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Original Article

The Relationship Between Deficits in Executive Functions and Processing Speed with PTSD Symptoms in Cancer Patients: The Mediating Role of Fatigue and Attention Bias

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Abstract

Background and Aim: The rapid and increasing growth of cancer disease in developed and developing countries and its multi-factorial and destructive personal, social and economic consequences have drawn this disease as a deliberate problem that threatens people's mental health, drawing special attention from specialists and researchers in the health field.. theaim of this research is to analyze the relationship between deficits in "executive function" and "processing speed" with "PTSD symptoms" in cancer patients, by examining the mediating role of fatigue and attention bias.

Materials and Methods: This research was conducted by the path analysis-correlation method. Its statistical universe was all patients with gastrointestinal cancers (esophagus, stomach, colon, liver, and pancreas) referring to Tehran hospitals and medical centers (Iran) in the first six months of 2022. The statistical sample of this research was 158 men and women referring to two referal hospitals, who were selected for convenience sampling and participated in this research after obtaining informed consent. The research has used the post-traumatic stress disorder checklist (PCL-5), the Barkley Deficit in Executive Functioning Scale (BDEFS), Cancer Fatigue Scale (CFS), the Attention to Positive and Negative Information Scale (APNIS), and the Wechsler Adult Intelligence Scale (WAIS). The research data was tested using structural equation modeling method (path analysis); SPSS version 21 statistical software and Lisrel software were used to analyze the data.

Results: According to the results of the path analysis, the direct path of the "executive function" (β=-0.249, T=-3.328), the direct path of the "cancer fatigue (CRF)" (β=0.31, T=64.979), and the direct path of "positive attention bias"(β=-0.341, T=-4.648), " to the "PTSD symptom" is significant. However, the direct path of the "processing speed"(β=-0.024, T=-0.501) and the direct path of "negative attention bias" (β=-0.104, T=-1.774) to the "PTSD symptom" are not significant.The direct path of "executive function" to "cancer fatigue" (β=0.623, T=10.081) is significant, but, the direct path of the "processing speed" to "cancer fatigue" (β=0.119, T=1.932), direct path of "processing speed" to "positive attention bias" (β =-0.008, T=-0.132) and direct path of "executive function" to (β=-0.367, T=-4.782) to "negative attention bias" is insignificant.Moreover, according to the results, the indirect effect of the "executive functions" on the "PTSD symptoms" through "positive attention bias" is significant (b=0.077, P<0.05); but, the indirect effect of the "executive functions" on the "PTSD symptoms" through "negative attention bias" is not significant (b=0.013, P>0.05). The indirect effect of

the "processing speed" to the "PTSD symptoms" through " cancer fatigue"(b=0.066, P>0.05), the indirect effect of the "processing speed" to the "PTSD symptoms" through "positive attention bias"(b=0.005, P>0.05), and the indirect effect of the "processing speed" to the "PTSD symptoms" through "negative attention bias" is not significant (b=-0.001, p>0.05).

Conclusion: According to the existing research evidence, people show different reactions after being diagnosed with cancer, and during the treatment process, as a traumatic event.Considering the research results, it can be concluded that the experience of cancer-related stress disorder is influenced by cancer fatigue (CRF), information processing speed, and positive and negative attention bias. These results can be the basis for designing an intervention program to reduce symptoms of post-traumatic stress disorder (PTSD) in people with cancer, especially gastrointestinal cancers.

Keywords: Attention bias. Cancer, Executive functions, Fatigue, Processing speed, Post traumatic stress disorder

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Introduction

Cancer diagnosis and its treatment, as a stressful factor, will result in significant problems related to mental health, including anxiety and depression (1). This problem occurs due to the side effects of treatment, fear of death, and the feeling of decreased social value in patients; moreover, the long process of treatment, high mortality rate, treatment difficulties, side effects of adjuvant treatments, such as chemotherapy and radiation therapy, significant changes in the appearance, overwhelming mental and economic burden of the disease for families, reduction of social supports, as well as the patient's social role in the family and society has led to numerous cognitive and psychological problems for these patients. These consequences have noticeable effects on their mental health indices and their quality of life (2). According to research evidence, cancer patients are exposed to many mental health problems, including depression, due to the disease conditions and its difficult process of treatment (3-4); In this regard, research evidence demonstrate a high rate of suicidal thoughts and attempts in cancer patients one year after diagnosis (5).

In recent years, cancer-related PTSD (CR-PTSD), due to the diagnostic and treatment difficulties in these patients, has attracted the serious attention of specialists in the field of mental health (6-7). According to research evidence, the lifetime prevalence of cancer-related PTSD is between 5 and 36% (8). In this regard, the meta-analysis evidence has reported the lifetime prevalence of cancer-related PTSD between 7.4 and 20.7% (9). Furthermore, other studies showed that 10 to 20% of these patients may show PTSD symptoms (10).

Research evidence, on the other hand, places special emphasis on the role cancer fatigue plays in the relationship between executive functions and the psychological consequences of cancer. Cancer fatigue is a persistent feeling of mental anxiety resulting from physical, emotional, or cognitive fatigue, affecting almost 100% of cancer patients during and after treatment. Considering the research evidence, there is a strong relationship between cancer fatigue and the reduction of people's quality of life, as well as their physical and occupational performance (11). The research results of Feng et al. (12) indicate the physical and cognitive consequences of cancer fatigue.

In explaining the psychological problems of cancer patients, research evidence and theoretical foundations, especially emphasize the role of cancer-related cognitive impairment (CRCI). Cancer-related

cognitive impairment (CRCI) is one of the most important and effective outcomes in cancer survivors, which is caused by the long-term effects of cancer and the use of adjuvant treatments such as chemotherapy and radiation therapy (13-14). In the available theoretical and research foundations, the term "Chemical brain" or "Foggy brain" has been used for cognitive problems caused by chemotherapy in cancer patients (15). Common cognitive impairments observed in cancer patients, in particular, include the speed of complex information processing, working memory, learning efficiency, and executive functions (12-17). Moreover, the obtained evidence from self-report scales and neuropsychological evidence suggests cancer-related cognitive impairment (CRCI) in the field of memory, attention and concentration deficits, and reduced ability in multi-step tasks (18).

Considering the available theoretical and research foundations, one of the cognitive domains affecting cancer patients is executive function (12-19). In this regard, Goldstein et al (20) have described executive function as a single concept, which includes the efficiency of people to gain knowledge, and how to solve problems in 9 areas (attention, emotion regulation, flexibility, inhibitory control, initiation, organization, planning, self-monitoring, and working memory)(21). The existing evidence shows that cancer-related cognitive impairment (CRCI) has negative effects on cancer patients' quality of life, and their ability to deal with daily life problems (22).

This issue, considering the many problems that cancer patients experience in cognitive domains, including executive functions, and considering the mutual relationship between cognition and emotion, can have destructive effects on behavioral, and cognitive aspects and also the self-regulated emotions of these patients. Based on the theoretical model of Barkley's executive functions (23), and the hierarchical model of executive functions of McCloskey et al. (24), self-regulation is the conceptual basis and foundation of executive functions. Therefore, the drawback of executive functions, among others, many problems in the main areas, such as inhibitory control, working memory, and cognitive flexibility, affect the treatment process, and the management of stressful situations, following treatment orders, and observing self-care behaviors; and it will disrupt the medical treatment process of these patients due to many problems. In addition, this wrong process will lead to the fear of the recurrence of the disease, due to which will intensify the symptoms of post-traumatic stress in these patients.

Another important influencing variable in the relationship between executive function deficits and post-traumatic stress symptoms and cancer fatigue in patients with cancer is attention bias to the consequences after a traumatic event. According to the research evidence, positive or negative attentional biases can differently affect the adaptation of cognitive processing (25). According to specific valence models, when people's attention bias is more toward negative issues, they may have more negative and threatening interpretations regarding the events around them. This condition can lead to an increase in intrusive thoughts in a person, as well as an increase in post-traumatic stress symptoms (26). On the other hand, according to attention control models, attention bias may be caused by impaired attention control, which attracts a person's attention to traumatic stimuli, whereby a person cannot pay attention to other stimuli from a cognitive aspect; therefore, he/she is always careful and sees the environment as threatening, which this situation will increase psychological distress and aggravate post-traumatic stress symptoms. According to these models, attentional control is a mediating factor between negative and threatening attention bias and post-traumatic stress symptoms (27-28). In addition, other research evidence shows that attention biases may affect the positive consequences of adapting to stressful events. According to this research evidence, positive attention bias may have a positive effect on trauma-related processes, which in this way facilitates the process of psychological development of the individual (29).

Therefore, the present study was designed to examine the mediating role of fatigue and attention bias in the relationship between deficits in executive function and processing speed with PTSD symptoms in cancer patients with gastrointestinal cancers.

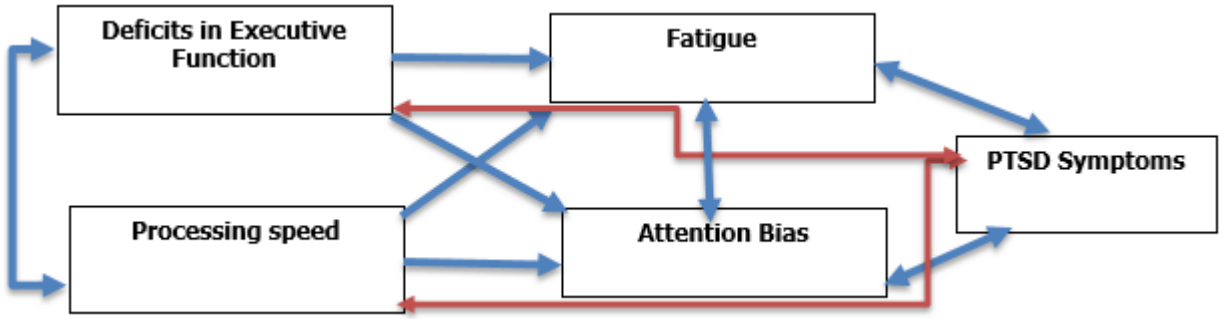

Figure 1. Assumed conceptual model to investigate direct and indirect relationships between research variables.

Methods

This research was conducted by the path analysis-correlation method. The sample population were all patients with gastrointestinal cancers (esophagus, stomach, colon, liver, and pancreas) referring to Tehran hospitals and medical centers in the first six months of 2022. According to Kline (30), the minimum ratio of sample size for each estimated parameter is 5 people, a ratio of 10:1 is more suitable, and a ratio of 20:1 is considered desirable. Therefore, according to 17 subscales in the used tools in this research, using a ratio of 10:1 among patients with gastrointestinal cancers and post-traumatic stress symptoms, 158 men and women referring to hospitals were selected by convenience sampling and participated in this research after obtaining informed consent.

Selecting the studied sample has been performed purposefully and according to the following criteria:

Inclusion Criteria: Afflicted by one of the gastrointestinal cancers (esophagus, stomach, colon, liver, and pancreas) based on the performed screening (reviewing the patient's medical records); History of suffering from gastrointestinal cancers (stage I to IIIA), taking into account that the progression of the disease to higher grades causes the person to be cognitively, psychologically and physically unable to participate in treatment sessions and attend them; education level in middle school and higher; age range of 20-60 years; proficiency in the official language; not having a history of head trauma or other injuries that better justify cognitive problems (question from the patient); passing at least 1 year since the diagnosis of cancer.

Exclusion Criteria: Participants who did not respond to more than 15% of the instruments' items were excluded from the study; moreover, patients with a history of seizures, neurological diseases, or effective medical conditions on cognitive function, and patients with symptoms of substance use disorder were excluded from the study (interview with the patient).

Materials

Post-Traumatic Stress Disorder Checklist (PCL-5)

This self-reporting checklist is designed based on DSM-5 diagnostic items. It has 20 items and measures PTSD symptoms in four areas: re-experiencing the traumatic event (5 items), avoidance of traumatic event stimuli (2 items), negative alterations in cognition and mood related to the traumatic event (7 items), and hyper-arousal and reactivity related to the traumatic event (6 items) (31). The internal consistency of this scale was reported in the study of Blevins et al. (2015) using Cronbach's alpha coefficient (α=0.94) and its retest reliability (r=0.82). The psychometric properties of this scale in Iran have been reported using Cronbach's alpha coefficient (α=0.9) in the study of Vermaghani et al (32).

Barkley Deficits in Executive Functioning Scale (BDEFS)

This scale is one of the most reliable and well-known behavioral rating scales of executive functions, among the world's researchers and therapists in the field of executive functions, which is designed by Barkley (33), to measure deficits in executive functions in the clinical and normal population. This self-report scale has 89 items, and it is used to measure executive function deficits in people aged 18 to 81 years. This

scale has five subscales: self-management to time, self-organization/problem-solving, self-control/inhibition, self-motivation, and self-regulation of emotions. In the original version of this scale, internal consistency using Cronbach's alpha coefficient for the subscales of self-management to time has been reported (α=0.94), and for self-organization/problem-solving, (α=0.95), self-control/inhibition, (α=0.93), self-motivation, (α=0.91), self-regulation of emotions (α=0.94), and it has been reported (α=0.91) for the total score of executive functions (Barkley, 2011). The internal consistency of this scale in Iranian society, for the total score of executive functions, has also been reported using Cronbach's alpha (α=0.91) (34)

Cancer Fatigue Scale (CFS)

This self-report scale has 15 items and was designed by Okuyama et al. (35) to measure cancer fatigue in three physical (7 items), emotional (4 items), and cognitive (4 items) domains. The participants evaluate their fatigue status on this scale in a five-point Likert scale, from zero (never) to four (very much). The score range of this scale is between 0 - 60, and a higher score means more cancer fatigue. In the original version, the internal consistency of the total scale was reported using Cronbach's alpha (α=0.88), and its retest reliability was reported as r=0.69 (Okuyama et al., 2000)(35). Moreover, the psychometric properties of this scale in the Iranian society were analyzed by AghaYousfi et al. (36), and its internal consistency using Cronbach's alpha for the physical, emotional, and cognitive subscales, respectively was (α=0 (α=0.88), (α=0.88) and (α=0.88) and its total score was (α=0.92).

The Attention to Positive and Negative Information Scale (APNIS)

The original version of this scale has 40 items and evaluates individual differences in attention bias, thinking, and focusing on positive or negative information about oneself, others, and past and future events. The subscale of attention to negative information has 18 items and evaluates negative and positive attentional bias, respectively. According to the study of Moshirpanahi, Moradi et al. (37), there are two factors in the final model of this scale: positive attention bias capacity (15 items) and negative attention bias capacity (11 items). The internal consistency of this scale, using Cronbach's alpha, has been reported for the subscale of positive attention bias (α=0.90), and for the subscale of negative attention bias (α=0.83), which indicates this 26-item version of this scale has suitable psychometric properties in Iranian society (Moshirpanahi et al., 2020) (37).

Wechsler Adult Intelligence Scale (WAIS-R)

Wechsler Adult Intelligence Scale (WAIS), is a set of tests that are performed individually, and is designed to evaluate the cognitive abilities of people aged 16 - 90, and includes 10 main subscales: similarities, vocabulary, information, block design, matrix reasoning, visual puzzles, digit span, arithmetic, symbol search, and coding. By using the main scales of WAIS-IV, it is possible to obtain the scores of four indices, Verbal Comprehension, Perceptual Reasoning, Working Memory, and Processing Speed, each of which has at least two subscales, and the standard score of each of five indices are obtained with an average of 100 and a standard deviation of 15. This test has appropriate validity and reliability, so that the average reliability coefficient, by the split-half method for index scores, ranges from 0.90 for the processing speed index to 0.96 for the verbal comprehension index. In addition, the average reliability coefficient, with the split-half method of the subscale, in the normative sample group was in the range of 0.78 for the verbal comprehension subscale, to 0.94 for the vocabulary subscale (38). The present study has used the processing speed score (the sum of coding and symbol search scores).

The assumed model in the present study was tested using the obtained data from the variables of the model and using the path analysis method. Statistical software of SPSS 21 and LISREL was used to data analyze.

Results

The present research sample, in terms of gender, consisted of 74 men (46.8%) and 84 women (53.2%). In terms of education, the education level of 14 people (8.9 %) were lower than a high school diploma, and 63 people (39.9 %) were a high school diploma; 62 people (39.2 %), had a bachelor's degree, and 19

Table 1: Descriptive indices of research variables.

Variable	Mean	SD	min	max
PTSD symptoms	39.77	14.09	6	65
Cancer fatigue	30.20	10.70	4	54
Positive attention bias	56.01	9.10	34	74
Negative attention bias	37.77	6.21	29	54
Processing speed	65.26	7.78	50	81
Executive functions	197.51	40.86	105	273

people (12 %) had master's degree and Ph.D. According to the type of cancer, 37 people (23.4%) were afflicted by esophageal cancer, 46 people (29.1%), stomach cancer, 35 people (22.1%), colorectal cancer, 20 people (12.7 percent), liver cancer and 20 people (12.7%) were suffering from pancreatic cancer. The research sample in terms of age consisted of 13 people (8.2 %), who were 26-36 years old, 66 people (41.8 %), 37-47 years old, and 54 people (34.2 %) over 48-58 years old, and 25 people (15.8%), who were more than 59 years old. It is worth mentioning that the age means and standard deviation of the participants, were 48.61 and 10.54 years, respectively.

The present research has evaluated a path analysis model. This model assumed that variables of cancer fatigue and positive and negative attentional bias, play a mediating role in the relationship between processing speed and executive functions with PTSD symptoms.

Table 2: Correlation matrix of research variables.

Variable	1	2				
PTSD	1					
Fatigue	0.692**	1				
Positive attention bias	-0.738**	-0.603**				
Negative attention bias	-0.494**	-.0338**				
Processing speed	0.191*	0.278**	-0.178*	-0.09	1	
executive functions	0.697**	0.653**	-0.668**	-0.367**	0.255**	1

**P<0.01 *P<0.05

In the following, the correlation matrix between research variables is reported in Table 2.

According to Table 2, there is a relationship between processing speed and executive functions with PTSD symptoms, and these relationships are 0.19 and 0.70, respectively, and are significant at 0.05 and 0.01. There is a relationship between processing speed and executive functions with cancer fatigue, and these relationships are 0.28 and 0.65, respectively, and these relationships are significant at 0.01. There is a relationship between processing speed and executive functions with positive attention bias, and these relationships are -0.18 and -0.67, respectively, and are significant at 0.01. There is a relationship between executive functions with negative attention bias, and these relationships are -0.37 and are significant at 0.01. There is a significant relationship between cancer fatigue and PTSD symptoms, which is 0.69 and is significant at 0.01. There is a relationship between positive and negative attention bias and PTSD symptoms, and these relationships are -0.74 and -0.49, respectively, and are significant at the 0.01 level.

Table 3 shows the fit indices of the structural model. First, the fit indices for the initial model, and then, the modified model, after removing the non-significant paths, and plotting the positive and negative bias error covariance, with cancer fatigue are presented. Structural model fit indices indicate the model's goodness of fit.

Table 3: Fit indices of the structural model.

Fit Index	Acceptable domain	Initial model	Modified model
Chi-2 (χ^2)	-	14.603	10.398
The ratio of Chi-2 (χ^2) to the degree of freedom	< 3	14.603	1.733
Comparative Fit Index (CFI)	> 0.90	0.969	0.990
Incremental Fit Index (IFI)	> 0.90	0.970	0.990
Goodness of Fit Index (GFI)	> 0.90	0.971	0.979
Root mean square error of approximation (RMSEA)	< 0.08	0.294	0.068
Square Root Mean Square Residual (SRMR)	< 0.08	0.046	0.040

Table 4: Skewness and kurtosis indices of research variables.

Variable	Skewness	Kurtosis
PTSD symptoms	-0.552	-0.567
Cancer fatigue	-0.53	-0.469
Positive attention bias	0.211	-0.87
Negative attention bias	0.863	-0.167
Processing speed	-0.095	-0.804
Executive functions	-0.49	-0.757

Analyzing the statistical assumptions of path analysis is very important. The fulfillment of these assumptions approves the appropriateness of using this statistical method for the current research.

In the assumed model of skewness, indicators were in the absolute value of 0.095 to 0.863, and their kurtosis was in the range of 0.167 to 0.870. Chou & Bentler (1995) consider the cut-off point of ±3 as a suitable skewness value. In general, values over ±10 are problematic for the kurtosis index (Kline, 2015). The obtained values for the skewness and kurtosis of the variables indicate the fulfillment of the univariate normality presumption.

Multicollinearity indicates a situation in which indicators are highly correlated. One of the common methods to examine multicollinearity is examining the correlation matrix between indicators. Examining the correlation matrix between the indicators did not indicate the lack of multicollinearity between them. Correlation coefficients higher than 0.85, due to causing the problem of multicollinearity, lead to problems in the correct estimation of the model (Klein, 2015). Moreover, to analyze the assumption of non-collinearity, Variance Inflation Factor (VIF) and tolerance index statistics were also used, considering that none of the values related to the tolerance index is less than 0.10, and none of the related values to the variance inflation factor is not more than 10, therefore, it is possible to be sure about the assumption of non-collinearity.

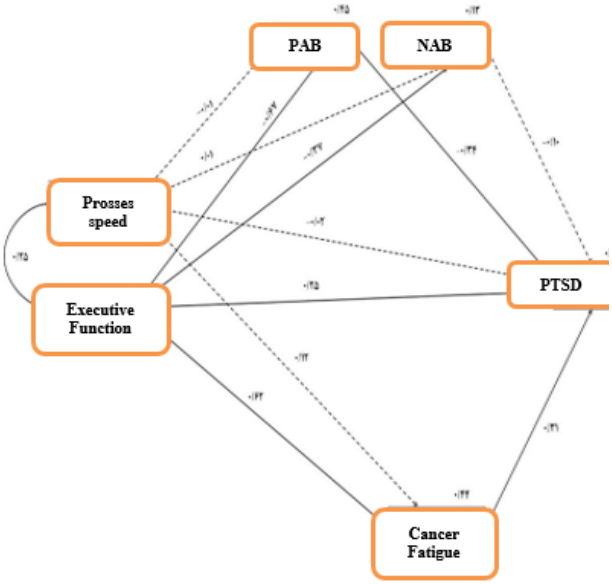

Figure 2. The research conceptual model along with the standardized path coefficients.

Next, the conceptual model of the research along with the standard path coefficients is shown in Figure 2.

All the variables whose direct paths to the dependent variable have a T value greater or smaller than ±1.96 have a significant effect on the dependent variable. The direct path of the "processing speed" to the "PTSD symptoms" is not significant (T=-.0501, β=-.024).

Table 5: The path coefficients of the variables' direct effects and the significance of the estimated parameters.

Independent variable	Dependent variable	Unstandardized coefficients	Standard coefficients	Standard error	t	P value
Processing Speed	PTSD symptoms	-0.043	-0.024-	0.087	-0.501	.0.617
Executive Functions	PTSD symptoms	0.084	0.249	0.025	3.328	0.001
Cancer Fatigue	PTSD symptoms	0.4	0.31	0.08	4.979	0.001
Positive Attention Bias	PTSD symptoms	-0.518	-0.341	0.111	-4.648	0.001
Negative Attention Bias	PTSD symptoms	-0.231	-0.104	0.13	-1.774	0.076
Processing Speed	Cancer fatigue	0.164	0.119	0.085	1.932	0.053
Executive Functions	Cancer fatigue	0.163	0.623	0.016	10.081	0.001
Processing Speed	Positive attention bias	-0.009	-0.008	0.072	-0.132	0.895
Executive Functions	Positive attention bias	-0.148	-0.666	0.014	-10.848	0.001
Processing Speed	Negative attention bias	0.003	0.003	0.061	0.045	0.964
Executive Functions	Negative attention bias	-0.056	-0.367	0.012	-4.782	0.001

Table 6: The mediating effect of cancer fatigue, and positive and negative attention bias, in the relationship between processing speed and executive functions with PTSD symptoms.

Independent variable	Mediating variable	Dependent variable	Unstandardized coefficients	Lower bound	Upper bound	P value
Processing speed	Cancer fatigue	PTSD symptoms	0.066	-0.006	0.178	0.072
Executive functions	Cancer fatigue	PTSD symptoms	0.065	0.031	0.114	0.001
Processing speed	Positive attention bias	PTSD symptoms	0.005	-0.079	0.092	0.836
Executive functions	Positive attention bias	PTSD symptoms	0.077	0.037	0.123	0.001
Processing speed	Negative attention bias	PTSD symptoms	-0.001	-0.039	0.031	0.899
Executive functions	Negative attention bias	PTSD symptoms	0.013	-0.002	0.039	0.097

It can be seen that the direct path of the "executive functions" to the "PTSD symptoms" is significant (T=-3.328, β=-0.249).

Moreover, according to the table, the direct path of "cancer fatigue" to "PTSD symptoms" is significant (T=4.979, β=0.31). The direct path of the "positive attention bias" to the "PTSD symptoms" is also significant (T=-43648, β=-0.341). The direct path of the "negative attention bias" to the "PTSD symptoms" is significant (T=-1.774, β=-0.104). The direct path of the "processing speed" to the " cancer fatigue" is insignificant (T=1.932, β=0.119). The direct path of the "executive functions" to the " cancer fatigue " is significant (T=10.081, β=0.623). The direct path of the "processing speed" to the "positive attention bias" is not significant (T=-0.132, β=-0.008). The direct path of the "executive functions" to the " positive attention bias" is significant (T=-10.848, β=-0.666). It can be seen that the direct path of the "processing speed" to the "negative attention bias" is not significant (T=0.045, β=0.003). The direct path of the "executive functions" to the " negative attention bias" is not significant(T=-4.782, β=-0.367).

Table 6 reports the mediating effect of the " cancer fatigue " and "positive and negative attention bias" in the relationship between "processing speed" and "executive functions" with "PTSD symptoms", through the Bootstrap method, with 2000 times sampling process and confidence interval of 95%.

Considering Table 6, it can be seen that the indirect effect of the "processing speed" to the "PTSD symptoms" through " cancer fatigue" is not significant (b=0.066, P>0.05). The indirect effect of the "executive functions" on "PTSD symptoms" through "cancer fatigue" is significant (b=0.065, P<0.05). Moreover, the indirect effect of "processing speed" to "PTSD symptoms" through "positive attention bias" is significant (b=-0.091, P<0.05). The indirect effect of the "executive functions" on the "PTSD symptoms" through "positive attention bias" is not significant (b=0.005, P>0.05). The indirect effect of the "executive functions" on the "PTSD symptoms" through "positive attention bias" is significant (P<0.05, b=0.077).

Moreover, the indirect effect of the "processing speed" on the "PTSD symptoms" through "negative attention bias" is not significant (b=-0.001, P>0.05). The indirect effect of the "executive functions" on the "PTSD symptoms" through "negative attention bias" is not significant (P>0.05, b=0.013).

Discussion

According to research results, the variable "executive functions" has an effect on the incidence and severity of PTSD symptoms in cancer patients. The results of this research are consistent with the results of studies that deal with the positive role of "executive functions" in self-regulation and management of stressful situations.

Regarding the relationship between "processing speed" and PTSD symptoms, the research results showed that "processing speed" does not affect the severity of PTSD symptoms in cancer patients.

To explain the results of this research, considering that processing speed does not affect PTSD, it can be argued that there are still many unanswered questions about cancer-related PTSD. One of the factors showing the inconsistency of the results of this research with other research in this field is the

difference in the experience of PTSD symptoms, according to the executive factor. The reason is that most of the events leading to PTSD are acute and in the short term, they often affect people's psychological activities. While in cancer-related PTSD, the symptoms are often chronic and manifest their effects over time. Perhaps this difference in the type of PTSD in cancer patients, due to the experience of continuous stressors and internal continuity factors, has different psychological consequences.

Another important factor showing this difference in results is the effect of demographic factors such as age, gender, and socio-economic status, as well as differences in the type of cancer, the stage of cancer progression, different types of treatment, and important events during the diagnosis process to the long process of treatment.

Regarding the relationship between cancer fatigue and PTSD symptoms, the research results imply that the variable of cancer fatigue affects the severity of PTSD symptoms in cancer patients.

This result is consistent with the results of research that emphasize the role of cancer fatigue after involving and facing the chronic process of cancer. According to research evidence, there is a strong relationship between cancer fatigue and the reduction of the quality of life, and physical and occupational performance of people (11). research results of Feng et al. (12) indicate the physical and cognitive consequences of cancer fatigue.

In line with these results, Berger, Gerber, and Mayer (39) dealt with analyzing cancer fatigue in their research; Cancer fatigue (CRF) has been documented as one of the most distressing symptoms reported by breast cancer survivors. Cancer fatigue affects performance and quality of life. Possible causative factors are physical conditions, emotional and cognitive states, pro-inflammatory cytokines, and metabolic factors. According to researchers cancer fatigue is common in the pre-and post-operative stages and the ongoing care stages. They suggest that clinicians should include CRF therapy in the ongoing care of women with breast cancer because its emotional consequences are inappropriate.

According to the research results on the relationship between attention bias and PTSD symptoms, the direct path of positive attention bias to PTSD symptoms is significant. While the direct path of negative attention bias to PTSD symptoms is not significant. This result indicates that positive attention bias has a reducing effect on the occurrence of PTSD symptoms. In explaining these results, the researchers believe that the cognitive tendency to pay attention the positive and negative information may be related to the information process method. Since the mood of people with a positive mood sends positive messages to the brain, they are more likely to rely on the Top-Down cognitive process (40) On the other hand, people with a negative mood probably make more efforts to collect new information and process them in the bottom-up process; these results are in line with the results of this research on the effect of positive attention bias on the reduction of PTSD symptoms.

In this regard, Iacoviello et al (41), in their research on the impact of information processing biases in the etiology of anxiety disorders, in two separate studies, dealt with the threat-based attention biases, mood symptoms, and anxiety and the variety of post-trauma attention biases. They also hypothesized that within-subject attention bias in posttraumatic patients may be a useful indicator of attentional dysregulation and the development of PTS symptoms. According to the results of the first study, attention bias is higher in the PTSD group compared to the other 2 groups, and there is a positive and significant relationship between attention bias and PTSD symptoms, which is in line with the results of this study. The second study evaluates soldiers exposed and not exposed to the battlefield, before and during deployment. According to the results, the attention bias of the groups did not differ before deployment, but the two groups differed in attention bias after deployment in the exposed/non-exposed battlefield position. In the end, the researchers argue that attention bias can be a useful indicator for threat-based attention disorder symptoms associated with mood and anxiety symptoms after exposure to trauma, which is also consistent with the findings of this study.

Moreover, in explaining these results, the research results have demonstrated how patients' evaluation of their cancer disease affects PTSD symptoms (42). Some patients, in response to the diagnosis of cancer, evaluated it as an unbelievable event and punishment,

and as a feeling of being unreal, emptiness, anger, threat, and fear, and some of them considered it as a challenge in the path of life that had to deal with it (43). In general, it can be argued that all types of assessment may lead to different coping strategies in cancer patients; therefore, understanding how a person, when faced with negative changes in his health, will interpret this stressful event is highly important. Therefore, addressing the important mechanisms of influencing the relationship between cognitive evaluation and positive or negative consequences after a traumatic event should be given more attention.

According to the research results regarding the relationship between deficits in executive functions and PTSD symptoms with the mediation role of attention bias, the indirect effect of the executive functions on PTSD symptoms through positive attention bias is significant. While the indirect effect of executive functions on PTSD symptoms through negative attention bias is not significant. These results indicate that the variable of deficits in executive functions is effective in the incidence and severity of PTSD symptoms in cancer patients. Moreover, positive attention bias is an effective factor in the incidence of PTSD symptoms in these patients. As mentioned, in order to explain these results, according to research results, deficits in executive functions (inhibitory control, working memory, and cognitive flexibility) are effective in managing PTSD symptoms; furthermore, positive attention bias is effective in reducing PTSD symptoms. Therefore, it can be argued that positive attention bias, as a mediating factor, has affected the relationship between deficits in executive functions and PTSD symptoms. In this regard, researchers believe that information processing biases are effective in the etiology of anxiety disorders; the research of Iacoviello et al (41-43), which examined threat-based attention biases, mood and anxiety symptoms, and post-traumatic attention biases, showed that there is a positive and significant relationship between attention biases and PTSD symptoms, which it is consistent with the results of this research. In the end, the researchers argue that attention bias can be a useful indicator of threat-based attention disorder symptoms related to mood and anxiety symptoms after exposure to trauma, which is also consistent with the results of this study. On the other hand, this result that negative attention bias has no effect on the relationship between executive functions and PTSD symptoms is consistent with the research of Pinnells et al (44), who examined the role that attention biases play in PTSD: interference or facilitation. They showed that although the effect of attention bias has been shown in people with PTSD, it is not possible to remove the ambiguity that this effect takes place through the process of interference or facilitation. In other words, do PTSD symptoms such as difficulty diverting attention from threatening stimuli (interference) or recognizing threatening stimuli (facilitation) occur?.

Conclusion

In this research, the researcher has dealt with the mediating role of fatigue and attention bias in the relationship between deficits in executive functions and processing speed with PTSD symptoms in patients with gastrointestinal cancers. Cancer, as one of the serious challenges of human life, has gained the attention of researchers, therapists, and policymakers. A disease whose consequences will not be limited only to the time of the disease, but according to the available evidence, cognitive damage caused by cancer, chronic post-traumatic stress disorder, psychological distress, and cancer fatigue can also be seen years after the treatment. Considering the results of this research, it can be concluded that the degree of experiencing stress disorder symptoms after cancer is directly influenced by cancer fatigue, executive functions, and positive attention bias. These results can be the basis for designing an intervention program to reduce PTSD symptoms in cancer patients, especially gastrointestinal cancers.

The significant point in future research that should be carefully considered from a scientific point of view is the design and implementation of qualitative research through the Phenomenology methods, and narrative analysis, to understand the underlying aspects of cancer-related PTSD incidence to design and implement appropriate intervention programs in this population.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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