**The Role of Psychological and Cognitive Variables in Predicting the Quality of Life of Patients with Mild Traumatic Brain Injury**

**Running Title:** Quality of Life in TBI

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**Abstract**

**Background:** This study aimed at investigating the role of executive function, sleep quality and aggression in predicting changes in quality of life (QOL) in MTBI patients.

**Methods**: In this descriptive correlational study, 322 MTBI patients were selected by convenience sampling method. Data were collected using the QOL (WHOQOL‑BREF) questionnaire, Wisconsin Card Sorting Test, Trail Making Test (TMT), the Pittsburgh Sleep Quality Questionnaire (PSQI) and Buss and Perry Aggression Questionnaire. Data were analyzed using multiple regression analysis by the SPSS 23 software.

**Results**: There was a significant negative relationship (P<0.01) between aggressive behaviors, sleep quality and executive function with QOL. Also, aggression had a greater negative correlation with QOL among MTBI patients. The results also revealed that executive function, sleep quality and aggression could predict 53.6% of the variance of the variable of QOL in patients with MTBI. Overall, the results showed that all variables were significant in predicting QOL. However, none of the demographic information was significant in predicting QOL (P>0.1).

**Conclusions**: The findings of this study show that the relationship between executive function, sleep quality and aggression is a significant negative and reverse relationship. Thus, it is necessary to design-intensive psychological rehabilitation programs for MBTI patients.

**Keywords**: Traumatic Brain Injury, Executive function, Sleep, Aggression

**Introduction:**

According to the US Center for Disease Control and Prevention, traumatic brain injury (TBI) is a structural damage or a physiological disorder in brain function due to an external impact on the head.1 More than 10 million people around the world experience TBI annually. Also, in Iran, brain injury is ranked second in terms of mortality and is known as one of the causes of long-term disability in people under the age of 24.2 Although there is no precise statistic about the epidemiology of TBIs in Iran, it is revealed from different research that, unfortunately, this country is among the first countries of the world in terms of daily accidents. 1, 2 in Kashan, Iran, of every 100,000 people, 429 people experience TBIs, which is higher than many other countries around the world.3 Traumatic brain injury can be the result of a bump, or blow to the head or other penetrating head injury, which disrupts the normal functioning of the brain. The severity of symptoms and the level of disability after brain injury depend on the severity of the initial damage; however, in most cases, brain damage is accompanied by physical, emotional and cognitive complications.2, 4

Additionally, TBI can lead to various kinds of damages, such as disturbance in attention, functional performance, and concentration, which plays an important role in long-term disability, economic, and family problems. Patients with TBI experience difficulty returning to the previous level of performance and every day activities, and participating actively in the society. 5In addition, the occurrence of psychiatric disorders after TBI can lead to a wide range of biological, psychosocial and social problems and be the risk factor for mental disorders. Understanding the epidemiology and the nature of the psychiatric disorder after TBI not only can help understand the outcome of brain-related disorders, but also can be utilized to prepare neuropsychiatric rehabilitation protocols in patients and modify the existing therapies. One of the important things that can be influenced by TBI is the quality of life of TBI patients. 6

In recent years, the concept of quality of life has been considered as an important indicator for assessing individual health, judging about the overall health of the society, and finding the major problems in various aspects of the lives of individuals, especially patients with single chronic diseases. 5, 6

Considering the many problems of TBI patients in the areas of attention and executive function, improving the performance of the psychiatric nerve in TBI patients in its special form, i.e. functional performances through various scientific methods, has significant personal and social-economic revenues. 7 Function performance is one of the most common cognitive-behavioral problems that occur after TBI, which remains strong over time and results in a wide range of cognitive, social and behavioral problems of TBI patients due to its extensive overlapping domains. 7 Sleep disturbances are from the common outcomes of TBI patients. Some studies have shown that up to 72% of the TBI patients have sleep problems. 8, 9 Sleep problems disrupt memory and attention in TBI patients, and subsequently affect their quality of life and delay cognitive improvement in TBI patients. 10 Also, the incidence of aggressive behavior is one of the most harmful consequences of TBI, which threatens the family and occupational life of these patients. Aggression and violence threatens the safety of patients, their family members, and caregivers; this may prevent them from receiving the necessary care and rehabilitation services for their disabilities resulting from TBIs. In general, previous studies within and outside of the country have supported the existence of psychological disorders as one of the definite outcomes of brain injuries.11, 12

 The lack of proper identification of the physical and psychological consequences of TBIs will lead to increased burden of disabilities and high economic costs for individuals and health systems. So, the present study was performed to explain the psychological and cognitive outcomes in patients with TBI. [1] Assessing the psychological status of TBI patients as a combination of synchronized variables together can give experts a better understanding of the complications of TBI, and since the combination of multiple disorders can have a greater impact on the quality of life of patients, [2] reporting the prevalence of psychological and cognitive disorders highlights the necessity of rehabilitation measures. [3] A quick evaluation for less than ten days can determine that the psychological disorders are observable and capable of therapeutic intervention from the same early days and before they become chronic. Therefore, the aim of this study was to investigate the role of executive function, sleep quality and aggression in predicting the quality of life of patients with TBIs. We hypothesized that by a quick evaluation after injury, psychological disorders can be distinguished and treated.

**Methods:**

The present study was a descriptive correlational study. The statistical population consisted of all patients with MTBIs referred to emergency and neurosurgery departments of Shahid Beheshti Hospital in Kashan, Iran, in 2017. According to the Trauma Research Center of Kashan Shahid Beheshti Hospital, the annual population of patients with MTBIs has been around 2000 people, of whom, 322 patients were selected based on Morgan's table and through a convenience random sampling method. The inclusion criteria of the study included having the age range of 18 to 50 years, the Glasgow Coma Scale scores between 13 and 15, the localized or diffused damage of the brain tissue that results from an external mechanical force, radiographic findings or CT scan presenting TBI, such as fractured skull or acute brain damage, and the consent to participate in the research, and not having a history of previous neurological or psychiatric diseases, and substance use disorders. The exclusion criteria of the study included patients with any neurological disease before TBI, those with non-traumatic brain injury such as brain tumor or stroke, those with severe consciousness impairment, so that they were unable to respond to the interview, and patients who were not willing to participate in the study for any reason.

At this stage, 322 patients qualified to enter the study were clinically examined by a physician (neurosurgeon), diagnosed with TBI and their hospital records were reviewed and initially evaluated within a maximum of 10 days after they arrived at the hospital. After obtaining a written consent form, their demographic information was collected and then the questionnaires were used to measure the variables under study.

***Research Tools***

 **A researcher-made demographic and hospital information questionnaire**

This questionnaire was used to collect data regarding the age, gender, education level, and marital status of MTBI patients.

**Quality of Life Questionnaire (WHOQOL-BREF)**

The WHOQOL-BREF is a short version of the WHOQOL-100 questionnaire. The short formwas used in this study because of its small number of questions, which are easy to answer. This questionnaire has been translated and adapted into 40 languages ​​including Persian \. The questionnaire consists of 26 questions whose first and second questions, respectively, consider the quality of life and health status in general. In Iran, it has been translated and standardized according to scientific principles, and its reliability and validity have been approved to be used in Iranian society. 13

**The Wisconsin Card Sorting Test (WCST)**

The Wisconsin Card Sorting Testis one of the most well-known neuropsychological test that is frequently used to measure such higher-level cognitive processes as attention, perseverance, abstract reasoning, cognitive flexibility, problem solving, conceptualization, set shifting, the ability of the hypothesis testing and using feedback of errors, the strategy of starting and stopping action, and concentrating. This test has been developed by Esta A.  Berg [1948] and reviewed by Heaton et al. [1993]. In the study of Exner et al., the reliability between the scores of this test was reported 0.92 and the reliability within the scores was reported 0.94. The validity of this test in assessing cognitive deficits following brain damages was more than 0.86. The reliability of this test was 0.83 based on the agreement coefficient of assessors in the Spearman's and Strauss' study. 14

**The Trail Making Test (TMT):**

TMT is a neuropsychological test of visual attention and task switching.]. This test consists of two parts. In the first part, the person is asked to match a series of randomly written numbers (1-2-3-4 ...) in ascending order. In the second part, the person is asked to match the randomly written numbers and letters together in ascending and continuous order [1-A-2-B-3-C] and at the maximum possible speed. In this test, the time it takes to complete the test is considered as an indicator of efficiency. This test has content and construct validity and its reliability has also been confirmed. **15**

 **The Pittsburgh questionnaire**

The Pittsburgh questionnaire has seven scales and measures the sleep mental quality, delay in falling into sleep , useful sleep duration, sleep adequacy (the ratio of useful sleep duration to the total time spent in bed), sleep disorders, the amount of soporific medicine taken, and finally daily performance (i.e., the difficulties due to insomnia experienced by an individual during the day). The score for each scale is between 0 and 3, and the score of 3 for each scale determines the maximum negative value. The total score of this questionnaire is 0 to 21, and the overall score of 6 and higher indicates inappropriate sleep. Reliability and validity of this questionnaire have been confirmed in various Iranian studies. 16

 **The Buss-Perry Aggression Questionnaire**

The Buss–Perry Aggression Questionnaire (BP-AQ) is a 29-item, four-factor instrument that measures physical aggression, verbal aggression, anger, and hostility. The scoring method is based on the Likert scale from 1 (totally contrary to my characteristics) to 5 (perfectly indicates my characteristics). The scoring for questions 24 and 29 is inverted. The total score is the sum of all the scores for all questions and its range is from 29 to 45. To determine the reliability or internal consistency of the questionnaire, Cronbach's alpha, test-retest, and split-half methods were used; their coefficients were obtained 0.89, 0.78, and 0.73, respectively. The validity of this questionnaire was also determined by the concurrent and convergent validity and factor analysis.16

**Procedure**

The researchers used an anonymous paper survey for collecting data during April- July 2017. After screening based on medical and psychiatric disorders, an appointment was made with each patient in Kashan Shahid Beheshti Hospital, Iran, in order to collect data. They individually answered the test items under the supervision of the first and second authors. Written informed consent was obtained from all the participants, and the Ethics Committee of Kashan University of Medical Sciences approved the study protocol (ethical code: IR.KAUMS.NUHEPM.REC.1396.12).

**Data analysis**

The present study investigated the effect of executive function, sleep quality and aggression on the quality of life. Therefore, in this regard and given the objectives of this study, data were analyzed using both descriptive (frequencies and percentages, mean, and standard deviation) and inferential (Pearson correlation and multivariate regression) statistics.

**Results**

In this study, from a total of 322 patients with MTBI, more than a half were male and married. The mean age of the patients was 38.8 ± 10.8 years. At first, data were collected using a demographic questionnaire including age, gender, marital status, and education level (Table 1). This table shows demographic characteristics of the respondents such as gender, age, marital status and education levels.

**Table 1.** Demographic information of participants

|  |  |  |
| --- | --- | --- |
| Variables | Status | N (%) |
| Gender  | Female  | 248 (77%) |
|  | Male  | 74 (23%) |
| Marital status | Single  | 102 (31.6) |
|  | Married  | 220 (68.4) |
| Education | Under diploma | 40 (12.4) |
|  | Diploma | 143(44.4%) |
|  | B.A | 6 (1.9%) |
|  | M.A | 28 (8.7%) |
|  | Ph.D. | 13 (4%) |
| Age  | <20 | 6(1.9%) |
|  | 20‑30 | 94(29.2%) |
|  | 30‑40 | 80(24.8%) |
|  | 40‑50 | 82(25.5%) |
|  | 51> | 60(18.6%) |

B.A: Bachelor of Art, M.A: Master of Art, Ph.D.: Doctor of Philosophy

The mean and standard deviation of the study variables in the whole studied samples were reported in Table 2. The results of the present study showed that the quality of life in female patients with MTBI was significantly lower that the male patients (P<0.001). Additionally, the results showed that aggression level, sleep quality and executive function in males were more than in females (P<0.001).

**Table 2.** Descriptive statics of research variables

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variable |  | Mean + SD |  | P value |
|  | Total | Female | Male |  |
| Aggression | 93.66±27.37 | 89.7±26.5 | 109.04±24.34 | 0.001\* |
| Sleep Quality | 47.06±10.47 | 46.15±10.81 | 50.12±8.6 | 0.004\* |
| Executive Function | 283.62±67.25 | 273.25±69.08 | 318.39±46.35 | 0.001\* |
| Quality of Life | 75.48±12.41 | 76.98±13.24 | 70.44±7.15 | 0.001\* |

SD: Standard Deviation

The univariate correlations (Pearson’s correlation) between aggression, sleep quality, executive function and the quality of life are presented in Table 3. As shown in Table 3, there was a significant negative relationship (P< 0.01) between aggressive behaviors, sleep quality, and executive function with the quality of life; so that by decreasing the levels of these variables, quality of life was improved. Level of aggression (aggressive behaviors) had a greater negative correlation (r = −0.66) with the quality of life among TBI patients. Also, multiple regression analysis was used to examine the impact of aggression, sleep quality, executive function on the quality of life of MTBI patients.

**Table 3.** Pearson's correlation matrix among variables

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variables | Quality of life | aggression | sleep quality  | Executive function |
| Quality of life | 1 |  |  |  |
| Aggression | -0.66\*\* | 1 |  |  |
| Sleep quality  | -0.4\*\* | 0.37\*\* | 1 |  |
| Executive function | -0.43\*\* | 0.44\*\* | 0.44\*\* | 1 |

\*\*Significant at level P<0.01, the relationship between the variables is the indicator of a significant relationship at the error level of <0.01 and a confidence level of 0.99

Normality and homoscedasticity analysis was performed before running the regression. The Kolmogorov–Smirnov test was used to determine normality of distribution. The results showed that the variables had normal distribution. Also, a scatter plot was employed to show homoscedasticity. In the presented data, the residuals and the variance of the residuals were the same for all the predicted variables. Multiple outliers were assessed by Mahalanobis distance. None of the distances were bigger than or equal to Chi‑square; so, there were no multiple outliers among the data set. To predict the quality of life (criterion variable) based on sleep quality, level of aggression and executive function (predictive variables), step‑by‑step multiple regression analysis was employed. Three models were implemented in which the third one demonstrated the highest R square. This model included three variables, namely sleep quality, aggression and executive function. Furthermore, we added demographic information, including gender, marital status, education level and age to the regression analysis. The results has been shown in Table 4.

According to Table 4, a significant regression equation was found: (F (6, 315) = 13.98, P < 0.001) with an R2 = 0.482, which confirmed that the model adequately fits the data. Overall, the results showed that all variables were significant in predicting the quality of life. However, none of the demographic information was significant in predicting the quality of life (P > 0.1). Approximately 48% of the variance was explained by the current model.

This model takes the form of a statistical equation where:

Ypred = a + b1 x1 + b2 x2 + b3 x3

Ypred= 115.882-0.238(aggression) -0.199(sleep quality) -0.031(executive function)

It was observed that aggression had the most predictive power.

**Table 4.** Regression analysis of psychological symptoms

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Variable | B | SEB | β | t | P |
| Aggression  | -0.238 | 0.021 | -.542 | -11.85 | 0.00 |
| Sleep quality | -0.199 | 0.051 | -0.168 | -3.87 | 0.00 |
| Executive function | -0.031 | 0.008 | -0.168 | -3.729 | 0.00 |

SEB: Standard error for the unstandardized beta

**Discussion:**

The aim of the present study was to examine the role of executive function, sleep quality and aggression in predicting the changes in the quality of life of MTBI patients. Correlation analyses showed that quality of life has a significant relationship with all predictive variables. The results of the regression analyses also indicated that variables of executive function, sleep quality and aggression are able to predict the quality of life. In other words, executive function, sleep quality and the level of aggression can predict 48% of the variance of the quality of life variable in MTBI patients. According to the results, it can be said that the variables of anxiety has an effect on the quality of life.

The findings of the present study are consistent with the results of many studies including the following research in terms of the existence of mental disorders as one of the common post-TBI consequences .17-19While in some studies, the incidence of mental disorders was not observed in MTBI patients until one year. In general, addressing the issue of incidence of post-TBI mental disorders is not an emerging phenomenon, and even they have been referred in the classic researches of the first years of the twentieth century. For example, Emil Kraepelin believed that local brain damage could be the direct cause of depression disorder, and damage to parts of the brain was associated with a specific psychopathology. 20 In addition, the psychosocial consequences can be the results of brain damage. In general, it can be said that the frequency rates of mental disorders in the post-TBI phase along with many new cases of personality change are high. The anxiety mood disorders are considerably high and TBI patients should be monitored and evaluated at least at the 4-month follow-up after TBI for the emergence of mental disorders for preventive measures and better pathologic management. According to one study, after GCS clearance, the psychological variables in TBI patients can be the powerful factors in predicting psychological and motor effects, which is line with the results of the present study. Given that the TBI patients participated in our research were evaluated just 10 days after the impact, it can be concluded that the incidence and severity of mental disorders is a reliable predictive factor of their quality of life after TBI.21 In addition, the results showed that improvement of the psychological and cognitive status of patients increases the degree of independence in their motor and psychological functions, and this reduces their overload years at their young age18. As the results of Hoofien et al., Fann et al., and Koponen et al. studies have shown, a significant number of patients show some signs of mental abnormalities years or even decades after TBI.18, 22 Given the findings of this study on the ability to evaluate and track the psychological and cognitive consequences even a few days after the impact, it seems necessary to take preventive care to screen patients with TBI exposed to the risk of developing psychological and cognitive impairment due to the high epidemiology of head injuries.

The results of the regression model of the research showed that variables of executive function and aggression have an effect on the quality of life. In general, the disruption of cognitive and functional performances can have a wide range of adverse effects on the ability of people to perform effectively in their daily life and cause disruption of the occupational and social performances, as well as daily activities, and interpersonal relationships. According to the performed researches, the multifaceted damage to sensory areas, dorsal cortex as well as damage to the frontal area of ​​the brain can be the cause of reduced performance of the patients. Given the confirmation of the hypothesis of the relationship between functional performance and the quality of life of patients with MTBI, it is necessary to implement intensive rehabilitation programs to improve the cognitive and psychological abilities of patients with MTBI immediately after discharge from the emergency department or neurosurgery.23 In addition, it can be said that, despite the fact that CT scan findings are normal, MTBI can even lead to problems in controlling the patient's emotions. Thus, early and timely treatment in these patients reduces the difficulty in adjustment of the emotions in these patients, which consequently leads to improved quality of life. 24

 **Conclusions**

The findings of the present study reveal that there is a relationship between executive function, sleep quality and the level of aggression in MTBI patients and their quality of life. So, one of the important complications of MTBI is the emergence of psychological and cognitive disorders, and with regard to the mean age of this complication, which is in a sensitive age range and this sensitivity is increasing day to day, we should try in order to treat, care, and return these patients to their psychosocial status. In future researches, the psychological rehabilitation program should be implemented after the evaluation and its results must be presented, and the rehabilitation program should be as a specialist treatment team that will deal with all areas of effect, and patients continue to live with the least complication. As one of the limitations of the present study, we can refer to the target society of our study who was not able to cooperate with our research because of frequent physical disabilities.

**Declarations**

**Abbreviations**

MTBI: Mild Traumatic Brain Injury, WHOQOL‑BREF: quality of life questionnaire, DASS‑21L depression, anxiety and stress scale. QOL: Quality of Life.

**Ethics approval and consent to participate**: Written informed consent (about participation in the study) was received from all patients before the beginning of the study. The scales used in this research were all filled anonymously and a numeric code was used. This project was assessed and certified by the ethics committee of Kashan University of medical science (IR.KAUMS.NUHEPM.REC.1396.12).

 **Consent for publication**: during sampling individual session was held. We received consent for publication results from each participant.

**Availability of data and material**: Data of participants who consented to the public sharing of data are accessible from the corresponding author upon reasonable demands.

**Competing interests**: The authors certify that they have no competing interests.

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**Authors' contributions**: The Sh.sh and A.O conceived of the presented idea. The PS with Sh.Sh developed and performed the sampling. SHP and N.SH operating the analytical methods. The Sh.Sh encouraged the A.O and M.D to investigate this matter and supervised the results of the findings. All authors discussed, read and approved the manuscript.

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