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ORIGINAL ARTICLE

Cognition and Quality of Life of People with Spinal Cord Injury

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Objectives: The aim of this study was to assess the cognitive abilities of people with spinal cord injury (SCI) using the Edinburgh Cognitive and Behavior Amyotrophic Lateral Sclerosis Screen (ECAS), a tool designed for testing cognition in individuals with limited hand motor function. The impact of cognitive dysfunction on quality of life was also assessed. **Methods:** Forty-one patients with SCI were assessed using ECAS, the brief version of the World Health Organisation Quality of Life questionnaire (WHOQOL-BREF), and the Spinal Cord Independence Measure. **Results:** Overall, 28 of the 41 participants scored below the cut-off threshold for normal population in ECAS. The domains affected were language, 63%; memory, 51%; executive function, 44%; verbal fluency, 44%; and visuospatial skills, 24%. On multiple regression analysis, the ECAS total score moderately strongly explained the variance in the WHOQOL-BREF psychological ($\beta = 0.428$, $t = 2.958$, $P = 0.005$) and environmental ($\beta = 0.411$, $t = 2.819$, $P = 0.008$) domains. ECAS memory scores independently influenced WHOQOL-BREF physical ($\beta = 0.398$, $t = 2.67$, $P = 0.011$) and environmental ($\beta = 0.37$, $t = 2.697$, $P = 0.010$) domains. WHOQOL-BREF psychological scores were significantly influenced by ECAS executive scores ($\beta = 0.415$, $t = 2.85$, $P = 0.007$), whereas the social domain was not significantly influenced by ECAS scores. **Conclusions:** It was feasible to use ECAS in individuals with SCI. Cognitive ability influenced the quality of life of people with SCI.

Key Words: cognition; spinal cord injury; quality of life

INTRODUCTION

Recent studies have demonstrated that people with spinal cord injuries (SCIs) are at higher risk of developing Alzheimer's disease.[1)] The prevalence of cognitive impairment in people with SCI ranges between 10% and 60% and affects different aspects of cognition such as memory, learning, and emotions.[2–4)] Cognitive impairment affects the quality of life (QoL) of people with long-term neurological conditions such as Parkinson's disease and stroke.[5,6)] However, the impact of cognition on the QoL of people with SCI is not clear. A study by Dudley-Javoroski et al. showed that cognitive impairment did not impact QoL of people with SCI. The authors attributed this to the "recalibration" of goals by people with SCI.[7)] Most of the currently used neuropsychological assessments involve performing tasks such as drawing and writing, which require intact hand function. People with cervical SCI often have weakness of the hands and therefore are unable to complete such tests.[4)] The aim of this study was to test the cognitive function of people with SCI and to assess the impacts of cognitive dysfunction on their QoL.

MATERIALS AND METHODS

In this cross-sectional observational study, the Edinburgh Cognitive and Behavioral Amyotrophic Lateral Sclerosis

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screen (ECAS) was used to assess the cognition of people with SCI. The participants were recruited from the Princess Royal Spinal Injuries Unit, a tertiary SCI center at the Northern General Hospital, Sheffield, UK. The study was carried out over a period of 3 months in 2015. We approached all the individuals who attended the outpatient spinal injuries clinic on the days the researcher was present in the clinic. Patients between 18 and 80 years of age who sustained their SCI more than 3 months previously were included in this study. Patients with known causes of cognitive dysfunction, such as traumatic brain injury, dementia, and learning difficulties, were excluded from the study. A consultant in SCI screened all the patients and reviewed their medical notes. Information regarding the location, level, severity, and date of the SCI and any neurological illness prior to, along with, or after the SCI was collected. The level of SCI and the injury severity were measured using the American Spinal Injury Association (ASIA) impairment scale.

The ECAS is a brief battery of cognitive tests that assesses five areas of cognition and behavior, namely, language, visuospatial awareness, memory, verbal fluency, and executive functioning. The ECAS has been specifically designed for individuals with amyotrophic lateral sclerosis and can be completed by people without hand motor function. The testing takes 15–20 min. The ECAS has been validated and can be administered in a clinical setting.[8] In the current study, the ECAS was used to assess the cognition of participants. Permission from the copyright holders of this screening tool was obtained prior to the study commencing. The same researcher administered the test for all participants, and the test was performed in a separate room for outpatients and at the bedside for inpatients. All the responses were transcribed and entered in an electronic database. The guidelines for administration and scoring ECAS provided by Abrahams et al. were followed throughout.[8] As suggested by Abrahams et al., a total ECAS score of less than 105 was used as the cut-off for cognitive impairment.[8]

QoL was assessed using the World Health Organization Quality of Life Brief (WHOQOL-BREF) questionnaire, which comprises 26 items and focuses on perceived QoL over the previous 2 weeks.[9,10] Two questions refer to perceptions of general QoL and health, whereas the remaining 24 items can be categorized into four domains: physical health, psychological wellbeing, social relationships, and environment. Each item is rated on a 5-point Likert scale and summed to 100, with higher scores indicating a better QoL. This questionnaire was self-administered by respondents wherever possible; however, assistance from the investigator was available if required.

Activity limitation was measured using the Spinal Cord Independence Measure (SCIM) version III, a comprehensive functional rating scale measuring the ability of people with SCI to conduct everyday tasks.[11] SCIM covers 19 tasks, grouped into functional subscales: self-care (scored 0–20), respiration and sphincter management (0–40), mobility in room and toilet (0–10), and mobility indoors and outdoors (0–30).

Statistical analysis was conducted using SPSS version 22 (IBM, 2013). Correlations between measures were analyzed using Spearman's rank correlation coefficient (ρ). We investigated the effect of the ECAS total score on WHOQOL-BREF domains, after adjusting for age, and on SCIM total score using stepwise linear regression. The regressions were repeated using the subscales for ECAS and SCIM in place of the totals. Assumptions for the normality and homoscedasticity of residuals were met, and the partial scatterplots were verified by visual inspection. All P-value scores (except for the regressions) were corrected for multiple comparisons using the Benjamini-Hochberg correction, which controls for the false discovery rate.[12] The correction was applied batch-wise to P-values from each type of statistical test. For the correlations, a batch was considered to be a series of correlations between the sub-scores of one scale and those of another.

Good Clinical Practice research guidelines were followed, and ethical approval was obtained from NRES Committee Southwest, Frenchay, United Kingdom, REC reference: 15/SW/0053, IRAS ID: 174664. All applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during this research. Written informed consent was obtained from all 45 participants.

RESULTS

We approached 47 patients with SCI, of which 45 gave consent to participate in the study. Two patients chose not to participate: one of these individuals cited time restraints, whereas the other gave no specific reason. Four participants who had associated traumatic brain injury in addition to the SCI were excluded. Of the 41 subjects, 34 were men and 7 were women and their ages ranged from 20 to 88 years (mean ± SD 58.5 ±16.0 years, median 60 years). The age at the time of SCI varied between 15 and 86 years (mean 39.4 ± 20.5 years, median 36 years). The mean time elapsed since the SCI was 228.5 ± 189.6 months (median 180, range 7–696 months). In total, 38 subjects had traumatic SCI and 3 had

Table 1a. Comparison of the ECAS scores of people with spinal cord injuries with those of the general population

ECAS	Mean (SD)	Median	Range	Threshold	n (%) below threshold[a]	W	P
Total	95.7 (19.2)	97*	43–124	105	28 (68%)	–2.583	0.023*
Language	24.2 (3.5)	25*	15–28	26	26 (63%)	–2.746	0.017*
Verbal fluency	14.4 (5.7)	16	0–22	14	18 (44%)	0.785	0.550
Executive	33.8 (8.8)	35	13–48	33	18 (44%)	0.943	0.533
Memory	12.2 (5.1)	13	1–19	13	21 (51%)	–0.077	0.939
Visuospatial	11.1 (1.6)	12**	4–12	10	10 (24%)	4.024	0.000**

SD, standard deviation; n, number of participants with scores below the normal threshold; W, one-sample Wilcoxon signed-rank test.
[a]Cut-off levels for abnormality based on values more than 2 SDs from the mean for general population.
*P < 0.05, **P < 0.001.

Table 1b. Comparison of the WHOQOL BREF scores of people with spinal cord injuries with those of the general population

WHOQOL-BREF	Mean (SD)	Median	Range	Threshold	n (%) below thresholda	W	P
Physical	54.8 (22.3)	56**	6–94	73.5	32 (78%)	–4.185	0.000**
Psychological	67.0 (22.9)	69	19–94	70.6	22 (54%)	–0.396	0.807
Social	60.4 (18.6)	69*	0–94	71.5	28 (68%)	–2.750	0.017*
Environmental	76.9 (16.8)	81	31–100	75.1	17 (41%)	0.877	0.533

[a]Cut-off levels for abnormality based on values more than 2 SDs from the mean of normative data for the general population.
*P < 0.05, **P < 0.001.

non-traumatic SCI. Injury severity on the ASIA scale was A (complete impairment) in 16 subjects, B (incomplete with only sensory function below the level of SCI) in 2 subjects, C (incomplete with motor function below the level of SCI and more than half of key muscles having a Medical Research Council [MRC] power grade < 3) in 2 subjects, D (incomplete with motor function preserved with more than half of the key muscles below the level of SCI having a MRC power ≥ 3) in 18 subjects, and E (normal sensory and motor functions below SCI) in 3 subjects. The levels of the injuries were cervical in 6 subjects, thoracic in 20, and lumbar in 15. On review of the medical records, nine participants had neurological and psychiatric disorders (stroke in two, epilepsy in two, and depression in five).

All 41 patients completed the ECAS questionnaire. The scores for the ECAS sub-domains and their comparison with scores for healthy volunteers as reported by Abrahams et al. are given in **Table 1a.**[8] Overall, 28 of the 41 (68%) patients had an ECAS total score below 105, the threshold for general population. The WHOQOL-BREF scores were below the population norms in the physical domain in 32 (78%) subjects, in the psychological domain in 22 (54%), in the social domain in 28 (68%), and in the environmental domain in 17 (41%) (**Table 1b**). The mean total SCIM score was 52.4 ± 22.3 (median 56, range 14–100). The scores for the different domains were self-care, 12.8 ± 6.5 (median 16, range 0–20); respiration and sphincter management, 22.8 ± 10.2 (median 25, range 4–40); and mobility, 16.8 ± 10.1 (median 17, range 3–40).

Correlations of ECAS domains with the domains of WHOQOL-BREF and SCIM are shown in **Table 2**. The correlations between ECAS scores and WHOQOL-BREF scores ranged from very weak to moderate.

The results of multiple regression analysis are shown in **Table 3**. The ECAS total score could moderately strongly explain the variance in scores on the WHOQOL-BREF psychological domain and the WHOQOL-BREF environmental domain. The ECAS memory scores independently influenced the WHOQOL-BREF physical domain and the WHOQOL-BREF environmental domain. The WHOQOL-BREF psychological scores were significantly influenced by the ECAS executive scores. The social domain was not significantly influenced by any of the ECAS domains.

Table 2. Correlations between ECAS sub-scores and WHOQOL-BREF and SCIM domains

		ECAS Total	ECAS Language	ECAS Verbal fluency	ECAS Executive	ECAS Memory	ECAS Visuospatial
WHOQOL Physical	ρ	0.351[b]	0.239[b]	0.307[b]	0.271[b]	0.509[c]	0.123[a]
	P-value	0.061	0.200	0.087	0.139	0.024*	0.560
WHOQOL Psychological	ρ	0.373[b]	0.356[b]	0.346[b]	0.343[b]	0.335[b]	0.111[a]
	P-value	0.061	0.061	0.061	0.061	0.066	0.565
WHOQOL Social	ρ	0.110[a]	0.008[a]	0.016[a]	0.068[a]	0.172[a]	0.308[b]
	P-value	0.565	0.963	0.962	0.734	0.375	0.087
WHOQOL Environmental	ρ	0.463[c]	0.347[b]	0.381[b]	0.411[c]	0.450[c]	0.178[a]
	P-value	0.024*	0.061	0.061	0.048*	0.024*	0.375
SCIM Self-care	ρ	0.173[a]	0.036[a]	0.115[a]	0.116[a]	0.197[a]	0.087[a]
	P-value	0.487	0.859	0.633	0.633	0.476	0.703
SCIM Respiration and sphincter management	ρ	0.272[b]	0.265[b]	0.293[b]	0.291[b]	–0.061[a]	0.117[a]
	P-value	0.416	0.416	0.416	0.416	0.768	0.633
SCIM Mobility	ρ	0.227[b]	0.102[a]	0.215[b]	0.153[a]	–0.001[a]	0.218[b]
	P-value	0.422	0.667	0.422	0.544	0.993	0.422

ρ, Spearman's rank correlation coefficient.
[a]Very weak correlation, [b]weak correlation, [c]moderate correlation.
*Significant at $P < 0.05$.

Table 3. Multiple regression analysis on impact of cognitive impairments on quality of life.

		Beta standardized	Beta unstandardized coefficient	Standard error	t	P
WHOQOL-BREF Psychological domain	ECAS Total score	0.428	0.512	0.173	2.958	0.005
	ECAS Executive score	0.415	1.086	0.381	2.85	0.007
WHOQOL-BREF Physical domain	ECAS Memory score	0.398	1.756	0.648	2.708	0.010
WHOQOL-BREF Environmental domain	ECAS Total score	0.411	0.360	0.128	2.819	0.008
	ECAS memory score	0.37	1.224	0.454	2.697	0.010

DISCUSSION

Rehabilitation following SCI requires familiarization with new information and the acquisition of new skills. Cognitive dysfunction can interfere with participation in rehabilitation following SCI. People with SCI and concomitant traumatic brain injury had poorer outcomes following rehabilitation than those with SCI alone.[13] Most cognitive screening tools require tests of drawing and writing, which limit their use in people with SCIs. In a previous study, 9 of the 33 people with SCI were unable to complete neuropsychological tests because of physical constraints.[4] In the present study, all participants were able to complete the ECAS, suggesting that this test overcomes the practical limitations (such as hand motor function) associated with the administration of other neuropsychological tests to people with SCI. The current findings imply that it is feasible to use ECAS as a cognitive test in people with SCI.

A recent systematic review on cognitive impairment in individuals with SCI reported that people with SCI demonstrated lower cognitive abilities than those without SCI.[14] In the current study, 28 of the 41 participants scored below the cut-off for the total score for cognitive impairment on ECAS. These findings are consistent with previous research suggesting that people with SCI perform lower than expected on neuropsychological tests.[14] In our study, language was the most affected domain; English was the first language of all the participants. Previous research using ECAS also found the language domain to be the most frequently impaired.[7,15]

The findings of this study are consistent with previous

research suggesting that the QoL of people with SCI is lower than that of the general population.[16,17] In the current study, 78% of participants scored below the population norm for the physical domain of WHOQOL-BREF. This is consistent with findings of previous research suggesting that QoL deficits in the SCI population are most pronounced in the domains of physical functioning and physical role limitations.[18] Craig et al. found that 6 months after discharge, approximately 55% of people with SCI had difficulties with social participation.[19] In our study, 68% of participants scored below the expected value of the general population in the social domain.

In our cohort, the WHOQOL-BREF psychological domain scores were similar to the population norms. Kennedy et al. also reported that 72% of people with SCI were satisfied with their psychological health.[20] Barker et al., however, reported reduced psychological health in people with SCI.[21] One reason for this discrepancy is the difference in time since SCI. Participants in the current study have had their SCI for almost 20 years, whereas participants in the study by Barker et al. had had an SCI for a much shorter time.[21] As time goes on, people with disabilities cope by adjusting their life goals.[22] On multiple regression analysis, ECAS executive functioning scores moderately strongly explained the variance in WHOQOL-BREF psychological domain scores. Executive functions such as cognitive flexibility and reasoning may be required for adequate psychological adaptation following SCI.

On multiple regression analyses, ECAS memory scores were found to strongly explain the variance in WHOQOL-BREF environmental scores. Cognitive functioning, particularly in the domain of memory, has an important influence on a person's interaction with their environment. Those with better memory are more likely to learn skills to overcome environmental barriers. Multiple regression analysis demonstrated that memory scores were able to explain the variance moderately strongly in physical domain scores of WHOQOL-BREF. The ECAS scores did not explain the variance in the WHOQOL-BREF social domain.

Cognitive ability has an impact on activities of daily living in long-term neurological conditions such as stroke and Parkinson's disease.[6] Our results indicate that activity limitation measured using SCIM was not significantly influenced by the ECAS scores. The SCI itself results in significant limitation of physical activity; therefore, the cognitive impairment may not significantly add to activity limitations.

This study has several limitations, some of which highlight the difficulties in conducting studies involving cognitive testing in people with SCI. The study had a small sample size and was conducted at a single spinal injuries center in the UK. The design excluded those who were not engaging with spinal injury services. The study did not investigate the etiology of the cognitive dysfunction in this cohort. People with SCI face a unique set of barriers to cognitive assessments. Sandalic et al. highlighted the need for a specialized cognitive screening tool to pick up minimal cognitive impairment in this group.[23] We used ECAS because it does not include drawing tasks. However, it has not been evaluated for validity and reliability in people with SCIs. The data are cross-sectional; therefore, the directions of causality in the relationships cannot be demonstrated based on the analysis itself. Another limitation is that we used the general population-based cut-off for ECAS and WHOQOL BREF, not the clinically meaningful cut-offs. The regression analyses for relationships between cognition and QoL measures were adjusted for very few factors, thereby leaving a considerable possibility of residual confounding.

The current study demonstrated that ECAS is a good screening test for assessing cognitive functions in people with SCI in a clinical setting and showed that cognitive impairment adversely affected the QoL of this cohort. Future research on the decline of cognitive functions with aging and its impact on independence, the burden of care, and QoL of people with SCI is warranted.

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CONFLICTS OF INTEREST

Dr KPS Nair received funding from GWS Pharma and Pharma Olan for drug trials on spasticity in multiple sclerosis. He also received funding from the National Institute of Health and Care Research UK, Medical Research Council UK, and the MS Society UK. The other authors declare that there are no competing financial interests in relation to the work described.

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