with the findings of some other studies (Tarter et al., 2003).

These findings can be explained from psychological perspectives. Impulsivity is the strong urge to take actions in response to a mental or external stimulus. Impulsivity based on behavioral viewpoint includes short-term gains with low value compared to long-term gains with value (Petry, 2001). The psychological perspective examines impulsivity based on the three categories of punishment or extinction, reward selection, and response/attention inhibition. Furthermore, it maintains that the definition of impulsivity should include the following three elements: reducing a person's sensitivity to the negative consequences of behavior, rapid and unwanted response to stimuli

before thoroughly evaluating information, and ignoring the long-term consequences of behavior (Zucker, 2015), all of which can lead to impulsive behaviors such as running away from home, drugs abuse, and sexual relations. Sensation seeking and weakness in behavior regulation are associated with the onset and maintenance of many high-risk behaviors in adolescence (Verdejo-García et al., 2008). Considerable empirical evidence indicates that impulsivity increases from childhood to adulthood (Steinberg et al., 2009); thus, adolescents experience significant increase in impulsive behaviors (Smith et al., 2012). The results of brain imaging studies illustrate that the decline of adolescent impulsive behaviors depends on the maturation of areas of the brain that are controlled by cognitive components (Eppinger et al., 2012). Tarter et al. (2003) hypothesized that the early sign of external behaviors such as problem in executive functions is a pattern called neurobehavioral disinhibition and is considered as the primary source of these behaviors. They found that adolescents with high level of malfunction in these patterns at the age of 10-12 would have higher levels of drugs use in adolescence (Aytaclar et al., 1999).

The executive functions are an umbrella term that covers a variety of cognitive processes that serve purposeful behaviors and actions. Although there is no consensus on the components of executive functions, response inhibition, working memory, and planning are regarded as the main components of executive functions by most specialists (Barkley, 2006). Barkley (1997) believes that response inhibition is a multidimensional structure consisting of three interconnected processes 1. dominant response inhibition to an event, stopping the current response or response pattern, and creating an opportunity to delay the decision to respond or continue the response and 2. maintaining the period of delay and self-directed responses that occur from interrupting events and competing responses in this period (interference control). Researchers believe that the growth of the cerebral cortex and subcortical regions with an imbalance between the subcortical reward system, which matures faster than the frontal control system, results in poor control of impulsive behaviors in adolescence (Nelson et al., 2005; Steinberg, 2008). Brain imaging studies show that the posterior and frontal regions of the brain represent a gradual path of pruning and demyelization of the ventral and occipital regions (Sowell et al., 2003) and the development of these frontal areas is not complete until the person reaches the third decade of life. Based on these models, the authors expect executive functions could control impulsive behaviors in early adolescence. Therefore, if there are malfunctions in executive functions, it will be effective in the occurrence of adolescents' disinhibition and impulsive behaviors. Hence, Klingberg et al (2005) reported that improving working memory in children aged 7-12 reduced impulsive behaviors in adolescents.

Limitations

One of the most critical limitations of the present study was the lack of generalizability of the results due to the convenient sampling method. Therefore, it is suggested that a random sampling method be considered in the future studies. Furthermore, using EEG and fMRI for objective evaluation and measurement of executive functions is recommended.

Conclusion

In general, the results of this study indicate that runaway girls with high-risk behavior are deficient in executive function components. Hence, to improve cognitive abilities and reduce the incidence of high-risk behaviors in this group, it is possible to use strategies focused on executive functions and underlying brain structures. Researchers would use the results of this study to design studies to understand and investigate the underlying factors of high-risk behaviors in adolescence.

Author Note:

All the authors actively participated in conceptualization, methodology, editing & review. The authors are grateful to reviewers for their constructive comments. The authors also thank all the participants recruited into the experiments who without them this research would not be possible, especially the Welfare Organization of Tehran.

Statements:

There is no conflict of interest. No funds. This study was approved by the scientific and ethical committee of Iran University of Medical Science. The participants were informed about the research procedure and a written consent form was obtained from all of them. They were also assured about the confidentiality of their information and were free to leave the study whenever they wished, and, if desired, the research results would be available to them.

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Received November 4, 2021
Revision received September 7, 2022
Accepted November 10, 2022