

Silent Epidemic: The Effects of Neurofeedback on Quality-of-Life

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ABSTRACT

Background: The complex interaction of human, vehicle and environmental factors along with a lack of sustainable preventive programs has contributed to the “silent epidemic” of traumatic brain injuries (TBI). TBI poses a grave threat to the quality-of-life (QOL). **Aim:** The aim of the present study was to examine the effects of neurofeedback in QOL in patients with TBI. **Materials and Methods:** Pre- and post-interventional study design was adopted. Sixty patients, 30 in the intervention group (IG) and 30 in waitlist group with the diagnosis of TBI in the age range of 18-49 years were assessed on QOL scale, after obtaining the informed consent. Patients in the IG were given 20 sessions of alpha-theta neurofeedback training (NFT), 5 sessions / week. **Statistics Analysis:** Descriptive statistics, Spearman’s correlation, Mann-Whitney and Chi-squared test was used. **Results and Conclusion:** Patients in the IG showed statistical improvements in QOL post post-neurofeedback. Results are encouraging for the incorporation of NFT into treatment programs for patients with TBI in improving QOL.

Key words: Neurofeedback training, quality-of-life, traumatic brain injury


INTRODUCTION

In India, lack of sustainable preventive programs has contributed to the “silent epidemic” of traumatic brain injuries (TBI) in India.^[1] The cognitive and emotional changes, contribute most to the disruption of life activities for people with TBI. Along with the cognitive changes, personality changes, decrease the quality-of-life (QOL) for the brain injured person and their family. QOL is directly correlated with the degree to which universal needs are met.^[2] The complexity of QOL increases when damage to the brain is involved. The optimistic

goal for people who have sustained TBI would be to return to their pre-injury QOL.^[3] In a study, decreased societal participation and life satisfaction ($n = 60$) was reported.^[4] Poorer QOL with the group ($n = 126$) who had cerebral lesions was reported.^[5] In a 5-7 year follow-up study, more post-concussion symptoms and significant reduction in QOL in TBI.^[6] Current perspective on QOL is that patients with TBI experience serious long-enduring problems with QOL. The trauma is the leading cause of long-term disablement in young persons. The recovery of TBI would be maximized by appropriate rehabilitation, which occurs within months of the damage. In a case study, neurofeedback training (NFT) was found to be useful in learning and memory and QOL.^[7] The present study is an attempt to evaluate the NFT and its effect on the QOL.

MATERIALS AND METHODS

Consecutive patients with a diagnosis of TBI were recruited post 3 months of injury into an intervention

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group (IG) and waitlist group (WG). The sample was collected from in-patient and out-patient service of Department of Neurosurgery, National Institute of Mental Health and NeuroSciences, Bangalore. Right handed patients with the first episode of mild, moderate or severe head injury, (Glasgow Coma Scale (GCS) with the score of 3-15 on GCS) in the age range of 18-50 years, with the ability to read and write were chosen. Patients with a previous history of psychiatric disorder, neurological illness and neurosurgical conditions, mental retardation, substance dependence, hypertension, cardiac complications, post-traumatic epilepsy and patients with medico legal registration were excluded. Socio-demographic data sheet and World Health Organization (WHO) QOL scale (WHOQOL, 1998)^[8] was used to assess the patients. The WHOQOL (1998)^[8] was administered after obtaining the informed consent. WHOQOL-BREF contains 26 items, which constitute four domains, physical health, psychological health, social relationship and environment. It was developed by the WHOQOL Group (1998).^[8] The 26 items are extracted from 100 items of WHOQOL-100 often validation and reliability studies conducted in 15 field trial centers in parts of the world, including India. Domain scores produced by the WHOQOL-BREF correlate highly (0.89 or above) with WHOQOL-100 domain scores. WHOQOL-BREF, domain scores have demonstrated good discriminant validity, content, internal consistency, and test retest reliability (WHOQOL Group, 1998).^[8] It was used to assess QOL of patients.

Procedure

Sixty patients as per the inclusion and exclusion criteria were recruited for this study and were divided into two groups, IG and WG. The socio-demographic details were obtained from patients and family and QOL scale was administered. The IG received the NFT of 20 sessions, each session lasting for 40 minutes duration with 5-6 sessions/week. The IG was trained on the O1 and O2 channels of neurofeedback for alpha-theta training. The patients were educated about the procedure and doubts were clarified when sought. The NFT was done in a quiet dimly lit room. The patient was seated in a comfortable chair in front of the neurofeedback unit. The electrodes were positioned at O1 and O2 points to reference and ground point according to 10-20 international system of electrode placement. The scalp was cleaned and was prepared with an abrasive gel. A pea sized ball of 10-20 paste was applied to the cup of gold electrodes and was placed on the scalp. The electrodes were placed on to the scalp and the connection with skin was ensured. Similarly ear lobes and forehead was cleaned and the electrodes were placed. The wires from the sensors were plugged into the connectors in front of the neurofeedback unit. The folder was made for each patient. The protocol

was selected i.e., Peak 2 (alpha-theta training). The procedure and goals of the game, which was displayed on the monitor, were explained to patients. The rewards were given through visual feedback. For the first few sessions, verbal feedback by the investigator was given about the achievement of the goals and points. The scores would be displayed on the screen from which the patients could obtain the feedback. The post-training assessment was for the IG after 20 sessions of NFT. QOL Scale was re-administered for all 60 patients. Pre- and post-intervention design was adopted.

RESULTS

The results obtained on various tests were analyzed using the descriptive statistics, such as mean and standard deviation for continuous variables; frequency and percentages, for qualitative variables. Spearman's correlation test was used to study the correlation between different variables. The effectiveness of intervention was analyzed using the repeated measure (Mann-Whitney). The categorical data was analyzed using Chi-squared test. $P < 0.05$ was considered as to be statistically significant. Effect size was calculated to analyze the effect of NFT. Data was analyzed using "Statistical Package for the Social Sciences, SPSS 15.0 (Department of Biostatistics, NIMHANS copy) for Windows.

Socio-demographic details

Table 1 shows a comparison of age and education between IG and WG. The mean age of IG is 28.27 ± 7.66 years and 30.80 ± 8.38 years for WG. Age did not show a significant difference between IG and WG. The mean number of years of education was 11.97 ± 2.71 years in IG and 9.10 ± 4.41 in WG. The number of years of education in the WG was lesser than the IG. This indicates significant difference between the IG and WG for mean number of years of education [$P = 0.041$] [Table 1]. However, there was no statistical difference between the groups in terms of school versus college educated ($P = 0.096$). Table 2 shows socio-demographic details of patients in terms of frequencies and percentages. There was no statistical difference between the IG and WG with regard to gender ($P = 0.665$) marital status ($P = 0.591$), employment ($P = 0.302$) and socio-economic status ($P = 0.681$). With regard to

Table 1: Comparison of age, education between IG and WG (n=60)

Variable	Intervention group (n=30)		Wait list group (n=30)		P value
	Mean	SD	Mean	SD	
Age (years)	28.27	7.66	8.38	0.819	0.819
Education (years)	11.97	2.71	4.41	0.041	0.041

SD – Standard deviation; IG – Intervention group; WG – Wait list group

urban versus rural distribution, there was a significant difference ($P = 0.001$) between the groups.

Table 3 shows clinical variable of patients. There were 7 (23.3%) mild, 6 (20%) moderate and 17 (56.7%) severely injured patients in IG. In WG, 12 (40%), were mild, 10 (33.3%) were moderate and 8 (26.7%) were with severe TBI. There was no significant difference

Table 2: Comparison of socio-demographic details between IG and WG (n=60)

Variables	IG		WG		P value
	n	%	n	%	
Gender					
Male	27	90	27	90	0.665
Female	3	10	3	10	
Marital status					
Married	20	66.7	13	43.3	0.591
Unmarried	10	33.3	17	56.7	
Education					
School	14	46.7	20	66.6	0.096
College	16	53.3	10	33.3	
Employment					
Employed	15	50	12	40	0.302
Unemployed	15	50	18	60	
Background					
Rural	6	20	19	63.3	0.001
Urban	24	80	11	36.7	
SES					
Lower	6	20	11	36.7	0.68
Middle	14	46.7	16	53.3	
Upper	10	33.3	3	10	

IG – Intervention group; WG – Wait list group; SES – Socio-economic status

Table 3: Clinical details IG and WG (n=60)

Variables	IG		WG		P value
	n	%	n	%	
Severity					
Mild	7	23.3	12	40	0.62
Moderate	6	20	10	33.3	
Severe	17	56.7	8	26.7	
Imaging					
Frontal	16	53.3	13	43.3	0.303
Temporal	16	53.3	11	36.7	0.150
Occipital	3	10	2	6.7	0.500
Parietal	9	30	10	33.3	0.500
Assessment					
<1 year	19	63.3	26	86.7	0.036
>1 year	11	36.7	4	13.3	
Surgery					
Yes	13	43.3	11	36.7	0.396
No	17	56.7	19	63.33	
Lateralization					
Left	5	16.7	4	13.3	0.653
Right	5	16.7	9	30	
Bilateral	7	23.3	5	16.7	
Unknown	13	43.3	12	40	

IG – Intervention group; WG – Wait list group

between the groups in terms of severity ($P = 0.062$), imaging and lateralization ($P = 0.653$). There was more number of patients in the IG than WG for surgery. There was a significant difference between the two groups for the assessment point 26 (86.7%, $P = 0.036$) in the WG underwent neuropsychological assessment within 1 year of the TBI, whereas in the IG 19 (63.3%) underwent before completion of 1 year of TBI.

Table 4 shows correlation of QOL with age and education. There was no significant statistical correlation between age and QOL in IG and WG. Education was positively correlated with environment domain of QOL ($\rho = 0.310^*$, $P = 0.016$) in IG and WG.

Table 5 shows the QOL between IG and WG. Patients in IG and WG were comparable on the domains of psychological, social and environmental. There was a significant difference on the physical domain of QOL (IG mean = 17 ± 3.42 , WG = 19.67 ± 3.19 , $P = 0.003$). The physical domain of QOL in WG was greater than IG.

Table 6 shows a comparison of pre-post QOL in IG. The pre- and post-mean scores of domains of QOL are as follows, physical QOL 17.00 ± 3.42 and 22.90 ± 2.02 ($P \leq 0.001$), psychological 15.17 ± 3.05 and 19.10 ± 1.82 ($P \leq 0.001$), social 8.47 ± 1.97 and 10.47 ± 0.97 ($P \leq 0.001$), environment 28.00 ± 5.11 and 30.77 ± 2.81 ($P = 0.001$), total QOL 68.63 ± 11.85 and 83.23 ± 5.68 ($P \leq 0.001$). The results indicate that there is statistical significant difference between the pre- and post-scores across all domains of QOL.

Table 7 shows a comparison of pre-post QOL in WG. Results show that there was a minimal improvement in the WG from pre to post. The mean scores were not statistically significant for QOL.

DISCUSSION

QOL is subjective to well-being in relation to self and society. It was measured using WHO-QOL BREF. According to Tarter,^[9] QOL is a multi-faceted construct that encompasses the individual's behavioral and cognitive capacities, emotional well-being and abilities requiring the performance of domestic, vocational and social roles. QOL is therefore, a dynamic concept that not only incorporates physical, psychological and social domains, but individual perceptions and values of their role function. The well-being of individuals is based on the idea of good health and life satisfaction. Variables such as age and education were correlated to analyze whether it has an impact on the well-being of individual. The present study indicated that there was no correlation between age and QOL. Both younger

Table 4: Correlation between QOL with age and education (n=60)

Variables	QOL	Physical	Psychological	Social	Environment	Total
Age (years)	Rho	0.019	-31	0.066	-0.25	-0.007
	P value	0.884	0.817	0.615	0.849	0.958
Education (years)	Rho	-0.087	0.161	0.04	0.310*	0.159
	P value	0.507	0.22	0.763	0.16	0.225

QOL – Quality of life; *: Significance at 0.05 level

Table 5: QOL in IG and WG (n=60)

QOL	IG		WG		P value
	Mean	SD	Mean	SD	
Physical	17	3.42	19.67	3.19	0.003
Psychological	15.17	3.05	16.73	2.59	0.05
Social	8.47	1.97	8.97	1.45	0.314
Environment	28	5.11	2.8	3.56	0.744
Total	68.63	11.85	73.16	8.36	0.131

QOL – Quality of life; IG – Intervention group; WG – Wait list group; SD – Standard deviation

Table 6: Comparison of pre-post QOL in IG (n=30)

QOL	Pre		Post		P value
	Mean	SD	Mean	SD	
Physical	17	3.42	22.9	2.02	0.001
Psychological	15.17	3.05	19.1	1.82	0.001
Social	8.47	1.97	10.47	0.97	0.001
Environment	28	5.11	30.77	2.81	0.001
Total	68.63	11.85	83.23	5.68	0.001

QOL – Quality of life; IG – Intervention group; SD – Standard deviation

Table 7: Comparison of pre-post QOL in WG (n=30)

QOL	Pre		Post		P value
	Mean	SD	Mean	SD	
Physical	19.67	3.19	19.77	3.52	0.924
Psychological	16.73	2.59	17.27	3.23	0.168
Social	8.97	1.45	9.33	1.47	0.286
Environment	27.8	3.56	27.8	3.38	0.882
Total	73.16	8.38	74.16	9.28	0.33

QOL – Quality of life; WG – Wait list group; SD – Standard deviation

and older adults experience poorer QOL post-TBI. The findings are corroborated by a study conducted, in which it was hypothesized that increased age would be associated with decreased QOL. The study revealed that increased age was associated with lower QOL in Caucasians, whereas no relationship was observed between age and QOL measures among African Americans. The environment domain of QOL was positively correlated with the number of years of education [Table 4]. Education has been found to be the protective factor, which increases the QOL. The findings are corroborated by studies, conducted with spinal cord injury, Clayton and Chubon,^[10] found in a sample of 100 persons with spinal injury, that education was associated with perceived life quality. Education is considered to increase access to work and economic

resources. Education increases a sense of control over the life for a person with disabilities and creates opportunities for social relationships.^[11] It is therefore hypothesized that in patients with TBI, severity, age and concussion symptoms influence health related QOL and early social reintegration.^[12] Patients in IG and WG were comparable on the domains of psychological, social and environmental at baseline. There was a significant difference on the physical domain of QOL (IG mean = 17 ± 3.42 , WG = 19.67 ± 3.19 , $P = 0.003$). The physical domain of QOL in WG was greater than IG [Table 5].

The main objective was to compare QOL in intervention and waitlist group pre- and post-NFT. The QOL scale measured the changes in the areas of physical, psychological, social and environmental domains. The results for the IG indicate that there was statistically significant difference between the pre- and post-scores across all domains of QOL [Table 6]. The results indicate that NFT is effective in enhancing the QOL in patients with TBI. The WG underwent neuropsychological assessment post 1 month without NFT. The mean scores for QOL indicate that there was minimal improvement in the WG. The improvement was not statistically significant from pre to post. This could be due to the fact that WG were not part of NFT [Table 7]. The hypothesis was that there will be no significant difference between the intervention and the WG on the QOL after the NFT has been rejected. There were significant improvements in IG when compared to WG on all domains of QOL. NFT targeting QOL has been effective in enhancing QOL. The findings were corroborated by a study (Reddy *et al.*, 2009).^[7] The effect size was calculated to examine the effect size of NFT in patient with TBI and to assess the changes post NFT. The results show that total QOL showed larger effect size (physical 1.57, psychological 1.25, social 0.96 and total QOL 1.43). Environment domain of QOL social domain of QOL had medium effect size (0.75). The NFT as a cognitive rehabilitation procedure emphasized patients to relax. The relaxation in turn has reduced stress experienced by patients. Reduction in stress contributes to positive perception of self, subjective well-being and awareness, thus improving QOL. Increased QOL, decrease could therefore, be implicated in reduction of post-concussion symptoms following TBI and contributing to improvement in cognitive functions. The mechanism of NFT along with neuronal plasticity contributed to the improvement. Liner model of QOL indicates that disability or impairment due to TBI, leads to poor cognitive functioning which in turn leads to poor QOL.^[13] In accordance with this model, in the present study, NFT improved QOL significantly.

Persons with TBI, who tend to have low perceptions of QOL, hence often experience feelings of guilt, failure, and unhappiness. These individuals due to lack of awareness of deficits often have a lack of insight into planning, lack of social judgment, impulsivity, difficulties adjusting to change and interpersonal problems, and low long-term psychological adjustment.^[14] Most of the studies targeted in evaluating the QOL, measuring the components of QOL, very few studies have studied the management of enhancing the QOL. With this back ground, the present study aimed to evaluate the NFT and its effect on the QOL. The group was interviewed and assessed on QOL scale. The training focused on enhancing well-being of the person psychologically, the psychological well-being has in turn effected the overall improvement in the QOL. The improvement could be attributed to NFT. The alpha-theta training (8-11 Hz alpha and 4-8 Hz theta) guides the individuals to their deepest level of consciousness in order to facilitate and process psychological issues. According to researchers the alpha-theta neurofeedback counteracts increased beta-endorphin levels and promotes stress reduction.^[15] It is proposed that electroencephalogram (EEG) biofeedback training may affect cortical regulation in a broad sense when it is used to train the EEG toward more state appropriate frequency distributions. This is accomplished by impacting on those mechanisms, originating in the reticular formation of the brain stem and mediated by the thalamus and the hypothalamus, which govern states of arousal and level of consciousness, including cortical activation (Serman, 1982).^[16] Though the theoretical aspect explains the mechanism, the exact mechanism of alpha-theta neurofeedback remains elusive. The results show that there is statistically significant improvement in the post-training in QOL. The results indicated that neurofeedback as training mechanisms can be useful in enhancing the QOL in patients with TBI. The limitation of the study is that there was no follow-up of patients. The implication of the study is that NFT as a mechanism is effective to enhance the QOL.

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