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Predictors of health-related quality of life and participation after brain injury rehabilitation: The role of neuropsychological factors

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ABSTRACT

The aims of this longitudinal study were: (1) to assess associations between neuropsychological factors and health-related quality of life (HRQoL) and participation three months after discharge from inpatient acquired brain injury (ABI) rehabilitation; and (2) to determine the best neuropsychological predictor of HRQoL and participation after controlling for demographic and injury-related factors. Patients with ABI ($n = 100$) were assessed within approximately two weeks of enrolment in inpatient rehabilitation. Predictor variables included demographic and injury-related characteristics and the following neuropsychological factors: active and passive coping, attention, executive functioning, verbal memory, learning potential, depressive symptoms, motivation, extraversion, neuroticism and self-awareness. Bivariate analyses revealed that passive coping, executive functioning, depressive symptoms, extraversion, and neuroticism were significantly associated with HRQoL and/or participation. Neuropsychological factors significantly explained additional variance in HRQoL (18.1–21.6%) and participation (6.9–20.3%) after controlling for demographic and injury-related factors. However, a higher tendency towards passive coping was the only significant neuropsychological predictor ($\beta = -0.305$ to -0.464) of lower HRQoL and participation. This study shows that neuropsychological functioning, and in particular passive coping, plays a role in predicting HRQoL and participation after inpatient ABI rehabilitation and emphasises the importance of addressing patients' coping styles in an early phase of ABI rehabilitation.

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Introduction

The sequelae of acquired brain injury (ABI) can substantially impact patients' long-term health-related quality of life (HRQoL) and participation (Carod-Artal & Egido, 2009; Desrosiers et al., 2006; Hartman-Maeir, Soroker, Ring, Avni, & Katz, 2007; Passier et al., 2012). HRQoL is a multidimensional construct referring to "how health impacts on an individual's ability to function, and his or her perceived well-being in physical, mental and social domains of life" (Coons, Rao, Keininger, & Hays, 2000). Participation reflects patients' involvement in life situations (e.g., employment, leisure) (World Health Organization, 2013) and is considered part of HRQoL (Barclay-Goddard, Ripat, & Mayo, 2012). Variations in HRQoL and participation after ABI are not fully explained by demographic characteristics and injury-related factors (Van Mierlo et al., 2013). Therefore, in recent years, increasing attention has been directed towards the role of neuropsychological factors such as patients' cognitive, emotional (e.g., depression) and psychological functioning (e.g., coping). Information concerning the predictive role of such factors may offer directions for neuropsychological rehabilitation of patients with ABI.

Impairments in cognitive domains, such as attention and memory, have been repeatedly identified as important predictors of reduced long-term HRQoL after ABI (see, for example, Haacke et al., 2006; Hochstenbach, Anderson, van Limbeek, & Mulder, 2001; Nys et al., 2006; Passier et al., 2012; Sturm et al., 2004). Closely related to cognitive functioning is patients' self-awareness. Mixed findings for self-awareness have been reported in patients with ABI. Some studies have shown that impaired self-awareness may lead to unfavourable participation (i.e., employment outcomes) (Sherer, Bergloff, Levin et al., 1998; Sherer et al., 2003) and higher HRQoL (Goreover & Chiaravalloti, 2014), whereas another study found no significant association between self-awareness and HRQoL (Brookes et al., 2014).

The role of emotional and psychological factors on HRQoL and participation has also been examined in several studies. In a systematic review (Van Mierlo et al., 2013) on psychological predictors of post-stroke HRQoL, it was, for example, concluded that personality, coping, internal locus of control, self-worth, hope, and optimism were all significant predictors of HRQoL post-stroke. A psychological factor that was found to be a significant predictor of HRQoL in other patient populations (e.g., prolonged musculoskeletal disorders, Grahn, Ekdahl, & Borgquist, 2000; severe mental illness, Mulder, Jochems, & Kortrijk, 2014) is motivation. The role of treatment motivation on long-term HRQoL and participation has not yet been examined longitudinally in patients with ABI.

Besides assessing the predictive role of individual neuropsychological factors on HRQoL and participation, it is also important to determine which of those neuropsychological factors is the most influential in predicting patient outcomes. One study of outpatients with subarachnoid haemorrhage (SAH) examined whether or not demographic and SAH characteristics, cognitive and emotional complaints, depressive symptoms, anxiety, memory, attention, executive functioning, visuoconstruction, and a passive coping style play a role in predicting physical and psychosocial HRQoL one year later (Passier et al., 2012). In that study, cognitive complaints and passive coping were the strongest predictors of psychosocial HRQoL, and visuoconstruction of physical HRQoL. In a study of inpatients with stroke (Haacke et al., 2006), demographic and clinical factors, global cognitive functioning, anxiety and depression were considered as potential predictors of HRQoL. Of these, depression was the strongest independent neuropsychological predictor of HRQoL four years post-stroke.

At present, there is a paucity of longitudinal studies examining the predictive value of multiple neuropsychological factors on long-term HRQoL and participation following ABI rehabilitation. Hence, in this study we examined a variety of possible neuropsychological predictors assessed at the start of inpatient ABI rehabilitation: attention, executive functioning, verbal memory, learning potential, self-awareness, depressive symptoms, coping style, motivation, and personality. The objectives were: (1) to assess associations between early neuropsychological functioning and long-term HRQoL and participation in patients with ABI; and (2) to determine which of these neuropsychological factors is the best predictor of HRQoL and participation after controlling for demographic and injury-related factors. More knowledge of predictors of rehabilitation outcome may prove useful in tailoring treatment to the individual.

Methods

Participants

Patients in this longitudinal, prospective cohort study were recruited between November 2012 and December 2013 from inpatient clinics of five rehabilitation centres in The Netherlands. Inclusion criteria were: (1) diagnosis of ABI based on medical records; (2) aged 18 years or above; and (3) sufficient command of the Dutch language based on clinical judgement. Exclusion criteria were: (1) severe aphasia based on a Dutch Aphasia Foundation (Stichting Afasie Nederland, SAN; Deelman, Koning-Haanstra, Liebrand, & van de Burg, 1987) scale score less than 4 or clinical judgement; (2) premorbid psychiatric disorder and/or substance abuse for which hospital admission was necessary; (3) minimally conscious state or post-traumatic amnesia at the time of recruitment; (4) degenerative or progressive brain disease; (5) active participation in another study to avoid participation burden; and (6) no informed consent.

Measures

Rehabilitation outcome

HRQoL. HRQoL was measured with the Stroke Specific Quality of Life Scale—12 (SS-QoL-12; Post et al., 2011). The SS-QoL-12 consists of 12 items divided into two dimensions: physical HRQoL (e.g., "Did you need help taking a bath or shower?") and psychosocial HRQoL (e.g., "I had trouble remembering things"). The dimension scores are the unweighted averages of the item scores. For both dimensions, scores range from 1 to 5 with higher scores indicating better physical or psychosocial HRQoL. The SS-QoL-12 has good reliability and validity in patients with stroke and SAH (Hsueh, Jeng, Lee, Sheu, & Hsieh, 2011; Post et al., 2011).

Participation. The Utrecht Scale for Evaluation of Rehabilitation—Participation (USER-P; Post et al., 2012) is a generic measure of participation. It consists of 31 items divided into three scales: Frequency, Restrictions, and Satisfaction. The Frequency scale consists of 12 items such as, "In the last four weeks, how many times did you visit your family or friends?" Possible answers are "0", "1–2", "3–5", "6–10", "11–18" or "19 or more". The Restrictions scale consists of 10 items such as, "Are you, because of your disease or condition, limited in doing sports or other physical exercise?" Possible answers are, "I do not perform this activity, but this is not due to my condition or disease"; "I do not perform this activity and this is due to my condition or disease"; "I do perform the activity without any trouble or help"; "I do perform (part of) the activity but receive help because of the disease"; "I do perform (part of) the activity but need considerably more time, rest, or help or do it less often or for a shorter period of time". The Satisfaction scale consists of 9 items such as, "How satisfied are you about the relationship with your partner?" Possible answers range from "very unsatisfied" to "very satisfied". For this study, the Restrictions and Satisfaction scales were used. The sum of scores for the two scales are based on the items that are applicable to the patient's situation and each sum score is converted to a 0–100 scale with higher scores indicating better participation (i.e., less restrictions, higher satisfaction) (Post et al., 2012). The USER-P has adequate reliability and validity in patients with physical disabilities (Post et al., 2012).

Possible predictors

Demographic characteristics and injury-related factors. Demographic predictors included age, gender and education. Education was categorised into high level of education (this includes higher general secondary education, pre-university education, higher vocational education, and university education) and less than a high level of education (less than higher general secondary education). Injury-related factors were time since injury, type of injury (traumatic vs. non-traumatic brain injury), length of inpatient stay, and activities of daily living (ADL) independence. ADL independence was assessed with the Barthel Index (BI; Wade & Collin, 1988) score at admission to inpatient rehabilitation. Scores range from 0 to 20; a higher score reflects more ADL independence.

Neuropsychological functioning. *Coping style*. To assess patients' coping style, two frequently used subscales of the Utrechtse Coping Lijst (UCL; Schreurs, van de Willige, Tellegen, & Brosschot, 1988) were used: Active Problem-Solving and Passive Reactions. For both subscales, scores range from 7 to 28; higher scores indicate a higher tendency towards active problem-solving or passive reactions. The UCL has good feasibility and responsiveness in an ABI population (Wolters Gregório, Brands, Stapert, Verhey, & van Heugten, 2013).

Cognitive tests. Attention was evaluated with the Trail Making Test Parts A and B (TMT; Reitan, 1956). Executive functioning was evaluated with the Category Fluency Test using "animals" (CFT; Lezak, Howieson, & Loring, 2004) and the Letter Fluency Test using the letters "N" and "A" (LFT; Schmand, Groenink, & van den Dungen, 2008). Verbal memory was assessed with the Rey Auditory Verbal Learning Test (RAVLT; Rey, 1958) Immediate and Delayed Recall. The TMT, CFT, LFT and RAVLT are described in more detail elsewhere (Lezak et al., 2004). Learning potential was examined with the dynamic Wisconsin Card Sorting Test (dWCST; Wiedl & Wienöbst, 1999). The dWCST was administered following a one-session pre-test–train–post-test design. The pre- and post-test were administered according to standard WCST administration procedures (Heaton, 1981). During the brief training, additional feedback and instructions were provided. The dWCST administration procedures are described in more detail elsewhere (Boosman, Visser-Meily, Ownsworth, Winkens, & van Heugten, 2014).

Depressive symptoms. The presence of depressive symptoms was evaluated using the Depression subscale of the Hospital Anxiety Depression Scale (HADS-D; Zigmond & Snaith, 1983). Scores range from 0 to 21 with higher scores indicating more depressive symptoms. A cut-off score of ≥ 8 was used to classify patients in a "no depression" (0–7) or "possible depression" (8–21) group (Bjelland, Dahl, Haug, & Neckelmann, 2002). The

HADS-D has adequate psychometric properties in a stroke population (Aben, Verhey, Lousberg, Lodder, & Honig, 2002).

Motivation. Motivation for rehabilitation was examined with the Motivation for Traumatic Brain Injury Rehabilitation Questionnaire (MOT-Q; Chervinsky et al., 1998). The MOT-Q is a 31-item self-report questionnaire used to assess the desire to undertake, and interest in undertaking, rehabilitation. A sample item is "Therapists would waste my time". Total scores range between −62 and 62; higher scores indicate higher motivation for rehabilitation. The MOT-Q total score has adequate psychometric properties in patients with ABI (Boosman, van Heugten, Winkens, Smeets, & Visser-Meily, 2015; Chervinsky et al., 1998).

Personality. Personality was assessed using two subscales of the Eysenck Personality Questionnaire–Revised Short Scale (EPQ-RSS; Sanderman, Arrindell, Ranchor, Eysenck, & Eysenck, 2012; Sanderman, Eysenck, & Arrindell, 1991): Extraversion and Neuroticism. These subscales were selected because of their reported relation with health (Sanderman et al., 2012). Scores range from 0 to 12 with higher scores indicating more extraversion and neuroticism. Both subscales have adequate reliability and construct validity in clinical populations (Sanderman et al., 2012).

Self-awareness. The Patient Competency Rating Scale (PCRS; Prigatano et al., 1986) assesses self-awareness using a self–other discrepancy method. An informant rating was obtained from the patient's neuropsychologist. Awareness scores were obtained by calculating the discrepancy in ratings between the patient and the neuropsychologist. A sample item of the patient's version is, "How much of a problem do I have in preparing my own meals?" and of the neuropsychologist's version, "How much of a problem do they have in preparing their own meals?" Discrepancy scores range from −120 to 120 with greater discrepancies indicating poorer self-awareness. Positive discrepancies indicate overestimation and negative discrepancies indicate underestimation of difficulties. The PCRS has good reliability and validity in patients with ABI (Smeets, Ponds, Verhey, & van Heugten, 2012).

Procedures

At the start of inpatient rehabilitation, all patients were screened for eligibility by the treating rehabilitation physician. Eligible patients were asked whether they were willing to participate in the study. After written informed consent was obtained, demographic characteristics and injury-related factors were obtained from the medical records. The initial assessment took place within approximately two weeks of enrolment and included the dWCST and all questionnaires. All measures were administered in a quiet room by a trained clinician or trained neuropsychology student. Within seven days of the initial assessment, the treating neuropsychologist of each patient completed the PCRS and a cognitive screening was conducted by a psychological assistant as part of routine assessment procedures. A follow-up assessment was completed three months after discharge from inpatient rehabilitation, and included the SSQoL-12 and the USER-P. These outcome measures were administered by a trained clinician or trained neuropsychology student by phone, mail or at the patient's home according to the patient's preference.

The medical ethics committee of the University Medical Centre Utrecht and the five participating rehabilitation centres approved the study protocol. All patients gave informed consent.

Statistical analyses

Normality was assessed using skewness, kurtosis and visual inspection of histograms. Non-parametric statistics were used in case of non-normally distributed data (skewness and kurtosis $\geq$ 1). Descriptive statistics were used to describe characteristics of the patients. A non-response analysis was performed by comparing patients who were re-examined at follow-up to those who were not. Chi-square tests, independent samples *t*-tests or Mann-Whitney *U* tests, and one-way between-groups analysis of variance (ANOVA) or Kruskall Wallis tests were used to evaluate between-group differences in demographic characteristics (gender, age, education) and injury-related factors (ADL independence, type of diagnosis, time between ABI and admission).

For all questionnaires except the USER-P, missing values were replaced with the mean of the non-missing values within the same (sub)scale. None of the patients had missing values on the UCL, HADS-D and the neuroticism subscale of the EPQ-RSS. Twelve patients had a maximum of one missing value on the MOT-Q, four patients had a maximum of one missing value on the extraversion of the EPQ-RSS, six patients had a maximum of one missing value on the physical subscale of the SS-QoL-12, and one patient had one missing value on the psychosocial subscale of the SS-QoL-12. For the PCRS, the maximum number of missing values per patient was higher but data were imputed only for patients for whom no more than 25% of the PCRS-items were missing ($n = 35$ patients). For the USER-P, subscale sum scores were calculated based on the items that were applicable to the patient's situation (no data were imputed). Cognitive domain scores were calculated for attention, executive functioning and verbal memory by averaging percentile scores of tests belonging to the same cognitive domain. Mean percentile scores were considered impaired when $\leq$ 5th percentile. For the dWCST, previously established cut-off values (Boosman, van Heugten, et al., 2015; Wiedl & Wienöbst, 1999) were used to categorise patients as "high achiever" (pre- and post-test $\geq$ 43 correct); "strong learner" (pre- to post-test improvement $\geq$ 15 points); "poor learner" (pre- to post-test improvement < 15 points); or "decliner" (pre- to post-test decline $\geq$ 15 points).

Pearson or Spearman correlation coefficients were used to check for collinearity between continuous predictor variables. Collinearity was considered present in case of Pearson or Spearman correlation coefficients exceeding 0.80. One-sample *t*-tests or one-sample Kolmogorov Smirnov Tests were used to compare patients' scores for physical and psychosocial HRQoL and for participation restrictions and satisfaction. Bivariate analyses, using Pearson or Spearman correlation coefficients with Bonferroni correction for multiple comparisons (0.05/11 neuropsychological tests) were used to calculate associations between neuropsychological variables and HRQoL and participation. Subsequently, hierarchical regression analyses were conducted to assess the ability of neuropsychological variables, that were significant in bivariate analyses, to predict HRQoL and participation, after controlling for the influence of demographic and injury-related factors. For all analyses, continuous scores were used when available. Alpha level was set at .05 for bivariate analyses and .01 for multivariate analyses. Data were analysed using SPSS version 22.0.

Results

Participants

Patients were excluded from participation in this study for a variety of reasons: insufficient command of the Dutch language, aphasia, active participation in other studies, premorbid psychiatric disorder or substance abuse, and minimally conscious state at the time of recruitment. Figure 1 shows that 160 patients were eligible and were approached for participation in the study; 35 patients refused to participate. Eventually, 125 of the 160 eligible patients with ABI were recruited from the five rehabilitation centres. Of these 125 patients, three were excluded at initial assessment and 22 patients were not assessed at follow-up. In total, data of 100 patients were used in this study (Figure 1). There were no significant differences between patients who were included ($n = 100$) and patients who were excluded at the initial assessment or who did not complete the follow-up assessment ($n = 25$) regarding age ($U = 1120.0$, $z = -0.8$, $p = .42$, $r = -.08$), gender ($\chi^2 = .074$, $p = .785$, phi $= .024$), education ($\chi^2 = 3.25$, $p = .072$, phi $= -0.161$), ADL independence ($U = 809.0$, $z = -1.5$, $p = .14$, $r = -.15$), and type of diagnosis ($\chi^2 = 2.47$, $p = .116$). The groups did significantly differ in the time between ABI and admission ($U = 725{,}5$, $z = -3{,}2$, $p = .001$, $r = -.32$); patients who were included in this study were admitted to inpatient rehabilitation approximately two weeks earlier than the other patients (median = 14 versus 28 days, respectively).

Table 1 shows the characteristics of the patients who were included in this study. Most patients suffered non-traumatic brain injury (79.0%), in particular stroke (62.0%). The mean BI at admission was 15.7 ($SD = 4.8$); 65.2% of patients were ADL independent or mildly disabled (BI 15–20) and 34.8% were moderately to severely disabled in ADL (BI 0–14) The initial assessment of the majority of patients took place within 3 months post-ABI (93.0%). Table 2 presents the descriptives of the measures that were administered during the initial and follow-up assessment. All outcome measures, but not all predictor

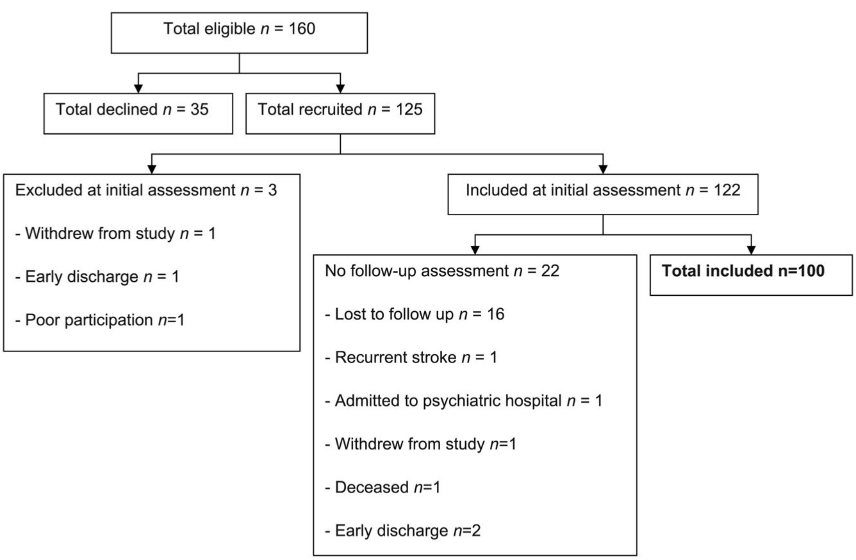

Figure 1. Flowchart for patient inclusion.

Table 1. Patient characteristics ($n = 100$).

Gender, % male	59%
Mean age in years (*SD*)	53.9 (13.4)
Age range	20–78
Education, high	48%
Diagnosis, %	
Cerebrovascular accident	62%
Traumatic brain injury	21%
Tumour	7%
Post-anoxic brain damage	6%
Neuro-inflammatory disease	4%
Mean time between injury and initial assessment (*SD*) (days)	50.4 (35.0)
Mean length of inpatient rehabilitation (*SD*) (days)	66.8 (37.8)
Mean Barthel Index at admission (*SD*)[a]	15.7 (4.8)

[a]$n = 92$.

Table 2. Descriptives potential neuropsychological predictors and outcome measures.

Domain	Measure(s)	Score used (range)	*n*	Mean (*SD*)	Median	Range	% impaired
Neuropsychological predictors							
Coping							
Active coping	UCL	Total score (7–28)	100	19.5 (3.7)	19.0	12–28	–
Passive coping	UCL	Total score (7–28)	100	9.9 (2.5)	9.0	7–20	–
Cognitive domains							
Attention	TMT-AB	Mean percentile score (0–100)	89	20.4 (21.6)	11.5	0–82	33.7[a]
Executive functioning	CFT, LFT	Mean percentile score (0–100)	96	19.2 (21.2)	9.3	0–89	28.1[a]
Verbal memory	RAVLT	Mean percentile score (0–100)	98	22.0 (27.4)	7.8	0–99	43.9[a]
Learning potential	dWCST	Learner groups	88	–	–	–	25.0[b]
Depressive symptoms	HADS-D	Total score (0–21)	99	4.7 (3.7)	4.0	0–16	22.2[c]
Motivation	MOT-Q	Total score (−64–64)	100	24.1 (12.4)	25.0	−22–51	–
Personality							
Extraversion	EPQ-RSS	Total score (0–12)	100	7.1 (3.0)	7.0	0–12	–
Neuroticism	EPQ-RSS	Total score (0–12)	100	3.0 (2.8)	2.0	0–11	–
Self-awareness	PCRS	Discrepancy score (−120–120)	88	9.4 (20.2)	10.5	−30.0–54.4	–
Outcome measures							
Physical HRQoL	SS-QoL-12	Unweighted average (1–5)	98	4.3 (0.6)	4.5	2.7–5	–
Psychosocial HRQoL	SS-QoL-12	Unweighted average (1–5)	99	3.6 (1.0)	3.7	1.2–5	–
Participation restrictions	USER-P	Converted sum score (0–100)	100	75.4 (20.1)	81.0	26–100	–
Participation satisfaction	USER-P	Converted sum score (0–100)	96	66.6 (18.2)	71.9	16–100	–

[a]Mean percentile score ≤ 5th percentile;
[b]Poor learners;
[c]Total score ≥ 8.
TMT-A = Trail Making Test part A; TMT-B/A = Trail Making Test part B corrected for part A; CFT = Category Fluency Test; LFT = Letter Fluency Test; RAVLT = Rey Auditory Verbal Learning Test; SCT = Star Cancellation Test; UCL = Utrechtse Coping Lijst; HADS-D = Hospital Anxiety and Depression Scale Depression subscale; dWCST = dynamic Wisconsin Card Sorting Test; MOT-Q = Motivation for Traumatic Brain Injury Rehabilitation Questionnaire; EPQ-RSS = Eysenck Personality Questionnaire Revised Short Scale; PCRS = Patient Competency Rating Scale; SS-QoL-12 = Stroke Specific Quality of Life Scale-12; USER-P = Utrecht Scale for Evaluation of Rehabilitation—Participation.

variables, showed a normal distribution. There was no collinearity between continuous predictor variables.

Table 2 shows that, of all cognitive domains, impairments in attention (33.7%) and verbal memory (43.9%) were most common. About one quarter of patients had impairments in executive functioning (28.1%) and learning potential (25%). Furthermore, 22.2% of patients were classified as having possible depression.

HRQoL and participation

Patients' mean physical HRQoL score (4.3 ± 0.6) was significantly higher than patients' mean psychosocial HRQoL (3.6 ± 1.0) ($p < .01$). The mean score for participation restrictions (75.4 ± 20.1) was higher (i.e., better) than the mean score for satisfaction with participation (66.6 ± 18.2) ($p < .01$).

Neuropsychological factors and physical HRQoL

Bivariate analyses revealed that two neuropsychological factors were significantly associated with lower physical HRQoL: a higher tendency towards passive coping ($r = -.391$, $p < .001$) and more depressive symptoms ($r = -.355$, $p < .001$) (Table 3). Multiple

Table 3. Associations and predictors (start of inpatient rehabilitation) of physical and psychosocial HRQoL three months after discharge.

	Physical HRQoL			*Psychosocial HRQoL*		
		Multivariate (β)			*Multivariate (β)*	
Predictor	*Bivariate (Spearman's r)*	Step 1	Step 2	*Bivariate (Spearman's r)*	Step 1	Step 2
Demographic & injury-related						
Age		.061	−0.023		.110	0.014
Education (0 ≤ high, 1 = high)		−.083	−0.067		.008	0.020
Gender (0 = male, 1 = female)		−.175	−0.086		−.231	−0.131
ADL independence		**.403****	**0.446***		.062	0.112
Length of inpatient stay		−.131	−0.092		−.094	−0.038
Type of injury (0 = traumatic, 1 = non-traumatic)		−.184	−0.**245***		−.014	−0.079
Time since injury		.053	0.047		.066	0.055
Neuropsychological						
Coping						
Active coping	−.004	NE	NE	.123	NE	NE
Passive coping	−**.391****	NE	−0.**418***	−**.513****	NE	−0.**464***
Cognitive domains						
Attention	.014	NE	NE	.022	NE	NE
Executive functioning	−.271*	NE	NE	−.058	NE	NE
Verbal memory	.175	NE	NE	.056	NE	NE
Learning potential	−.061	NE	NE	−.003	NE	NE
Depressive symptoms	−**.355****	NE	−0.069	−**.452****	NE	−0.115
Motivation for rehabilitation	−.122	NE	NE	−.009	NE	NE
Personality						
Extraversion	.095	NE	NE	.134	NE	NE
Neuroticism	−.265*	NE	NE	−**.328****	NE	0.047
Self-awareness	.142	NE	NE	.105	NE	NE
R^2		.266	0.447		.084	0.300
Adjusted R^2		.204	0.385		.006	0.213

NE = not entered.
*Multivariate analyses: $p \leq .01$, **Bivariate analyses: significant after Bonferroni correction $p \leq .005$.

regression analyses showed that demographic and injury-related factors explained 26.6% of the variance in physical HRQoL (step 1) (gender was the only significant predictor). Neuropsychological factors (passive coping, depressive symptoms) explained an additional 18.1% of the variance in physical HRQoL (F change = 13.1, $p < .001$) (step 2). In the final model, lower ADL independence ($\beta = 0.446$, $p < .001$), traumatic brain injury ($\beta = -0.245$, $p = .008$) and a higher tendency towards passive coping ($\beta = -0.418$, $p < .001$) were the only significant predictors of lower physical HRQoL ($R^2 = .447$).

Neuropsychological factors and psychosocial HRQoL

Bivariate regression analyses showed that three neuropsychological factors were significantly associated with lower psychosocial HRQoL: a higher tendency towards passive coping ($r = -.513$, $p < .001$) and neuroticism ($r = -.328$, $p = .001$), and more depressive symptoms ($r = -.452$, $p < .001$) (Table 3). Multiple regression analyses demonstrated that demographic and injury-related factors explained 8.4% of the variance in psychosocial HRQoL (step 1). Neuropsychological factors (depressive symptoms, passive coping, neuroticism) explained an additional 21.6% of the variance in psychosocial HRQoL (F change = 8.3, $p < .001$) (step 2). In the final model, a higher tendency towards passive coping ($\beta = -0.464$, $p = .001$) was the only significant predictor of lower psychosocial HRQoL ($R^2 = .300$).

Neuropsychological factors and participation restrictions

According to bivariate analyses a higher tendency towards passive coping ($r = -.307$, $p = .002$) and more depressive symptoms ($r = -.286$, $p = .004$) were significantly associated with more participation restrictions. Multiple regression analyses showed that demographic and injury-related factors explained 37.2% of the variance in participation restrictions (step 1) (gender was the only significant demographic predictor). Neuropsychological factors (passive coping, depressive symptoms) explained an additional 6.9% of the variance in participation restrictions (F change = 5.0, $p = .009$) (step 2). In the final model, female gender ($\beta = -0.267$, $p = .004$), longer inpatient stay ($\beta = -0.324$, $p = .008$), and a higher tendency towards passive coping ($\beta = -0.305$, $p = .005$) were the only significant predictors of more participation restrictions ($R^2 = .441$).

Neuropsychological factors and satisfaction with participation

Bivariate analyses revealed that two neuropsychological factors were significantly associated with lower satisfaction with participation: a higher tendency towards passive coping ($r = -.416$, $p < .001$) and more depressive symptoms ($r = -.342$, $p = .001$ (Table 4). Multiple regression analyses showed that demographic and injury-related factors explained 6.0% of the variance in participation satisfaction (step 1). Neuropsychological factors (depressive symptoms, passive coping) explained an additional 20.2% of the variance in participation satisfaction (F change = 10.8, $p < .001$) (step 2). In the final model, a higher tendency towards passive coping ($\beta = -0.453$, $p < .001$) was the only significant predictor of lower satisfaction with participation ($R^2 = .263$).

Table 4. Associations and predictors of participation restrictions and satisfaction with participation.

	Restrictions in participation			Satisfaction with participation		
		Multivariate (β)			Multivariate (β)	
Predictor	Bivariate (Spearman's r)	Step 1	Step 2	Bivariate (Spearman's r)	Step 1	Step 2
Demographic and injury-related						
Age		−.006	−0.068		.006	−0.085
Education (0 ≤ high, 1 = high)		.104	0.127		.007	0.026
Gender (0 = male, 1 = female)		−**.299***	−0.**267***		−.086	0.003
ADL independence		.205	0.206		.077	0.117
Length of inpatient stay		−.304	−0.**324***		−.158	−0.125
Type of injury (0 = traumatic, 1 = non-traumatic)		.040	−0.004		−.058	−0.124
Time since injury		−.180	−0.177		.095	0.090
Cognitive						
Coping						
Active coping	.122	NE	NE	.148	NE	NE
Passive coping	−**.307****	NE	−0.**305***	−**.416****	NE	−0.**453***
Cognitive domains						
Attention	.050	NE	NE	−.016	NE	NE
Executive functioning	−.031	NE	NE	−.096	NE	NE
Verbal memory	.026	NE	NE	−.114	NE	NE
Learning potential	.117	NE	NE	.017	NE	NE
Depressive symptoms	−**.286****	NE	0.056	−**.342****	NE	−.053
Motivation for rehabilitation	.028	NE	NE	.046	NE	NE
Personality						
Extraversion	.131	NE	NE	.217	NE	NE
Neuroticism	−.157	NE	NE	−.253	NE	NE
Self-awareness	.041	NE	NE	−.093	NE	NE
R^2		.372	0.441		.060	0.263
Adjusted R^2		.319	0.379		−.021	0.179

NE = not entered.
*Multivariate analyses: $p \leq .01$, **Bivariate analyses: significant after Bonferroni correction $p \leq .005$.

Discussion

This longitudinal study investigated the predictive role of neuropsychological factors on HRQoL and participation three months after discharge from inpatient rehabilitation. The results showed that neuropsychological factors explained additional variance in physical and psychosocial HRQoL, participation restrictions, and satisfaction with participation after controlling for demographic and injury-related factors. Across all outcomes, a higher tendency towards passive coping was the only significant neuropsychological predictor of lower HRQoL and participation.

Neuropsychological factors and HRQoL and participation

Of the variance explained by all factors combined, the neuropsychological factors, and in particular passive coping, explained a significant part of the variance in physical and psychosocial HRQoL, satisfaction with participation and participation restrictions. For all four outcomes, passive coping emerged as the only significant predictor of all neuropsychological factors considered. Passive coping being such an important predictor may be explained by the fact that a passive coping style implies a tendency to not take any action when problems or changes occur, which does not seem to be an efficient strategy to maximise rehabilitation outcomes. In a previous study in patients with ABI, an increase in the use of non-productive coping styles has been reported between the start of rehabilitation and five months later. Decreased use of passive coping styles and increased use of active coping styles predicted higher quality of life in the long term (WoltersGregório, Stapert, Brands, & van Heugten, 2010). Therefore, it is important to target patients' coping styles in an early phase post-ABI to optimise rehabilitation outcomes. Effective coping strategies may, for instance, be taught by means of cognitive-behavioural therapy (Anson & Ponsford, 2006; Backhaus, Ibarra, Klyce, Trexler, & Malec, 2010).

Although passive coping was the strongest neuropsychological predictor, bivariate analyses also showed significant relations between depressive symptoms and neuroticism and HRQoL and participation. It should be noted that in our study the percentage of patients who were classified as having possible depression (22.2%) was lower than typically found. Prevalence of depression usually varies from 27% to 61% in patients with TBI (Hibbard, Uysal, Kepler, Bogdany, & Silver, 1998; Kreutzer, Seel, & Gourley, 2001) and around 33% in stroke patients (Hackett, Yapa, Parag, & Anderson, 2005). The difference between the prevalence of depression found in our study and that reported in other studies may be due to differences in time post-onset (Kreutzer et al., 2001, for example, included outpatients, and Hibbard et al., 1998, studied patients who were on average eight years post-onset, whereas the patients in our study were inpatients at the time of assessment of depression and were on average 50 days post-onset). Alternatively, the difference in prevalence may be due to the use of different measurement instruments. Nevertheless, in our study, depressive symptoms were significantly correlated with HRQoL and participation. The significant role of depressive symptoms may be explained by previous findings reporting that depression can substantially interfere with patients' recovery (Haacke et al., 2006), their efficient use of rehabilitation services (Gillen, Tennen, Eberhardt McKee, Gernert-Dott, & Affleck, 2001), and their life satisfaction (Underhill et al., 2003). Depressive symptoms may also negatively influence patients' responses on health status measures. It has been found that patients' ratings of mood are positively related to quality of life ratings (Atkinson & Caldwell, 1997). Additionally, depression is considered part of HRQoL, which suggests a conceptual overlap between measures (Van Mierlo et al., 2013).

Regarding the role of personality, patients who are inclined towards neuroticism generally tend to over-react to unpleasant events (e.g., frustration) and have difficulty adapting to new situations (Sanderman et al., 2012). Those patients are likely to report more symptoms and consequently may experience lower HRQoL and participation (Larsen, 1992).

Neuropsychological factors unrelated to HRQoL and participation

In the current study, attention, executive functioning, verbal memory, learning potential, active coping, motivation, extraversion and self-awareness were not significantly associated with HRQoL and participation. The previously reported relations between HRQoL or participation and attention, executive functioning and verbal memory (Hochstenbach et al., 2001; Nys et al., 2006; Passier et al., 2012), and learning potential (Boosman, Bovend'Eerdt, Visser-Meily, Nijboer, & van Heugten, 2014) were not replicated in the current study. This may be explained by the use of different cognitive tests, other outcome measures, and different patient populations. In the current study, only one or two tests were used for each cognitive domain. For example, verbal memory was examined with the RAVLT whereas a previous study used verbal and nonverbal tests including the RAVLT and three other memory tests (Passier et al., 2012). In addition, not all cognitive tests were completed by all patients, for instance, due to visual problems. This may have influenced the predictive value of cognitive impairments on patients' HRQoL and participation. Regarding learning potential, this was the first study that examined its role in predicting HRQoL and participation after inpatient ABI rehabilitation. Most previous studies were performed in patients with psychiatric disorders (Boosman et al., 2014) and used specific outcome measures on the level of community, vocational or social functioning. This limits the comparison of results.

Regarding active coping, it was previously reported that problem-focused coping (e.g., active coping) starts to play a significant role in HRQoL five months after discharge (Van Mierlo et al., 2013). Hence, the timing of assessment in the current study (approximately 3 months post-discharge) may explain the lack of an association between active coping and HRQoL and participation. Also, it should be noted that patients obtained relatively high scores on active coping which were comparable to those obtained by healthy individuals (Ramaeker, Ector, Demyttenaere, Rubens, & van de Werf, 2006).

The timing of assessment may also have played a role in the findings on motivation. Patients' motivation for rehabilitation was assessed about four weeks after admission to inpatient rehabilitation. At that time, most patients were relatively highly motivated for a rehabilitation treatment. Unmotivated patients may have been discharged before being approached for the study or they may have declined to participate. Alternatively, the instrument used to assess motivation (i.e., MOT-Q) may also explain the lack of a significant association with HRQoL and participation. Higher scores on the MOT-Q do not per se imply better motivation and may reflect socially desirable responding. For instance, some patients might be reluctant to admit not wanting to follow treatment advice in order to avoid making a negative impression (Boosman, van Heugten, et al., 2015). Different motivation questionnaires measure different aspects of motivation, and may therefore yield other results on predictive validity.

For extraversion, no significant associations were found with HRQoL and participation. This is in agreement with previous findings that extraversion and HRQoL are unrelated in patients with stroke (Van Mierlo et al., 2013). Other studies did however report a positive association between extraversion and life satisfaction in healthy individuals (Gale, Booth, Mõttus, Kuh, & Deary, 2013; Herringer, 1998).

Furthermore, despite the perceived importance of self-awareness for rehabilitation success (Winkens, van Heugten, Visser-Meily, & Boosman, 2014) and the previously reported relations between self-awareness and HRQoL (Goreover & Chiaravalloti, 2013) and participation (Sherer, Bergloff, Levin, et al., 1998; Sherer et al., 2003), the results of this study suggest otherwise. The lack of a significant association in the current study may be explained by differences in measures used to examine self-awareness. Previous studies (Goreover & Chiaravalloti, 2014; Sherer, Bergloff, Levin, et al., 1998; Sherer et al., 2003) used the Awareness Questionnaire (AQ; Sherer, Bergloff, Boake, High, & Levin) whereas the PCRS was used in the current study. A conceptual difference between these measures is that the AQ asks patients to rate their ability to perform certain tasks as compared to before their brain injury (e.g., much worse) whereas the PCRS asks patients about current competencies (Smeets et al., 2012). Also, in the current study, ratings were compared between the patient and the neuropsychologist whereas in previous studies (Sherer, Bergloff, Levin, et al., 1998; Sherer et al., 2003) ratings of the patient and a significant other were compared. In the current study, neuropsychologists were asked to complete the PCRS at the start of inpatient rehabilitation. That may have been too soon for a reliable judgement of a patient's self-awareness. This is illustrated by the fact that one-quarter of neuropsychologists' ratings showed missing values varying from 1 to 8 items with a missing response.

Limitations of this study

This study has several limitations. First, although the studied neuropsychological factors significantly contributed to predicting HRQoL and participation, a considerable part of the variance remains unexplained. Based on previous studies, other demographic, injury-related or neuropsychological factors may have played a significant role in predicting patients' HRQoL and participation. For example, socioeconomic status, stroke severity (Paul et al., 2005), locus of control, self-worth, hope, optimism (Van Mierlo et al., 2013), cognitive complaints (Passier et al., 2012), and visual perception (Nys et al., 2006; Passier et al., 2012; Sturm et al., 2004). Regarding the latter, data on the presence of visuospatial neglect were available but showed unimpaired performance for the vast majority of patients (85.3%). Further, pre-injury factors may also contribute to patients' perceived post-injury functioning. In a previous study, a decrease in the frequency of participation between pre- and post-stroke was associated with more participation restrictions and lower satisfaction with participation (Blömer, van Mierlo, Visser-Meily, van Heugten, & Post, 2014). Another study reported that pre-injury factors, such as employment and learning problems, accounted for 6.7% of the variance in life satisfaction 1 year after TBI (Davis et al., 2012).

A second limitation is the timing of the follow-up assessment. Patients' HRQoL and participation was assessed at one point in time, approximately three months after discharge from inpatient rehabilitation. Immediately after discharge from inpatient rehabilitation, 56 patients were referred to outpatient clinics for further treatment. We do not know exactly how many of these patients were still receiving outpatient treatment at follow-up assessment. However, it is likely that some patients were still receiving outpatient treatment at follow-up, which may have influenced their perceived HRQoL and participation.

Third, inherent to a longitudinal design is the risk of losing patients at follow-up. In total, 20% of patients were lost to follow-up for varying reasons. This may have biased the results.

Fourth, disparities in reported predictors of HRQoL and participation may be attributed to the use of different neuropsychological and outcome measures as compared to previous studies. Other measures of, for instance, motivation and self-awareness may have yielded different results. Also, relatively narrow measures were used to predict broad, subjective rehabilitation outcomes. That is, HRQoL and participation are container concepts that cover a wide variety of life domains (e.g., work, leisure, physical functioning). Narrow measures may be better at predicting narrow outcomes.

A final limitation is the total number of predictors that were examined in this study. Although the sample size was acceptable for the commonly used ratio of 10 patients per predictor, a 15:1 ratio is generally preferred. This implies that the sample size may be underpowered. Therefore, the results should be viewed with some caution and require replication in larger samples.

Conclusion

Neuropsychological functioning at the start of inpatient ABI rehabilitation plays a role in predicting rehabilitation outcome three months later. In particular, a tendency towards passive coping was a strong predictor of poor HRQoL and participation after inpatient rehabilitation. These results emphasise the importance of assessing patients' coping styles in ABI rehabilitation. Further research is needed to evaluate the role of other neuropsychological factors in predicting rehabilitation outcomes and to examine methods of teaching effective coping strategies in an early phase post-ABI.

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