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Patient compliance in brain injury rehabilitation in relation to awareness and cognitive and physical improvement

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The purpose of the present study was to investigate the relationship between patients' compliance and awareness and outcome of brain injury rehabilitation. Subjects were 98 patients who underwent a holistic neuropsychological outpatient rehabilitation programme. Patients had suffered a traumatic brain injury ($n = 26$), a cerebrovascular accident ($n = 58$), or another neurological insult ($n = 14$). Measures: Two staff members, a neuropsychologist and a physiotherapist, retrospectively and separately rated patients' awareness and their compliance. Outcome was measured with the d2 test of concentration, measures of oxygen uptake, strength endurance, running speed, and patients' and relatives' ratings of patients' cognitive, physical, and overall problems on the European Brain Injury Questionnaire (EBIQ). The discrepancy between patients' and relatives' ratings on the EBIQ was incorporated as a second measure of patients' awareness. Results: The neuropsychologist's compliance ratings were significantly related to measures of insight, improvement of d2 performance accuracy and stability, improvement of oxygen uptake, and reduction of cognitive and overall problems as reported by the patients, while the physiotherapist's compliance ratings were related to measures of insight, improvement of d2 performance speed, improvement of oxygen uptake and strength endurance, and all three EBIQ patient scales. Discussion: The results suggest a differential relationship between situation-specific compliance and outcome.

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INTRODUCTION

There is evidence that a stimulative training of specific attentional functions results in improvement of those functions in brain-damaged people with varying a etiologies. This is especially true for the basic intensity aspects of attention, but also for the more complex functions of selective and divided attention (Cappa et al., 2003; Sohlberg & Mateer, 1987; Sturm, Fimm, Zimmermann, Deloche, & Leclercq, 1999; Park & Ingles, 2001; Sturm, Hartje, Orgass, & Willmes, 1993, 1994; Sturm, Willmes, Orgass, & Hartje, 1997). Recent studies have indicated that these improvements can be seen as real training effects, resulting in functional re-organisation of damaged brain areas (Sturm et al., 2004). However, there is no common agreement about how remediation of attentional functions should be conducted. Sohlberg and Mateer (2001) propose a combined approach, integrating both the retraining of cognitive functions and work on patients' awareness and compensatory skills.

Unlike the retraining of attentional functions, there is no doubt about the usefulness of physical exercise for brain-injured individuals. There is striking evidence that intensive strength and endurance training improves the physical condition of brain-injured patients (see also Hesse et al., 2001; Kwakkel et al., 1999) and reduces the risk of further stroke incidents (Wannamethee & Shaper, 1999). There is also evidence that physical exercise affects emotions (Lawlor & Hopker, 2001) and cognitive functions (Cotman & Berchtold, 2002; Kramer et al., 2003). However, we are unaware of any studies that have investigated the benefit of physical exercise for psychological functions within brain injury rehabilitation.

There is also evidence that brain injured patients experience the positive effect of cognitive and physical training themselves (Sohlberg et al., 2000; Svendsen, Teasdale, & Pinner, 2004).

In summary, there is evidence for the efficacy of both cognitive and physical training with brain injured people. However, treatment success varies between patients such that even a good programme does not have the same beneficial effect on all patients. This is partly due to what does and does not happen during therapy. In psychotherapy research, there is now a strong focus on the analysis of the therapeutic process and the impact of elements of this process on outcome. Patients' compliance with the treatment regimen is regarded as an important process element.

In the context of medical therapy, the importance of patients' compliance for outcome and the enormous costs of non-compliance are well documented (for a review, see Meichenbaum & Turk, 1987; Volmer & Kielhorn, 1998). The consistent findings are seemingly easy to explain. A treatment can only be effective if the patient complies with the treatment regimen. However, following Petermann and Mühlig (1998), compliance is more than the patient's willingness to do what he/she is told. A complex therapeutic intervention can only be fully effective if the patient not only follows the therapeutic advice, but also participates and engages actively and independently. Compliance as we understand it is not a stable personality trait, but rather a complex, dynamic, and situation-specific phenomenon that may change and can be influenced in the course of therapy (Meichenbaum & Turk, 1987; Petermann & Mühlig, 1998).

In the context of brain injury rehabilitation, it is a common experience that individuals with impaired self-awareness or denial face difficulties with motivation and participation in therapy, and that compliance is a prerequisite for successful therapeutic work (see also Fleming & Strong, 1995; Katz et al., 2002; Pepping & Prigatano, 2003). However, we could only find three studies that evaluated patients' compliance as a predictor of rehabilitation outcome. Kime, Lamb, and Wilson (1996) showed a positive relation between compliance with memory rehabilitation and improvement of neuropsychological functions in a single-case study. Ezrachi et al. (1991) found that their therapist-rated measure of patients' acceptance of and coping with the programme routines, as well as patients' active engagement in the programme, were the most important predictors of employment outcome six months after programme completion. Schönberger, Humle, Zeeman, & Teasdale (2006) replicated this relation between compliance with holistic outpatient rehabilitation and follow-up outcome. The results of Schönberger et al. (2005) support a situation-specific view of patient compliance and show that the relationship between compliance and outcome depends on what it was that patients complied with. Compliance and outcome seem to be related differentially. The latter finding indicates that studies of compliance in brain injury rehabilitation can tell us something about the role of compliance in the rehabilitation process. By examining the association between situation-specific compliance and outcome, we can investigate the effectiveness of our interventions. For example, if patients' engagement in physical therapy not only leads to improvement of physical functions, but also enhances cognitive abilities, this may tell us something about the benefits of physical training. However, we are unaware of any studies that have formally studied the impact of awareness on compliance and described the relationship between compliance, success of physical training, rehabilitation of attentional functions, and patients' own experience of treatment success in brain injury rehabilitation. In the present study, we wanted to examine these relations. We asked the following questions and propose corresponding hypotheses:

1. How are awareness and compliance inter-related? We expect a positive relationship, such that patients with awareness of their brain injury related problems would be motivated to comply with and engage themselves in rehabilitation in order to overcome the problems they experience.

2. How are compliance in cognitive and physical training related to the improvement of attentional and physical functions? From the literature, we can hypothesise that compliance with an effective training of attentional functions should lead to improved cognitive functions, while compliance in physical training could lead to an improvement of both physical and attentional functions.
3. Can we measure the impact of compliance on outcome with objective measures (tests), subjective measures (questionnaires), or both? We predict an impact of compliance as measured by a change in test results from pre- to post-programme, and we predict the same finding for the subjective measures.

METHOD

Subjects

Subjects included in the present study comprised patients who underwent a post-acute neuropsychological rehabilitation programme at the Center for Rehabilitation of Brain Injury (CRBI) at the University of Copenhagen. The rehabilitation programme accepts adult patients with acquired brain injury. The programme involves attendance at the centre for four days a week for about four months with subsequent follow-up according to individual requirements. At the time the study was conducted, patients commenced the programme in groups of 15–20, twice yearly. A total of 103 patients entered the programme between August 1998 and June 2001. Of these, two patients did not complete the programme due to death or illness, while three patients were not contactable after programme end. Table 1 shows basic demographic and medical data concerning the remaining 98 patients who entered the study. Older patients are rarely referred to the rehabilitation centre, and within our sample, the oldest patient was 65 at the time of injury. There was considerable variation in the total duration of hospitalisation: median duration was 66 days. It can be seen that the time between injury and programme entry was comparatively short: 55% of patients entered the programme within one year of injury, and 90% within two and a half years. The preponderance of male patients arises from the traumatic brain injury group. The proportions of males and females in the other two diagnostic groups were approximately equal. Included within the "other" injury type category are patients with brain tumours, anoxia following cardiac arrest and with infections, e.g. meningitis.

TABLE 1
Patients' demographic and medical characteristics

	Mean	*SD*	*N (%)*
Age at injury (years)	42.4	11.9	
Duration of hospitalisation (days)	93	97	
Age at programme entry (years)	43.5	11.8	
Sex			
Male			57 (58)
Female			41 (42)
Type of Injury			
Traumatic brain injury			26 (27)
Cerebrovascular accident			58 (59)
Other			14 (14)

Interventions

The programme involves elements of cognitive, physical and social training; it is intentionally multidimensional and the centre's professional staff includes neuropsychologists, physiotherapists, speech pathologists, an occupational therapist and a special education teacher. The cognitive training is conducted both individually and in groups, approximately 3–6 hours per week. It incorporates individually tailored retraining of cognitive functions—basic and complex attentional functions—and work on patients' awareness and compensatory skills to ensure generalisation of training effects on everyday life. The physical therapy at the CRBI is conducted 2–6 hours per week. It comprises intensive training of muscle strength and endurance and incorporation of acquired skills and leisure time activities into daily living. Both during cognitive and physical training, patients are taught to monitor their own performance. This process of self-monitoring is both an intervention on patients' awareness of illness and consequences and on their self-efficacy expectancies and a training of problem solving strategies. Thus, the physical training also incorporates elements of cognitive training. Further details of the programme are presented elsewhere (Caetano & Christensen, 2000; Christensen & Caetano, 1999; Rasmussen, 1995).

Measures

In order to evaluate patients' awareness and their compliance within the programme, we constructed a rating form which was completed for all patients by the senior neuropsychologist (FH) and the senior physiotherapist (PZ) at the centre. The form was completed as part of a broader questionnaire comprising 11 items.

For the measurement of patient compliance, we computed the average of three items, separately for the neuropsychologist's and the physiotherapist's ratings, namely (1) patient engagement (rated on a five-point scale ranging from 1 = active and independent, spontaneous input, to 5 = poor or no activity), (2) patient acceptance of programme elements and objectives, and (3) patient following the therapist's advice. The former item was derived from a scale developed by Prigatano et al. (1994). The two latter items were derived from a study reported by Ezrachi et al. (1991). For the purpose of our study, these two items were rated on a five-point scale from 1 = not at all to 5 = a lot. A more detailed description of the compliance items can be found in Schönberger et al. (2006). We computed average compliance scores for each patient, separately for both raters. The scores were then dichotomised, again separately for both raters, using the scale midpoint as a cut off score. An average compliance score of 3 or lower was labelled as "poor", a score above three was labelled as "good".

In a fourth item on the rating form, we asked the therapists to rate patients' awareness on a five-point scale from 1 = not at all to 5 = a lot. Awareness was defined as impaired awareness of difficulties and impaired awareness of the implications of these difficulties for the patients' lives.

The rating forms were completed retrospectively between December 2002 and January 2003, i.e., between 18 months and 4 years after the patients finished the programme. The neuropsychologist and the physiotherapist had close, daily and, to a large extent, separate contact with the patients while they were in the programme, and their ratings were made independently of each other.

To measure patients' cognitive status before and after rehabilitation, we used the following tests, all of which were administered both at programme start and end.

For the measurement of patients' concentration, we used the d2 test of concentration (Brickenkamp, 1981). The d2 is a letter cancellation task. Subjects are presented with a paper sheet containing different letters with a varying number of dashes above and below. Subjects are asked to cancel all d's with 2 dashes. The d2 sheet contains 14 lines. For each line, the time limit is 20 seconds. Subjects are asked to work both quickly and accurately. The d2 provides (1) a score of performance speed, that is, the total number of processed letters, called TS score, (2) a score of performance accuracy, the sum of all errors divided by the number of processed letters, multiplied by 100 (percentage of errors), and (3) a score of performance stability, the difference between the highest and the lowest number of processed letters per line. A good performance in the d2 test requires, among others, the ability to focus selectively on the target stimulus and the ability to process information at high speed.

We examined patients' physical fitness in three different ways. Firstly, we measured patients' physiological endurance by measuring their maximal oxygen uptake (VO_{2max}) with the Åstrand cycling test (Åstrand & Rodal, 1986). Second, we measured patients' strength endurance with a modified version of the Harvard step test that was adapted for use with brain injured people. In the Harvard step test, subjects are asked to step up and down on an individually adjusted box for five minutes with a cadence as close as possible to 30 steps per minute. The result of the test is computed as a Physical Fitness Index (PFI). Our third measure of patients' fitness was self-chosen running speed or walking speed (if the patients could not run). Patients were asked to walk or run on an outdoor asphalt track as fast as possible. However, this test is a measure of self-chosen walking or running speed, because the patients were not urged to run faster than they wanted to. Many of them ran slower than they otherwise could have done, because they were afraid of falling. Most patients were asked to walk or run a distance of 1,270 meters. For some patients, however, the distance was adjusted, if their physical condition did not allow them to walk or to run the full distance. These were typically patients with a low walking speed.

For the measurement of patients' and their relatives' view of patients' problems, we used the European Brain Injury Questionnaire (EBIQ; Teasdale et al., 1997). The EBIQ is comprised of 62 items, covering a wide range of brain injury-related everyday problems, as well as three questions regarding the relatives. Patients completed the "self" version in which they were asked to indicate how much they had experienced any of the problems in question within the last month. Their responses were recorded on a three-point scale: "not at all" (1), "a little" (2) or "a lot" (3). Correspondingly, close relatives completed the "relative" version in which they gave their perceptions of the person with brain injury. From both the patients' and the relatives' questionnaires, nine subscales can be calculated. For the purpose of this study, we selected three of the subscales of both the self and the relative version, namely (1) the somatic scale, which measures subjective experiences of somatic problems, (2) the cognitive scale, which addresses cognitive problems, and (3) the core scale, containing those EBIQ items with the closest interrelations, forming the "core" of the reported problems. The somatic, cognitive and core scales contain 8, 13 and 33 items, respectively. Details of the EBIQ can be found elsewhere (Svendsen et al., 2004; Teasdale et al., 1997).

To achieve a second measure of patients' awareness, we computed the difference between the patients' and their relatives' scores on the three EBIQ scales we used at programme start by subtracting the relatives' ratings from the patients' ratings, assuming that if patients reported fewer problems than their relatives, the discrepancy could be seen as an indicator of a lack of awareness.

Most inferential statistics were computed two-tailed, only associations between the compliance ratings on the one hand and awareness measures and pre–post programme test data on the other hand were computed one-tailed. Analyses were performed using SPSS 12.0. It should be mentioned that the test data were in some cases missing. For the walking test, this was mainly because the running track was sometimes icy during the winter, which made it impossible to conduct the test.

RESULTS

Ratings

The compliance ratings were generally positive (Table 2). Cronbach's alpha for the compliance scale (not dichotomised) as rated by the neuropsychologist was .90, for the physiotherapist's ratings, it was .89. Although both raters agreed significantly (Cohen's Kappa = .48, $p < .001$), the neuropsychologist gave more positive ratings than the physiotherapist (McNemar test $p < .05$; Table 2). A detailed description of the items included in the compliance scale is given elsewhere (Schönberger et al., 2006).

The awareness ratings were moderately positive. With a mean awareness rating of 3.85 ($SD = 1.17$), the physiotherapist rated patients significantly higher, $t(97) = -5.22$, $p < .001$, than the neuropsychologist ($M = 3.28$, $SD = 1.11$). However, the inter-rater correlation was moderate and significant, $r = .55$, $p < .001$.

Test results

With a mean TS score (performance speed) of 328.4 ($SD = 100.9$) at programme start, patients performed the d2 test slower than an age-matched German sample, while the error percentage of 5.6 ($SD = 6.1$) was within the lower normal range. The spread at programme start was 13.2 ($SD = 5.5$; we could not find valid norms for the d2 spread score). At programme end, patients had improved their d2 performance speed and accuracy

TABLE 2
Compliance ratings descriptives

	Physiotherapist compliance rating		
	Poor	*Good*	*Total*
Neuropsychologist compliance rating			
Poor	12	4	16
Good	13	69	82
Total Count	25	73	98

McNemar test $p < .05$; Cohen's Kappa = 0.48 ($p < .001$).

significantly (t-tests; $p < .05$), although they were still slower in their performance than the norm sample.

At programme start, the mean VO_{2max} was $M = 32.8$ ($SD = 9.8$), the mean Harvard Step Test score was $M = 56.6$ ($SD = 19.3$), mean running speed was $M = 7.7$ km/h ($SD = 3.4$). The patients improved all their physical test scores significantly from pre- to post-programme (t-tests; all ps $< .001$). While patients' muscle strength endurance and oxygen uptake (VO_{2max}) reached the average level of the normal population at programme end, their mean running speed was still lower. For the Harvard step test, we cannot make comparisons with the general population because of modifications we had made in the test procedure.

On the subjective level, patients had mean scores of $M = 1.69$ on the EBIQ somatic scale ($SD = 0.49$), $M = 1.86$ on the cognitive scale ($SD = 0.41$) and $M = 1.70$ on the core scale ($SD = 0.39$). Relatives' reported the same amount of problems at programme start. Both clients and relatives reported a significant improvement of both somatic and cognitive problems and problems in general (t-tests; all ps $< .001$). Inter-rater correlations for the somatic, cognitive and core scales at programme start were $r = .78$, $r = .60$ and $r = .70$, respectively.

Role of patient characteristics

No relationship was found between patients' demographic and medical characteristics (see Table 1) and the compliance ratings. (Mann-Whitney U-tests and X^2 tests; $p > .05$). However, noncompliant patients tended to have been hospitalised for a longer time than compliant patients ($p < .2$ and $p < .1$ for the neuropsychologist's and physiotherapist's rating, respectively). When we compared demographic and medical data with the awareness ratings, the only significant finding was that the physiotherapist rated women as having been more aware of brain injury-related problems than men, $t(95.4) = -2.1$, $p < .05$. The differences between patients' and their relatives' ratings of everyday problems on the EBIQ at programme start were not related to our control variables. Interestingly, the subjective experience of problems was not related to age, but to the time interval between injury and programme start. The longer the time interval between injury and programme start, the more problems patients and relatives reported on all three EBIQ scales at programme start (correlations between 0.26 and 0.30; no significant correlations between EBIQ and time since injury at programme end). Pre- to post-improvement on tests were not related to demographic or medical data.

Research question 1: Compliance and awareness

Both raters' compliance ratings showed a highly significant relation to both raters' awareness ratings (Mann-Whitney U-tests; $p < .001$). Patients rated as compliant by the neuropsychologist had a mean awareness rating of 3.5 ($SD = 1.0$) by the neuropsychologist and 4.1($SD = 1.0$) by the physiotherapist; patients rated as noncompliant by the neuropsychologist had awareness ratings of 2.0 ($SD = 0.9$) and 2.6 ($SD = 1.2$), respectively. Conversely, patients rated as compliant by the physiotherapist had a mean awareness rating of 3.6 ($SD = 1.0$) by the physiotherapist and 4.4 ($SD = 0.8$) by the neuropsychologist; patients rated as noncompliant by the physiotherapist had awareness ratings of 2.4 ($SD = 0.8$) and 2.4 ($SD = 1.0$), respectively. The compliance ratings were also significantly related to the discrepancy between patients' and relatives' overall ratings of problems on the EBIQ (EBIQ core scale; Mann-Whitney U test, $p < .05$), such that the patients with poor compliance ratings reported fewer problems than their relatives ($M = 0.13$ points difference on the EBIQ, $SD = 0.30$, for patients rated as uncompliant by the neuropsychologist, $M = 0.10$ points difference, $SD = 0.26$, when compliance was rated by the physiotherapist), whereas the patients with good awareness ratings reported as many problems as their relatives on the EBIQ core scale. We found the same tendencies for the relationship between the physiotherapist's compliance ratings and the discrepancy between patients' and relatives' report on the EBIQ somatic scale, and for the relationship between the neuropsychologist's compliance ratings and the discrepancy between patients' and relatives' report on the EBIQ cognitive scale. However, these latter tendencies were not significant.

Research questions 2 and 3: Compliance and subjective and objective improvement

While good compliance ratings given by the neuropsychologist were significantly related to a high d2 spread at programme start, good compliance ratings given by the physiotherapist were significantly related to a high d2 performance speed (Mann-Whitney U-tests, $p < .05$) and were near-significantly related to a fast walking or running speed (Table 3). We found no significant relationships between the compliance ratings and the EBIQ scales at programme start.

As Table 3 shows, the neuropsychologist's compliance ratings were positively related to the improvement of d2 performance accuracy and stability and the improvement of oxygen uptake (Åstrand cycling test) from pre- to post-programme (Mann-Whitney U-tests, $p < .05$). The physiotherapist's compliance ratings were positively related to the improvement of d2 performance speed, oxygen uptake, and strength endurance (Harvard Step Test) from pre- to post-programme (Mann-Whitney U-tests, all ps $< .01$). The compliance ratings were also related to a reduction in subjective problems as reported by the patients (Table 4). While good compliance ratings given by the neuropsychologist were related to a reduction of cognitive problems (EBIQ cognitive

TABLE 3
d2 test, Åstrand Cycling Test, Harvard Step Test and walking/running speed measurement in relation to compliance

	Compliance rating neuropsychologist				*Compliance rating physiotherapist*			
	Poor compliance		*Good compliance*		*Poor compliance*		*Good compliance*	
Test	*N*	*Mean (SD)*	*N*	*Mean (SD)*	*N*	*Mean (SD)*	*N*	*Mean (SD)*
d2 TS score (speed)								
pre	15	339.9 (128.9)	76	326.1 (95.2)	23	362.2 (105.4)	68	316.9 (97.4)*
pre−post	15	5.1 (73.5)	72	22.5 (57.9)	23	−16.0 (66.6)	64	32.2 (53.5)*
d2 error %								
pre	15	5.8 (5.9)	76	5.6 (6.2)	23	6.2 (5.8)	68	5.4 (6.2)
pre−post	15	−0.4 (6.0)	72	−1.8 (6.4)*	23	−2.1 (4.3)	64	−1.4 (6.9)
d2 spread								
pre	15	10.4 (3.4)	75	13.7 (5.7)*	23	12.6 (5.3)	67	13.4 (5.6)
pre−post	15	1.2 (4.4)	69	−1.9 (6.8)*	23	−1.3 (4.7)	61	−1.4 (7.1)
VO_{2max}								
pre	15	34.9 (7.6)	73	32.4 (10.2)	21	33.8 (10.4)	67	32.5 (9.6)
pre−post	14	4.0 (4.4)	69	7.2 (5.6)*	20	3.8 (4.7)	63	7.5 (5.5)*
Harvard Step Test								
pre	14	56.6 (22.7)	70	56.6 (18.7)	22	50.4 (23.3)	62	58.8 (17.4)
pre−post	12	12.4 (13.9)	63	12.5 (10.4)	19	7.2 (6.1)	56	14.2 (11.7)*
Walking/running speed								
pre	15	8.7 (3.9)	73	7.5 (3.3)	22	6.6 (3.4)	66	8.0 (3.4)
pre−post	7	1.1 (1.6)	61	1.3 (1.4)	13	1.0 (1.1)	55	1.3 (1.4)

*Significant mean differences between compliant and non-compliant patients (1-tailed Mann-Whitney *U*-tests, $\propto = 0.05$).

TABLE 4
EBIQ patients pre–post-programme in relation to patients' compliance

	Compliance rating neuropsychologist				*Compliance rating physiotherapist*			
	Poor compliance		*Good compliance*		*Poor compliance*		*Good compliance*	
EBIQ Scale	*N*	*Mean (SD)*	*N*	*Mean (SD)*	*N*	*Mean (SD)*	*N*	*Mean (SD)*
Somatic								
Patient	15	0.07 (0.29)	71	0.12 (0.26)	22	0.02 (0.24)	64	0.15 (0.27)*
Relative	11	0.11 (0.15)	69	0.16 (0.33)	18	0.05 (0.18)	62	0.18 (0.33)
Cognitive								
Patient	15	0.05 (0.22)	71	0.22 (0.31)*	22	0.09 (0.29)	64	0.23 (0.31)*
Relative	11	0.12 (0.15)	68	0.17 (0.30)	18	0.12 (0.18)	61	0.17 (0.31)
Core								
Patient	15	0.04 (0.24)	71	0.17 (0.26)*	22	0.03 (0.17)	64	0.19 (0.27)*
Relative	11	0.13 (0.17)	69	0.13 (0.24)	18	0.09 (0.18)	62	0.14 (0.25)

*Significant differences on the EBIQ between compliant and non-compliant patients (1-tailed Mann-Whitney *U*-tests, $\propto = 0.05$); positive differences mean that the problems are reduced post-programme.

scale) and the overall amount of problems (EBIQ core scale; Mann-Whitney *U*-tests, $p < .05$) as reported by the patients, good compliance ratings given by the physiotherapist were related to a reduction on both the patients' EBIQ somatic and cognitive scale (Mann-Whitney *U*-tests, all *p*s $< .05$) and the patients' EBIQ core scale (Mann-Whitney *U*-test, $p < .01$). No significant relationships were found between compliance ratings and improvement of EBIQ scores from pre- to post-programme as reported by the relatives. However, the physiotherapist's compliance ratings were close to significantly related to a fall in relatives' report of somatic problems on the EBIQ somatic scale from programme start to programme end.

DISCUSSION

Methodological considerations

The present study has some limitations which need to be considered. The neuropsychologist and the physiotherapist completed the rating forms independently of each other. Nevertheless, the interdisciplinary work at the CRBI involves close communication between the staff members to ensure that all therapists are informed about the patients' activities in all parts of the programme. This means that the ratings obtained for this study were made independently, on the basis of the therapists' own knowledge about the patients, but that the therapists shared some knowledge. The considerable agreement between the compliance ratings is likely partly to stem from this overlap in knowledge. However, the agreement is not complete, and may also be due to the fact that humans rarely change their behaviour completely from situation to situation. Thus, we would not have expected the compliance ratings to be uncorrelated. The question of whether differences between the raters are due to differences in the rating styles or differences in patients' behaviour nonetheless remains open. The problem could be solved by involving a larger number of raters and averaging ratings for each programme component.

It could also be questioned whether overall compliance and awareness ratings given retrospectively up to four years after the patients had attended the rehabilitation programme could be fully valid. Moreover, the therapists may have been guided by their knowledge of patients' outcome rather than by patients' actual behaviour during rehabilitation. However, our raters did have overall knowledge of the patients' outcomes, but could for the majority of patients not recall detailed test results, especially not results in tests that did not lie in their professional domain.

Finally, it should be pointed out that we were interested in the impact of patients' compliance on their attentional and physical functions, but we can of course only draw conclusions on the basis of what we have actually measured. The d2 test is a good measure that allows the examination of several cognitive functions that could be called "attentional", but the test does not cover all attentional functions. The following interpretation of the results should be seen in the light of these methodological considerations.

Research question 1: Compliance and awareness

We confirmed the hypothesised but previously undocumented relationship between compliance and both therapist-rated awareness and awareness measured as the discrepancy between patients' and their relatives' ratings of patients' problems. Although the finding was significant for the EBIQ core scale only, and not for the somatic and cognitive scales of the EBIQ, the predicted trend was found for all three EBIQ scales, namely that noncompliant patients tended to disagree with their relatives in the area of interest (somatic and core problems for the physiotherapist's compliance ratings, cognitive and core problems for the neuropsychologist's compliance ratings), whereas compliant patients did not. It should be noted that although noncompliant patients tended to have been hospitalised for a longer time, our data support the view that patients' awareness and compliance cannot solely be predicted by demographic and medical characteristics. We would, of course, expect that certain kinds of brain injuries and premorbid personality characteristics could influence awareness and compliance (and motivation), but other factors, such as the therapeutic alliance between client and therapist (see Schönberger et al., 2006), may also contribute.

Research question 2: Compliance and improvement

The finding that the physiotherapist's compliance ratings were related to both speed of d2 test performance and (near-significantly) walking/running speed can be explained as a correlation of compliance measures. Whereas patients are asked to walk or run as quickly as possible in the running test, patients are asked to work both quickly and accurately in the d2 test—but the patients set their pace themselves in both tests, and their motivation may very well influence both their speed in the tests as well as their engagement in the physical training, the latter then resulting in positive compliance ratings. The fact that all this is not the case for the neuropsychologist's compliance ratings may indicate that in holistic neuropsychological rehabilitation, factors other than one's willingness to push oneself hard are important, too, such as, for instance, the willingness to open up for one's problems and to reflect and correct one's behaviour. These "softer" behaviours may have influenced the neuropsychologist's compliance ratings more than they influenced the physiotherapist's ratings, whose main goal is to get the patients physically active. In this context, it is interesting to note that the neuropsychologist's compliance ratings tended to be more closely related to the awareness measures than the physiotherapist's compliance ratings. In physical training, a lack of awareness and motivation can partly be compensated by the therapist supporting the patients in staying active. This is in a minor extent the case in cognitive training, where patients may be supported in the retraining effort, but where patients' ability and willingness to reflect on obstacles and possible compensation strategies may be more important than in physical training. However, we do not know how the apparent relationship between the good compliance ratings given by the neuropsychologist and unstable d2 test performance fits into the picture; it might simply be a chance finding.

Since the physiotherapist rated those patients who pushed themselves hard as having been compliant, the neuropsychologist may have regarded other patient behaviours as being important when rating their compliance. This could explain the differential relationship between the compliance ratings and the change in the cognitive and physical test data from pre- to post- programme. The neuropsychologist may have rated positively those patients who were willing to reflect, and predicted improved performance accuracy and stability by that (however, this does not explain the improved oxygen uptake). Thus, willingness to reflect may have led to the successful learning of compensatory strategies during cognitive training, thereby enhancing performance accuracy and stability. The physiotherapist may have favoured the patients pushing themselves and working hard in his compliance ratings, thereby predicting the improvement of cognitive speed, oxygen uptake and strength endurance. A second explanation, however, could be that the compliance ratings partly overlap in their prediction of outcome simply because they correlate with each other. However, this would not explain why the two compliance ratings are related to different d2 scores.

A third explanation for the relationship between the compliance ratings and the change in the cognitive and physical test data may be that the training effects generalised. Cognitive training may have had a positive impact on patients' physical functions, and physical training may have had a positive impact on patients' cognitive functions, for example, by means of increasing levels of brain-derived neurotrophic factor (BDNF) and mobilising gene expression profiles that would be predicted to benefit brain plasticity processes (Cotman & Berchtold, 2002).

A fourth explanation, at least of the relation between compliance with physiotherapy and improvement of d2 performance speed, would be that the cognitive elements that were included in the physical training had a beneficial effect on patients' d2 performance speed. However, the cognitive training elements in the physical training were mostly planning and monitoring procedures. If we would expect them to improve d2 performance at all, we would not expect a relation to improved d2 performance speed, but rather improved d2 performance accuracy and stability.

A fifth explanation would be that the improvement of physical and cognitive functions themselves were motivating for the patients, resulting in behaviour that retrospectively was acknowledged as good compliance by the two raters. However, no matter which explanation is the correct one, we can see the overall tendency for patients' compliance to be linked to therapeutic success, and in our data, this relation is differential and likely to be linked to what happens during the process of neuropsychological and physical rehabilitation.

At the subjective level, the overall tendency of a relationship between compliance and outcome is reflected by the relationship between compliance ratings and the reduction of overall problems as reported by the patients from pre- to post-programme. Furthermore, both compliance ratings were related to a reduction in cognitive problems as reported by the patients, but only the physiotherapist's compliance ratings were related to a reduction of somatic problems as reported by the patients. The cause of this relationship is not readily identified. All of the above five explanations for the relationship between compliance ratings and test data could again apply. However, the findings are in accordance with our hypothesis that compliance with physical training would affect both physical and cognitive functions.

The fact that there are no significant relationships between compliance ratings and improvement of patients' problems as reported by the relatives may be due to the fact that these ratings are third-person observations. The patients may be better at seeing their therapeutic progress themselves. Moreover, it is a common clinical experience that relatives not always easily accept the physical and psychological consequences of the patients' brain injury. This means that, even if the relatives can see the improvements the patients make, they possibly do not appraise them as being as significant as the patients do, resulting in no or few changes in the EBIQ ratings from pre- to post-programme. Therefore, relatives' report of patients' problems and change in those may not under all circumstances be a valid measure of patients' problems and reduction of problems, but rather their appraisal of those problems they do see. This viewpoint is supported by the findings of (Schönberger & Svendsen, 2004) and is also the reason why we did not use the discrepancy between clients' and relatives' EBIQ ratings at programme end as an awareness measure.

Research question 3: The relationship between compliance and objective and subjective measures of outcome

We can conclude that we found a relationship between compliance and outcome both at a objective and subjective level. As mentioned earlier, these results were expected, but have not hitherto been demonstrated in the context of brain injury rehabilitation. The results of this study do match the relationships between compliance and follow-up outcome which we have reported earlier (Schönberger et al., 2006) in the same sample of patients. The fact that compliance is related to functional outcome both at the objective and subjective level and to follow-up outcome makes it seem likely that the improvements we see are real successes of holistically oriented rehabilitative work, and not just retest effects. However, a retest effect cannot be excluded, because the compliant patients could have had a strong wish to see a result of their effort, and this, in turn, might have had an impact on their test performance at the end of the programme.

Considerations for further research

For a further investigation of the relationship between process and outcome of post-acute brain-injury rehabilitation, studies with a prospective research design and with repeated awareness and compliance ratings given by a greater number of staff members throughout the process of rehabilitation are warranted. In such studies, the awareness and compliance ratings could be more detailed and differentiated than the retrospective design of the current study allowed. Moreover, it would be important to investigate a variety of other process factors, like patients' motivation and subjective beliefs about the rehabilitation programme's efficacy and their own capability to improve their situation as well as the role of interpersonal relationships in the course of rehabilitation, including the working alliance between patient and therapist. Rehabilitation outcome should be measured at both the physiological, functional, subjective and social level and incorporate both clients, relatives, and rehabilitation staff as data sources. We are currently planning and conducting studies with such a design.

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