Brain Injury, November 2006; 20(12): 1295–1306

informa
healthcare

The influence of neuropsychological rehabilitation on symptomatology and quality of life following brain injury: A controlled long-term follow-up

HENRIETTE AABY SVENDSEN[1] & THOMAS WILLIAM TEASDALE[2]

[1]*Centre for Rehabilitation of Brain Injury, Department of Psychology and* [2]*Department of Psychology, University of Copenhagen, Denmark*

(Received 11 May 2006; accepted 20 October 2006)

Abstract

Primary objective: To establish whether, following acquired brain injury, intensive post-acute neuropsychological rehabilitation could have long-term beneficial effects.

Methods and procedures: A group of 37 adults who had suffered cerebrovascular accidents or traumatic brain injuries and who had undergone a rehabilitation programme were followed up 12–22 years post-injury, together with a non-rehabilitated control group of 13 adults, matched for brain-injury and demographics characteristics. Both groups completed a set of questionnaires concerning broad aspects of psychological well-being. Significant others completed similar questionnaires.

Main outcomes and results: The rehabilitation group showed significantly lower levels of brain injury symptoms and higher levels of competency at follow-up. They also rated internal locus of control and general self-efficacy as significantly higher than the control group. Anxiety and depression levels were significantly lower and quality of life significantly higher in the rehabilitation group for both the subjects themselves and for their significant others.

Conclusions: Within methodological limitations this study suggests that post-acute neuropsychological rehabilitation can have long-term beneficial effects.

Keywords: *Brain-injury, rehabilitation, follow-up*

Introduction

Several studies of sequelae after brain injury indicate that improvement can continue well beyond the acute phase [1–4]. However, most long-term follow-up studies have shown that acquired brain injury in many cases is followed by persisting effects [1, 5–9] as well as by a burden on the significant others [10, 11]. These effects can be seen in the areas of brain injury symptoms [12, 13], lowered competency in activities [14], changes in beliefs about own capabilities [15], emotional symptoms [16] and lowered quality of life [6, 17, 18]. Significant others may also experience a variety of difficulties in their role as carers [19].

Common to the many different models and theories about rehabilitation is the basic aim of ameliorating, reducing or alleviating the patient's complex symptoms [20] and today the importance of reducing the burden on the significant others is also a prominent feature in many rehabilitation settings. During the last 30 years or so numerous neuro-psychologically based intensive post-acute rehabilitation centres have emerged worldwide and especially in the US and Europe [10, 21–23]. These programmes aim to consider the combined cognitive, social and emotional effects of brain injury, as opposed to purely cognitive retraining. Generally, studies of these programmes have reported positive results [21, 24–32] suggesting that rehabilitation can

Correspondence: Henriette Aa. Svendsen, Centre for Rehabilitation of Brain Injury and Department of Psychology, University of Copenhagen, Njalsgade 88, DK-2300 Copenhagen S, Denmark. Tel: +45 35 32 49 34. Fax: +45 35 32 48 02. E-mail: henriette.svendsen@psy.ku.dk

ISSN 0269–9052 print/ISSN 1362–301X online
DOI: 10.1080/02699050601082123

markedly improve level of functioning and well-being after brain injury.

Methodologically, when addressing evidence for the positive effect of these rehabilitation programmes, most of these studies have been observational without control groups, usually involving the patients being used as their own controls by comparing performance prior to and subsequent to rehabilitation [27, 29, 32–35]. Two studies have used historic controls [30, 31] and one study has implemented a non-randomized control group [22] comparing outcome from a consecutive group of subjects with a group who received conventional clinical care and rehabilitation. A further, prospective, non-randomized study compared intensive, milieu-based neuropsychological rehabilitation with 'standard' post-acute rehabilitation [21]. A recent review of the 'state of the science' of traumatic brain injury (TBI) rehabilitation [36] stated that, with regard to the evidence for rehabilitation, several factors are critical such as adequate sample size, the representativenes of the sample, appropriate comparison groups, random assignment to treatment and control conditions and outcome measures congruent with the expected effect. It would be difficult and time-consuming to engage in optimally large, prospective, randomized controlled trials with low attrition and no measurement biases which would be needed to provide conclusive evidence that these programmes are effective, but a NIH consensus conference concluded this is needed [37]. The present study performed a retrospective, non-randomized follow-up using a non-rehabilitated control group derived from an epidemiological study undertaken by Teasdale and Engberg [38, 39].

In terms of what outcomes to measure, the traditional neuropsychological test does not seem to be optimal when evaluating rehabilitation; for example, Carney et al. [40], in a comprehensive review of cognitive rehabilitation, did not find a strong association between test scores and real life outcome such as employment. Teasdale et al. [41] found that test-scores improved from pre- to post-rehabilitation but, at 1 year after rehabilitation, the scores were back to pre-rehabilitation levels. In a case study of a densely amnestic patient there was no improvement on standardized tests over a 10 year period, however the individual showed immense improvements in independent living and employability largely due to good use of compensation strategies [42]. Wilson and Evans [42] and Diller and Ben-Yishay [43] thus recommend reduction in dependency, the return to pre-morbid social and work related roles and relief in personal burden by reduced disability as well as the burden on the family, as some of the meaningful outcomes to consider.

This study chose to look at perceived symptoms of brain injury and impact on significant others, experienced competency, awareness of these above-mentioned components as well as perceived self-efficacy and locus of control, anxiety, depression as well as quality of life in both the subjects and their significant other. The study has thus investigated a number of hypotheses.

First, it was expected that those who received rehabilitation and their significant others would experience the symptoms of brain injury and impact of the brain injury on the significant others less than the control group. Secondly, it was expected that persons who received rehabilitation would have a higher degree of competence within activities of daily living (ADL), cognitive, inter-personal and emotional skills, as reported by themselves and their significant others. Thirdly, in terms of awareness, a greater level of agreement was expected between the persons with brain injury and their significant others as regards symptoms and competency, among the rehabilitation group than among the control group. Fourthly, the rehabilitation group was expected to have a higher degree of self-efficacy and internal locus of control as compared to the control group, according to their own self-ratings. Fifthly, lower levels of anxiety and depression were expected in the rehabilitation group compared to the control group and, finally, higher levels of self-reported quality of life were expected in the rehabilitation group compared to the control group.

Method

Subjects

The data stem partly from persons with acquired brain injury who had completed the post-acute, intensive, neuropsychological rehabilitation at the Centre for Rehabilitation of Brain Injury (CRBI) in Copenhagen and partly from persons with a moderate-to-severe acquired brain injury who had not received any such post-acute rehabilitation.

The CRBI programme adopts an inter-disciplinary, holistic approach, which is tailored to the individual in the light of neuropsychological assessments. Patients are admitted to the programme in groups of 12–16 and the programme runs for ~3–4 months with day attendance. This is followed by close contact and monitoring of progress in the community for at least a further 8 months. Exclusion criteria include alcohol and drug abuse, together with psychiatric or progressive neuro-degenerative illness. A degree of motivation and independence (ability to travel, feed, groom, etc.) is also required in order to

participate. Details of the Copenhagen programme are presented elsewhere [44]. Persons entering the programme had been unable to return to employment following their injury.

Rehabilitation group. For the purposes of the present study, all 85 non-aphasic subjects with either TBI or cerebro-vascular accident who underwent the CRBI programme between January 1987 and December 1992 were selected. It had been necessary to exclude 12 persons with aphasia since it proved difficult to find matching controls for them—see below. Not all 85 subjects were available for the study; 14 were deceased by the time of follow-up in 2004 and addresses could not be obtained for 11. Thus, 60 subjects were invited to participate in the study; 37 (62%) did so.

Control group. A non-rehabilitated brain injury group was recruited from earlier extensive randomized epidemiological studies by Engberg and Teasdale involving a randomized and nationally representative selection of subjects with either TBI [38] or stroke [39], as recorded in a Danish central register of hospitalizations. These parallel studies involved a postal questionnaire including an item indicating whether the subjects had been able to return to employment after their injury. From the available pool, 24 subjects were selected who had indicated that they had been unable to return to employment following their injury and who matched the rehabilitation group for sex, age at injury, injury type, Injury Severity Scale [45], duration of coma and post-traumatic amnesia (in the case of TBI), duration of hospitalization and Glasgow Outcome Scale [46] at discharge. A single potential subject proved to have clinically significant aphasia. Since this made it impossible to match for aphasia the subject was excluded along with the 12 mentioned above from the rehabilitation programme. Of the 24 control subjects, 13 (54%) took part in the study.

Table I shows a comparison of the participating rehabilitation and control subjects on the matching variables. The two groups are comparable in terms of age at injury, chronicity of injury at follow-up, gender, injury type, year of injury, hospitalization, duration of coma and post-traumatic amnesia. The majority of subjects were males with TBI, on average they had spent 6 days on life support and ~5 months in hospital after their brain injury. The subjects with TBI were on average in coma 10 days and more than half had post-traumatic amnesia for more than 2 weeks. Half of the subjects with stroke were at full consciousness 7 days after their stroke or latest operation. At discharge the majority in both rehabilitation and control group were rated moderately or moderately-to-severely disabled on the Glasgow Outcome Scale. At time of injury, the average age in the rehabilitation group was 26 years and in the control group the average age was 31 years. At follow-up, the average age was in the mid-forties and subjects were on average 15–17 years post-injury.

The catchment area for the CRBI programme was largely confined to the eastern island of Sjaelland, whereas the control group were drawn from epidemiological studies which covered all of Denmark. In consequence, as shown in Table I, there is a significant difference between the two groups with regard to geographical distribution.

It can be seen that the only other significant difference ($t = -3.498$, $\mathrm{df} = 33$, $p = 0.001$) between the two groups is the injury severity score where the control group has a higher score ($M = 29$, $\mathrm{SD} = 11$) compared to the rehabilitation group ($M = 18$, $\mathrm{SD} = 7$). The injury severity score summarizes all injuries to the head as well as the body, including loss of consciousness, broken bones, loss of limbs, etc.

This study looked at the correlations between the questionnaire results and either injury severity score or age at injury and they are all very small and on no scales do these two variables explain more than 10% of the variance. They are therefore not thought to constitute a major bias.

Instruments

At the time of follow-up in 2004, participating subjects were sent a package of questionnaires to be completed prior to an in-person interview typically conducted in the subject's home (findings from the interview will be reported elsewhere).

European Brain Injury Questionnaire (EBIQ). The EBIQ has been specifically designed in two parallel versions: a 'self' version for use on individuals with brain injury and a 'significant other' version to be completed by their close significant others [47]. It contains 62 questions relating to 'problems or difficulties that people sometimes experience in their lives', as well as three questions regarding what impact the injury has had on the significant other. Subjects with brain injury complete the 'self' version in which they are asked to indicate 'how much (they) have experienced any of these within the last month'. Their responses were coded on a three-point scale: 'not at all' (1), 'a little' (2) or 'a lot' (3). Correspondingly, significant others completed the 'significant other' version in which they give their perceptions of the person with brain injury. From both the subjects' and the significant others' questionnaires, eight scales were calculated corresponding to complaints categorized as: somatization,

Table I. Demographic and injury-related characteristics of rehabilitation and control group.

	Rehab group ($n=37$)		Control group ($n=13$)		
Variable	*n*	%	*n*	%	Probability
Sex					
Male (%)	26	70	7	54	ns†
Female (%)	11	30	6	46	
Injury type					
TBI	26	70	9	69	ns†
CVA	11	30	4	31	
PTA (TBI subjects)	25		8		ns+
<1 day	0	0	0	0	
<1 week	0	0	2	25	
<2 weeks	4	16	0	0	
<1 month	10	40	2	25	
≥1 month	11	44	4	50	
Level of wakefulness 7 days after trauma (CVA only)					
Clear and awake	6	55	2	50	ns+
Somnolent, confused	3	27	2	50	
Not contactable	2	18	0	0	
Glasgow outcome scale at discharge	36		13		
Severe disability	1	3	1	8	ns+
Moderate-to-severe disability	10	28	4	30	
Moderate disability	19	53	7	54	
Moderate disability to good recovery	6	16	0	0	
Good recovery	0	0	1	8	
Geographic residence at time of injury					$p=0.001$†
Island of Sjaelland	33	89	6	46	($\chi^2=10.4$)
Elsewhere in Denmark	4	11	7	54	
	M	SD	*M*	SD	
Accident occurred (year)	1987	3	1989	4	ns*
Hospitalization (days)	167	153	144	151	ns*
Days on life support (respirator)	6	8	6	6	ns*
Coma (days until GCS became 9, TBI)	13	10	14	13	ns*
Injury severity score (TBI only)	18	7	29	11	0.001 ($t=-3.498$, df=33)
Mean age at time of injury (years)	26	9	31	8	ns*
Mean age in 2004 (years)	44	9	46	9	ns*
Chronicity of injury in 2004 (years)	17	2	15	4	ns*

**T*-test; †Chi-squared test; + Mann Whitney.

cognition, motivation, impulsivity, depression, social isolation, physical symptoms and communication. An additional 'core' scale summarized complaints globally.

The scores on these scales were computed as the simple average of the scores (1, 2 or 3) for the questionnaire items pertaining to each scale. The scale scores can thus also range from 1.0–3.0. Further psychometric details are presented elsewhere [47].

Additionally, the EBIQ included three questions concerning the impact of the brain injury on the significant other, as judged by the persons with brain injury and the significant others themselves.

Patient Competency Rating Scale (PCRS). The PCRS comprises 26 items measuring competency on a 5-point Likert scale. The questionnaire is typically used for a comparison of ratings made by patient and a close significant other or clinician. Results can be presented as average score, total score on a scale from 26–130 and sub-scales related to ADL (eight items), cognition (eight items), inter-personal (seven items) and emotion (seven items), these scales can be converted into a 1–100 scale. Prigatano et al. [48] found good overall test and re-test reliability for patients ($r=0.97$) and their significant others ($r=0.92$).

Generalized Self-Efficacy Scale (GSEC). The GSEC is a 10-item psychometric scale that is designed to assess optimistic self-beliefs to cope with a variety of difficult demands in life [49]. In contrast to other scales that were designed to assess optimism, this one explicitly refers to personal agency, i.e. the belief that one's

actions are responsible for successful outcomes. The items are rated on a four-point Likert scale with a total score ranging from 10–40.

Locus of Control (LoC). The LoC scale was constructed for the purposes of the present study. It consists of six questions pertaining to how great a sense of control a subject feels towards life. The items are rated on a 4-point Likert scale similar to the above-mentioned self-efficacy scale and items were added to yield a total score ranging from 6–24, the higher the score the higher degree of internal locus of control. The LoC score proved to have a satisfactory reliability (Cronbach's alpha = 0.81).

Hospital Anxiety and Depression Scale (HADS). The HADS was designed to provide a simple yet reliable general instrument to measure emotional distress on two scales, namely anxiety and depression [50]. It consists of 14 items, seven items that reflect depression and seven that reflect anxiety. The scales have been created on the basis of factor analysis. The items are rated by the patient on a 4-point (0–3) ordinal scale, so possible depression as well as anxiety scale scores ranged from 0–21. A score of 0–7 for either sub-scale could be regarded as being in the normal range, a score of 11 or higher indicating probable presence ('caseness') of the mood disorder and a score of 8–10 being just suggestive of the presence of borderline symptomatology.

World Health Organization Quality of Life questionnaire (WHO-QoL). The WHO-QoL (BREF = brief version) is a widely used general questionnaire that measures quality of life. This study used the Danish translation [51]. It is a 26-item version of the original 100-item version, WHO-QoL-100. It covers four domains related to physical and psychological health (seven and six items, respectively), social relations (three items) and environmental safety (eight items) as well as two items concerning quality of life and health in general. Each item is rated on a 5-point Likert scale. Domain scores are scaled to range from 0–100 (this is in order to make it comparable to the 100-item version). The higher domain score, the higher the quality of life and health within the domain.

Scale scores for all six questionnaires proved to be approximately normally distributed. Therefore, repeated-measure analyses of variance were employed as well as independent samples *t*-tests to test the hypotheses. However, in some of the repeated measure analyses, the assumption of sphericity was not met. In such cases the Greenhouse-Geisser epsilon correction was applied to the appropriate degrees of freedom. Effect sizes are provided, where possible, as estimates of the magnitude of the significant results, this includes the *F*-statistics with one degree of freedom ([52], p. 453). All analyses were performed using SPSS 13.0.

When testing directional hypotheses, one-tailed significance levels are used. This is also the case with the *F*-test with one degree of freedom for the numerator. Because it derives from a null hypothesis with only one restriction, i.e. the difference between two coefficients, the *F*-statistic in this case has one degree of freedom for numerator and corresponds to a squared *t*-statistic. Thus, the *p*-value can be obtained for a one-tailed test using this relationship and the symmetry of the *t*-distribution (http://www.stata.com/statalist/archive/2004-08/msg00898.html).

Results

EBIQ

Table II shows the mean scores for the rehabilitation group and the control group on each of the nine scales, for subjects and their significant others (SO). As can be seen, self-rated means are higher in the control group compared to the rehabilitation group on all but one scale, namely the subjects' isolation scale. On all scales the mean score as rated by the significant others from the control group is higher than those rated by the significant others from the rehabilitation group. On all scales the mean score as rated by significant others is higher than means as rated by the subjects in both the rehabilitation and control group.

An overall repeated-measure analysis of variance revealed a significant main effect of scale ($F(5.7, 233.5) = 2.9$, $p = 0.012$), indicating that some scales are rated higher than others. There was a small-to-medium sized main effect of rater (own vs. SO) ($F(1, 41) = 2.9$, $p = 0.047$, $r = 0.26$ (one-tailed according to hypothesis)). The significant others rated the symptoms higher in general than the subjects themselves. There was a significant and medium-sized between-subject effect of rehabilitation ($F(1, 41) = 3.8$, $p = 0.03$ (one-tailed according to hypothesis), $r = 0.29$). The subjects and their significant others from the rehabilitation group reported lower levels of symptoms compared to the control group.

EBIQ: Impact of brain injury on the significant other. Table III lists the means of the three questions in the EBIQ that address the impact of

Table II. EBIQ scales: Rehabilitation *vs.* control group.

	Rehab group ($n=37$)				Control group ($n=13$)			
	Self		SO		Self		SO	
EBIQ scales	*M*	SD	*M*	SD	*M*	SD	*M*	SD
Somatic	1.52	0.40	1.66	0.52	1.75	0.41	1.80	0.61
Cognitive	1.60	0.36	1.73	0.51	1.86	0.40	2.03	0.56
Motivation	1.37	0.34	1.61	0.49	1.6	0.50	1.82	0.53
Impulsivity	1.62	0.42	1.73	0.53	1.74	0.38	1.90	0.56
Depression	1.48	0.43	1.59	0.51	1.84	0.52	1.88	0.68
Isolation	1.66	0.43	1.69	0.43	1.65	0.41	1.88	0.61
Physical	1.44	0.31	1.62	0.47	1.66	0.54	1.88	0.61
Communication	1.52	0.39	1.59	0.48	1.65	0.52	1.67	0.51
Core	1.50	0.34	1.66	0.45	1.75	0.39	1.90	0.54

SO = Significant other.

Table III. EBIQ impact on significant others: Rehabilitation *vs.* control group.

	Rehab group ($n=37$)				Control group ($n=13$)			
	Self		SO		Self		SO	
EBIQ—questions regarding impact on significant others	*M*	SD	*M*	SD	*M*	SD	*M*	SD
Did life change for the significant other as a result of the brain injury?	1.96	0.79	2.18	0.72	2.17	0.84	2.25	0.75
Does the significant other currently have problems as a result of the brain injury?	1.43	0.63	1.64	0.62	2.00	0.85	2.00	0.86
Is the significant other's mood currently affected?	1.29	0.54	1.61	0.69	1.92	0.67	2.00	0.74

SO = Significant other.

the injury on the significant other. The first question concerns the impact of the injury at the time of the injury. The last two questions concern to what extent the significant other is affected today in terms of practical problems and/or whether their mood is affected.

An overall repeated-measure analysis of variance revealed a significant main within-subject effect of question ($F(1.7, 63.6) = 21.3$, $p < 0.001$); one question regarding whether life changed because of the brain injury has a higher mean than the two other questions regarding current impact of brain injury. There was no effect of rater (own vs. SO); the SO does not endorse higher levels of impact compared to the subject. There was a medium-sized and significant between-subject effect of rehabilitation ($F(1, 38) = 4.4$, $p = 0.022$ (one-tailed according to hypothesis), $r = 0.32$). In the rehabilitation group, both subjects and their significant others rated levels of impact lower than the control group. There was a small-to-medium sized, significant two-way interaction between question and group ($F(1.7, 63.6) = 4.0$, $p = 0.030$, $r = 0.24$); the control and rehabilitation groups have similar ratings on the question of whether life changed as a result of the brain injury, whereas the rehabilitation group rated comparably lower on the questions addressing impact today. The significant others in the control group continue to have more current problems compared to the significant others in the rehabilitation group.

PCRS

Table IV shows the scale scores on the PCRS (ADL, Cognition, Inter-personal, Emotional and Total) converted into a 0–100 scale, as well as the conventional total score ranging from 30–150 and the average item score ranging from 1–5.

The overall repeated-measure analysis of variance finds a significant main effect of scale ($F(2.1, 87.7) = 4.0$, $p = 0.020$); some scales are rated a little higher than others. There is a significant and medium-sized within-subject effect of rater (own vs. SO) ($F(1, 41) = 4.4$, $p = 0.022$ (one-tailed according to hypothesis), $r = 0.31$). The significant others in general rated the subjects' competency lower than the subjects themselves did. There was a medium-size and significant between-subject effect of rehabilitation ($F(1, 41) = 6.6$, $p = 0.007$ (one-tailed

Table IV. PCRS scales: Rehabilitation *vs.* control group.

	Rehab group ($n=37$)				Control group ($n=13$)			
	Self		SO		Self		SO	
PCRS—scales	*M*	SD	*M*	SD	*M*	SD	*M*	SD
ADL (0–100 scale)	80	12	72	22	71	25	55	28
Cognition (0–100 scale)	72	17	69	20	64	23	59	16
Inter-personal (0–100)	74	19	67	20	65	16	61	19
Emotion (0–100)	69	17	63	21	59	16	51	22
Total (0–100)	74	13	68	18	65	15	57	17
Total score (30–150 scale)	119	15	111	22	108	19	98	20
Average item score	3.96	0.50	3.71	0.72	3.59	0.62	3.27	0.67

SO = Significant other.

Table V. HADS scales: Rehabilitation *vs.* control group.

	Rehab group ($n=28$)				Control group ($n=12$)			
	Self		SO		Self		SO	
HADS scales	*M*	SD	*M*	SD	*M*	SD	*M*	SD
Anxiety	6.0	4.2	3.5	3.9	7.7	2.8	7.7	5.7
Depression	4.6	4.1	2.9	2.8	7.8	2.8	5.8	5.3

SO = Significant other.

according to hypothesis), $r=0.37$); the subjects and their significant others from the rehabilitation group reported higher levels of competency than did the control group.

Awareness

The above-mentioned significant differences between subjects and significant others indicate a tendency for the former to under-estimate brain injury symptoms and to over-estimate their own competency. However, looking at typical answer style and mean differences between subjects and significant others, there were no results to indicate that the subjects in the rehabilitation group correlated more with their significant others on the rated items or that there were smaller mean differences between subjects and significant others in the rehabilitation group.

LoC and GSES

On average, the rehabilitation group experienced higher degrees of internal locus of control ($M=19.1$, $SD=3.9$) compared to the control group ($M=15.5$, $SD=2.9$). The difference was significant ($t(45)=3.0$, $p=0.003$ (one-tailed according to hypothesis)) and represented a medium sized effect ($r=0.41$).

Subjects from the rehabilitation group also rated themselves as having a higher sense of self-efficacy ($M=30.1$, $SD=7.0$) compared to the control group ($M=26.4$, $SD=5.4$). This difference was significant when using a one-tailed *t*-test according to hypothesis, ($t(46)=1.75$, $p=0.044$), representing a small-to-medium sized effect ($r=0.25$).

HADS

From Table V it can be seen that both the rehabilitation and control group have mean scores around 7 or below, which is used as a cut-of score on both scales discriminating between normal scores and borderline scores.

An overall repeated-measure analysis of variance revealed a medium-sized significant main effect of scale ($F(1, 38)=5.4$, $p=0.026$, $r=0.35$), indicating that anxiety levels are higher than levels of depression for the subjects and their significant others. There was a small-to-medium sized significant effect of rater (own vs SO) ($F(1, 38)=3.3$, $p=0.04$ (one-tailed according to hypothesis), $r=0.28$); the significant others rated their own levels of anxiety and depression as lower than the subjects. There was a medium-to-large sized, significant between-subject effect of rehabilitation ($F(1, 38)=11.5$, $p=0.001$ (one-tailed according to hypothesis), $r=0.48$). In the rehabilitation group both subjects and their

signficant others rated levels of anxiety and depression lower than the control group.

When comparing the subjects against a norm sample taken from a non-brain injured healthy Icelandic population [53], the subjects from both groups have more 'borderline' and 'disorder indicated' cases (scores above 7) than in the norms; however, the number of cases in the rehabilitation group is lower than in the control group. In the rehabilitation group, a total of 27% experienced anxiety problems at least at the borderline level (a score of 8 or above) and, among these, 13% could be considered to have an indication of clinical anxiety disorder (scores above 10). Among the control group, the corresponding percentages were 54% and 23%. In the Icelandic sample, 15% had at least borderline anxiety problems and only 6% were considered clinical cases. Twenty-three per cent of the rehabilitation group reported experiencing depression at least at borderline levels and 7% could be considered to have a clinical disorder. Among the control group, the corresponding percentages were 54% and 15%. In the Icelandic sample, 10% had symptoms of depression at least at the borderline level and only 4% were considered clinical cases.

QoL

As can be seen from Table VI, the rehabilitation group had higher mean scores on all scales of quality of life than the control group.

In a repeated-measure analysis of variance there is a significant main effect of scale ($F(2.1, 87.7) = 11.6$, $p < 0.001$); in particular, the environmental scale was rated higher than the other three. There is a medium-size within-subject effect of rater (own vs SO) ($F(1, 40) = 8.1$, $p = 0.004$ (one-tailed according to hypothesis), $r = 0.41$); the significant others have rated their own quality of life higher than have the subjects themselves. There is a significant two-way interaction between scales and rater ($F(4,160) = 4.2$, $p = 0.003$) reflecting the relatively larger differences between the subjects and their significant others on especially the psychological scale but also the physical scale compared to the other two scales. There is a medium-size between-subject effect of rehabilitation ($F(1, 40) = 9.2$, $p = 0.002$ (one-tailed according to hypothesis), $r = 0.43$); the subjects and their significant others in the rehabilitation group reported higher levels of quality of life than the control group.

Discussion

In considering the findings from this study, a number of limitations must be kept in mind. First, the matching of the control group could only be done on a limited number of variables. This, in combination with the relatively limited number of subjects, means that the two groups may differ on non-controlled injury-related characteristics. However, those subjects in both groups who have suffered a TBI have typically sustained rather diffuse injuries, thus diminishing the potential factor of localization. Similarly, those who had cerebrovascular accidents—having excluded persons with aphasia—will have made the two groups more comparable in terms of which problems they are facing. Given the relatively small sample sizes it was unfortunately not feasible to conduct separate analyses for patients with TBI and stroke, but it is worth noting that the two groups were not separated in the rehabilitation programme and the proportions did not differ between the rehabilitation and control groups.

Secondly, injury severity score is significantly higher and age at injury is non-significantly higher in the control group, albeit that the average age in the two groups only differs by 5 years at the time of injury. Potentially this could bias reports of brain injury symptoms, competency and locus of control, self-efficacy, anxiety and depression and quality of life results, disfavouring the control group. Extracranial injuries can contribute to a prolonged

Table VI. WHO-QoL BREF: Rehabilitation *vs.* control group.

	Rehab group ($n = 30$)				Control group ($n = 12$)			
	Self		SO		Self		SO	
WHO-QoL-BREF scales	*M*	SD	*M*	SD	*M*	SD	*M*	SD
General quality of life (1–100)	66	22	77	14	59	21	63	26
Physical quality of life (1–100)	74	17	83	12	60	20	71	22
Psychological quality of life (1–100)	66	18	79	10	50	20	71	19
Social quality of life (1–100)	71	18	79	14	66	20	66	17
Environmental quality of life (1–100)	80	13	85	12	70	10	75	16

SO = Significant other.

hospitalization and in-patient rehabilitation period. Sequelae in the form of chronic pain and reduced mobility could potentially affect experienced somatic symptoms, quality of life as well as depression and anxiety. Thus, this difference between the two groups could have contributed to the differences seen in the outcome measures. As mentioned earlier the correlation between the questionnaire results and either injury severity score or age at injury are all very small and on no scales do these two variables explain more than 10% of the variance and the correlation is therefore not thought to be a major bias.

Thirdly, the study is limited by its retrospective, non-randomized design, which potentially overlooks differences between the two groups that could have caused the different allocation to treatment and which could explain the present outcome differences. One such potential issue is geographical location. Relatively more people from the rehabilitation group came from the eastern island of Sjaelland, on which Copenhagen is situated, whereas the control group subjects had been proportionately distributed over other regions also, e.g. the islands of Bornholm and Fyn and the Jutland peninsula. This does not, however, correspond to a simple urban/rural environmental difference, and in general social and economic conditions are relatively homogeneous across the country. Furthermore, in the late 1980s and early 1990s there would also have been a serendipitous element in whether or not persons with brain injury came to be referred to the Centre since neuropsychological rehabilitation, still in its infancy, was not universally known among Danish medical and social-services circles. It is, however, also recognized that some of the difference could have arisen through a greater determination, for the rehabilitation group, on the part of the patients themselves or their relatives, to investigate and pursue treatment options. Such resourceful cases could be expected to have a better prognosis, irrespective of whether or not rehabilitation was actually obtained.

The first hypothesis was that the levels of symptoms of brain injury and brain injury impact on significant others were expected to be lower in the rehabilitation group. The rehabilitation group reported lower levels of brain injury symptoms compared to the control group irrespective of the rater being either the person with acquired brain injury or the significant other. This finding is consistent with a direct beneficial effect of the rehabilitation programme on experienced symptoms of brain injury. The two groups were close in reporting how much life had changed for the significant other after the brain injury. However, the rehabilitation group reported comparably lower levels of current impact on the significant other compared to the control group. The significant other in both groups endorsed higher levels of symptoms as well as impact on the significant other. This is consistent with earlier findings where this difference has been taken as indicating reduced awareness on the part of the persons with brain injury [47].

The second hypothesis predicted that subjects who had received rehabilitation achieved a higher degree of personal competency as experienced by themselves and their significant others. This was supported; both subjects and significant others in the control group rated the level of competency significantly lower compared to the rehabilitation group. As with the results on reporting symptoms this finding is also consistent with a beneficial effect of the rehabilitation programme. The rehabilitation group and control group subjects had similar profiles of personal competences but with the former having systematically better levels. The significant others seemed to differ especially concerning activities of daily living (ADL) and the significant others in the control group were furthest apart from their corresponding subjects on this scale. According to Sherer et al. [54], specific questions yields better agreement and it is assumed that the ADL-questions would have been easier to agree on in this context. Surprisingly, subjects from both groups rated themselves lowest on the emotional sub-scale, which in the literature has been reported as an area where subjects tend to under-estimate their problems compared to their significant others [4, 48, 55]. It is clear that persons with brain injury experience reduced competency by comparison with a Danish norm population collected in connection with a follow-up of a group of 150 persons with brain injury elsewhere in Denmark [14]. This latter group was also found to have reduced competency. Like both groups with brain injury, the norm population also tended to rate themselves relatively lowest on the emotional scale.

It was thirdly hypothesized that the subjects in the rehabilitation group would show more awareness as assessed by agreement/disagreement between the subjects and their significant others. Using three indices for this assessment [56], this study found, however, no evidence to support the expectation. The main conclusion here is that there is a tendency for significant others to report more symptoms of brain injury and lower competency as compared to subjects, which possibly might indicate a lack of awareness in both the rehabilitation and control group.

The fourth hypothesis was that subjects in the rehabilitation group would show a higher degree of internal locus of control and a higher degree of self-efficacy or personal agency. The results confirmed this. There was a medium sized effect of internal

locus of control and a small sized effect of the self-efficacy measure, both of these being consistent with a beneficial effect of rehabilitation. Taken together, higher degrees of internal locus of control and of self-efficacy mean that the subjects in the rehabilitation group may not only feel that if they act, they can change their life for the better (internal locus of control) but they also feel that they are capable of this action (self-efficacy). Moore and Stambrook [57] have reported, from a study of 53 men with TBI, that higher use of positive coping strategies (self-control and positive reappraisal) and higher degree of internal locus of control were associated with significantly lower mood disturbances, physical difficulties and a trend to be less depressed. The present study supports these findings; the rehabilitated group complained of less physical problems and reported higher competency and lower degrees of anxiety and depression.

Thus, the results also supported the fifth hypothesis, namely that the rehabilitation group would show lower levels of anxiety and depression compared to the control group. Rehabilitation proved to have a medium-to-large effect. There was a small-to-medium sized effect of rater, thus the levels of anxiety and depression are higher in persons with brain injury compared to their significant others. So, even though scores on the scale were mostly within normal levels, brain injury still showed an effect despite rehabilitation and time. In the above-mentioned follow-up study of 150 persons with brain injury, who had gone through a similar programme in Aarhus [14], it was found that rehabilitation alleviated anxiety and depression, although rates of anxiety and depression remained elevated relative to probably applicable Icelandic norms [53]. There seems to be an elevated occurrence of anxiety and depression even 12–22 years post-injury, even though rehabilitation could be acting as a buffer against this.

The sixth hypothesis predicted that members of the rehabilitation group would have a better quality of life than the control group and there was a medium sized effect of rehabilitation confirming the hypothesis. This is again consistent with a beneficial effect of rehabilitation. However, as with anxiety and depression, the subjects are not reporting as high levels of quality of life as their significant others. It was shown that the biggest differences between significant others and subjects themselves were on the psychological and physical quality of life scales and the smallest difference was on the environmental scale. This latter was perhaps to be expected given that Denmark is a fairly safe country with good options for handicap transport and the significant others and subjects otherwise share the same environmental conditions. The experience of quality of life that the subjects in the rehabilitation group is having is comparable to a Danish non-brain injured diabetic group and their significant others experience quality of life at the mean level of a healthy Danish norm sample [58]. This again is similar to what the Aarhus study found [14].

The subjects in the control group experienced their quality of life as lower than a chronically ill Danish sample did [58] and their significant others were more comparable to the diabetic sample than the normal sample. This would appear to indicate that brain injury continues to have an impact on the quality of life of the person with brain injury and to a lesser degree of his or her significant other, many years after the injury, notwithstanding that rehabilitation seems again to have a beneficial effect.

It needs to be recognized that rehabilitation has not eradicated all symptoms after brain injury (e.g. unawareness or depression) and these can remain present among patients with brain injury, even following intensive rehabilitation, albeit to a lesser degree than among patients not receiving rehabilitation. The conclusion must be that it is necessary to recognize the potential need for further rehabilitative interventions.

Overall, the results are consistent with a better outcome following post-acute intensive neuropsychological rehabilitation across broad domains of psychological well-being for persons with brain injury and their significant others. In this study these domains have covered brain injury symptoms, impact of injury on significant others, competencies, degree of internal locus of control and self-efficacy, anxiety and depression and quality of life. Within the domains, differences between persons who had experienced such rehabilitation and otherwise comparable persons who had not were persistently significant, and the effect sizes were most typically what would be regarded as medium sized [52]. Therefore, the recognized limitations of this study notwithstanding, it is believed that the present evidence suggests a definite efficacy of post-acute intensive neuropsychological rehabilitation.

Acknowledgements

We thank Mugge Pinner, MA, and Dr Aase Engberg for their collaboration in initially planning the project, we also thank Dr Engberg for permission to include some of her data, and Michael Schönberger, PhD, psychology student Ida Hamburger as well as secretaries Dorthe Thrane and Mona Olsen for technical assistance. This study was partially supported by a grant from the Danish Ministry of Social Affairs (Grant number: 871461-0051).

References

1. Wood RL, Rutterford NA. Psychosocial adjustment 17 years after severe brain injury. Journal of Neurology, Neurosurgery and Psychiatry 2006;77:71–73.
2. Ragnarsson KT. Results of the NIH consensus conference on 'Rehabilitation of persons with traumatic brain injury'. Restorative Neurology and Neuroscience 2002; 20:103–108.
3. Sbordone RJ, Liter JC, Pettlerjennings P. Recovery of function following severe traumatic brain injury—a retrospective 10-year follow-up. Brain Injury 1995;9:285–299.
4. Thomsen IV. Late outcome of very severe blunt head trauma—a 10–15 year 2nd follow-up. Journal of Neurology Neurosurgery and Psychiatry 1984;47:260–268.
5. Hammond FM, Hart T, Bushnik T, Corrigan JD, Sasser H. Change and predictors of change in communication, cognition, and social function between 1 and 5 years after traumatic brain injury. Journal of Head Trauma Rehabilitation 2004;19:314–328.
6. Dikmen SS, Machamer JE, Powell JM, Temkin NR. Outcome 3 to 5 years after moderate to severe traumatic brain injury. Archives of Physical Medicine and Rehabilitation 2003;84:1449–1457.
7. Santos ME, Castro-Caldas A, De Sousa L. Spontaneous complaints of long-term traumatic brain injured subjects and their close relatives. Brain Injury 1998;12:759–767.
8. Klonoff H, Clark C, Klonoff PS. Long-term outcome of head-injuries—a 23 year follow-up-study of children with head-injuries. Journal of Neurology, Neurosurgery and Psychiatry 1993;56:410–415.
9. Oddy M, Coughlan T, Tyerman A, Jenkins D. Social-adjustment after closed head-injury—a further follow-up 7 years after injury. Journal of Neurology Neurosurgery and Psychiatry 1985;48:564–568.
10. Ponsford J, Olver J, Ponsford M, Nelms R. Long-term adjustment of families following traumatic brain injury where comprehensive rehabilitation has been provided. Brain Injury 2003;17:453–468.
11. Brooks N, Campsie L, Symington C, Beattie A, Mckinlay W. The 5 year outcome of severe blunt head-injury—a relatives view. Journal of Neurology, Neurosurgery and Psychiatry 1986;49:764–770.
12. Svendsen HA, Teasdale TW, Pinner M. Subjective experience in patients with brain injury and their close relatives before and after a rehabilitation programme. Neuropsychological Rehabilitation 2004;14:495–515.
13. Teasdale TW, Christensen AL, Willmes K, Deloche G, Braga L, Stachowiak F, Vendrell JM, Castro-Caldas A, Laaksonen RK, Leclerq M. Subjective experience in brain-injured patients and their close relatives: A European brain injury questionnaire study. Brain Injury 1997;11:543–563.
14. Johansen LE, Pedersen MM, Lauersen O. Follow-up undersøgelse af 150 personer med erhvervet hjerneskade 1–10 år efter endt rehabilitering. Aarhus: Hjerneskadecentret; 2004.
15. Moore AD, Stambrook M. Coping strategies and locus of control following traumatic brain injury: Relationship to long-term outcome. Brain Injury 1992;6:89–94.
16. Hoofien D, Gilboa A, Vakil E, Donovick PJ. Traumatic brain injury (TBI) 10–20 years later: A comprehensive outcome study of psychiatric symptomatology, cognitive abilities and psychosocial functioning. Brain Injury 2001; 15:189–209.
17. Koskinen S. Quality of life 10 years after a very severe traumatic brain injury (TBI): The perspective of the injured and the closest relative. Brain Injury 1998;12:631–648.
18. Klonoff PS, Snow WG, Costa LD. Quality of life in patients 2 to 4 years after closed head injury. Neurosurgery 1986;19:735–743.
19. Blais MC, Boisvert JM. Psychological and marital adjustment in couples following a traumatic brain injury (TBI): A critical review. Brain Injury 2005;19:1223–1235.
20. Wilson BA. Towards a comprehensive model of cognitive rehabilitation. Neuropsychological Rehabilitation 2002;12: 97–110.
21. Cicerone KD, Mott T, Azulay J, Friel JC. Community integration and satisfaction with functioning after intensive cognitive rehabilitation for traumatic brain injury. Archives of Physical Medicine and Rehabilitation 2004;85:943–950.
22. Sarajuuri JM, Kaipio ML, Koskinen SK, Niemela MR, Servo AR, Vilkki JS. Outcome of a comprehensive neurorehabilitation program for patients with traumatic brain injury. Archives of Physical Medicine and Rehabilitation 2005;86:2296–2302.
23. Trexler LE. Emperical support for neuropsychological rehabilitation. In: Christensen AL, Uzzell BP, editors. International handbook of neuropsychological rehabilitation. New York: Kluwer Academic/Plenum Publishers; 2000. pp 137–150.
24. Klonoff PS, Lamb DG, Henderson SW. Outcomes from milieu-based neurorehabilitation at up to 11 years post-discharge. Brain Injury 2001;15:413–428.
25. Klonoff PS, Lamb DG, Henderson SW, Shepherd SW. Outcome assessment after milieu-oriented rehabilitation: New considerations. Archives of Physical Medicine and Rehabilitation 1998;79:684–690.
26. Christensen AL, Pinner EM, Moller PP, Teasdale TW, Trexler LE. Psychosocial outcome following individualized neuropsychological rehabilitation of brain damage. Acta Neurologica Scandinavia 1992;85:32–38.
27. Teasdale TW, Christensen AL, Pinner EM. Psychosocial rehabilitation of cranial trauma and stroke patients. Brain Injury 1993;7:535–542.
28. Prigatano GP, Fordyce DJ, Zeiner HK, Roueche JR, Pepping M, Wood BC. Neuropsychological rehabilitation after closed head injury in young adults. Journal of Neurology, Neurosurgery and Psychiatry 1984; 47:505–513.
29. Malec JF, Smigielski JS, DePompolo RW, Thompson JM. Outcome evaluation and prediction in a comprehensive-integrated post-acute outpatient brain injury rehabilitation programme. Brain Injury 1993;7:15–29.
30. Prigatano GP, Fordyce DJ, Zeiner HK, Roueche JR, Pepping M, Wood BC. Neuropsychological rehabilitation after closed head injury in young adults. Journal of Neurology, Neurosurgery & Psychiatry 1984;47:505–513.
31. Prigatano GP, Klonoff PS, O'Brian KP, Altman IM, Amin K, Chiapello D, Shepard J, Cunningham M, Mora M. Productivity after neuropsychologically oriented milieu rehabilitation. Journal of Head Trauma Rehabilitation 1994;9:91–102.
32. Ben-Yishay Y, Silver SM, Piasetsky E, Rattok J. Relationship between employability and vocational outcome after intensive holistic cognitive rehabilitation. Journal of Head Trauma Rehabilitation 1987;2:35–48.
33. Teasdale TW, Hansen HS, Gade A, Christensen AL. Neuropsychological test scores before and after brain-injury rehabilitation in relation to return to employment. Neuropsychological Rehabilitation 1997;7:23–42.
34. Teasdale TW, Caetano C. Psychopathological symptomatology in brain-injured patients before and after a rehabilitation program. Applied Neuropsychology 1995;2: 116–123.

35. Christensen AL, Pinner EM, Moller PP, Teasdale TW, Trexler LE. Psychosocial outcome following individualized neuropsychological rehabilitation of brain damage. Acta Neurologica Scandinavica 1992;85:32–38.
36. Gordon WA, Zafonte R, Cicerone K, Cantor J, Brown M, Lombard L, Goldsmith R, Chandna T. Traumatic brain injury rehabilitation: State of the science. American Journal of Physical Medicine and Rehabilitation 2006;85:343–382.
37. Ragnarsson KT, Moses LG, Clarke WR, Daling JR, Garber SL, Gustafson CF, Holland AL, Jordan BD, Parker JC, Riddle MA, et al. Rehabilitation of persons with traumatic brain injury. Jama: Journal of the American Medical Association 1999;282:974–983.
38. Engberg AW, Teasdale TW. Psychosocial outcome following traumatic brain injury in adults: A long-term population-based follow-up. Brain Injury 2004;18:533–545.
39. Teasdale TW, Engberg AW. Psychosocial consequences of stroke: A long-term population-based follow-up. Brain Injury 2005;19:1049–1058.
40. Carney N, Chesnut RM, Maynard H, Mann NC, Patterson P, Helfand M. Effect of cognitive rehabilitation on outcomes for persons with traumatic brain injury: A systematic review. Journal of Head Trauma Rehabilitation 1999;14:277–307.
41. Teasdale TW, Hansen HS, Gade A, Christensen AL. Neuropsychological test scores before and after brain-injury rehabilitation in relation to return to employment. Neuropsychological Rehabilitation 1997;7:23–42.
42. Wilson BA, Evans JJ. Does cognitive rehabilitation work: Clinical and economical considerations and outcomes. In: Prigatano GP, Pliskin NH, editors. Clinical neuropsychology and cost outcome research. New York: Psychology Press; 2003. pp 329–350.
43. Diller L, Ben-Yishay Y. The clinical utility and cost-effectiveness of comprehensive (holistic) brain injury day-treatment programs. In: Prigatano GP, Pliskin NH, editors. Clinical neuropsychology and cost outcome research. New York: Psychology Press; 2003. pp 293–312.
44. Christensen AL, Pinner EM, Rosenberg NK. Program for rehabilitation for brain damage in Denmark. In: Christensen AL, Uzzell BP, editors. Neuropsychological rehabilitation: Current knowledge and future directions. Boston: Kluwer; 1988. pp 115–124.
45. Association for the Advancement of Automotive Medicine. The abbreviated injury scale. 1990 Revision ed. USA: Association for the Advancement of Automotive Medicine; 1990.
46. Jennett B, Snoek J, Bond MR, Brooks N. Disability after severe head-injury—observations on the use of the Glasgow Outcome Scale. Journal of Neurology, Neurosurgery and Psychiatry 1981;44:285–293.
47. Teasdale TW, Christensen AL, Willmes K, Deloche G, Braga L, Stachowiak F, Vendrell JM, Castro-Caldas A, Laaksonen RK, Leclerq M. Subjective experience in brain-injured patients and their close relatives: A European Brain Injury Questionnaire study. Brain Injury 1997; 11:543–563.
48. Prigatano GP, Altman IM, O'Brian KP. Behavioral limitations that brain-injured patients tend to underestimate. The Clinical Neuropsychologist 1990;4:163–176.
49. Schwarzer R, Jerusalem M. Generalized self-efficacy scale. In: Weinman J, Wright S, Johnston M, editors. Measures in health psychology: A user's portfolio. Causal and control beliefs. Windsor, UK: NFER-Nelson; 1995. pp 35–37.
50. Zigmond AS, Snaith RP. The Hospital Anxiety and Depression Scale. Acta Psychiatrica Scandinavica 1983; 67:361–370.
51. Norholm V, Bech P. The WHO Quality of Life (WHOQOL) Questionnaire: Danish validation study. Nordic Journal of Psychiatry 2001;55:229–235.
52. Field A. Discovering statistics using SPSS. London: Saga Publications; 2005.
53. Magnusson A, Axelsson J, Karlsson MM, Oskarsson H. Lack of seasonal mood change in the Icelandic population: Results of a cross-sectional study. American Journal of Psychiatry 2000;157:234–238.
54. Sherer M, Boake C, Levin E, Silver BV, Ringholz G, High WM. Characteristics of impaired awareness after traumatic brain injury. Journal of the International Neuropsychological Society 1998;4:380–387.
55. Brooks N, Campsie L, Symington C, Beattie A. The effects of severe head injury on patient and relative within seven years of injury. Journal of Head Trauma Rehabilitation 1987;2:1–2.
56. Hart, T. The Patient Competency Rating Scale. The Center for Outcome Measurement in Brain Injury; 2000. Available online at: http://www.tbims.org/combi/pcrs, accessed 12 May 2006.
57. Moore AD, Stambrook M. Coping strategies and locus of control following traumatic brain injury: Relationship to long-term outcome. Brain Injury 1992;6:89–94.
58. Noerholm V, Groenvold M, Watt T, Bjorner JB, Rasmussen NA, Bech P. Quality of life in the Danish general population—normative data and validity of WHOQOL-BREF using Rasch and item response theory models. Quality of Life Research 2004;13:531–550.