ORIGINAL REPORT

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REHABILITATION WITH INTENSIVE ATTENTION TRAINING EARLY AFTER ACQUIRED BRAIN INJURY PROMOTES BETTER LONG-TERM STATUS ON HEALTH-RELATED QUALITY OF LIFE, DAILY ACTIVITIES, WORK ABILITY AND RETURN TO WORK

Gabriela MARKOVIC, PhD[1,2], Aniko BARTFAI, PhD[1,2], Marie-Louise SCHULT, PhD[1,2] and Jan EKHOLM, MD, PhD[1]

From the [1]Department of Clinical Sciences, Karolinska Institutet, Danderyd University Hospital, Stockholm, [2]Division of Rehabilitation Medicine, Danderyd University Hospital, Stockholm, Sweden

***Objective*: To describe long-term effects on activity, participation, and quality of life (*i*) at different post-injury starting time points of attention training and (*ii*) of two different types of rehabilitation with attention training in patients after stroke or traumatic brain injury; and to describe their functioning level.**

***Design*: 2 years after rehabilitation intervention, comparisons were made in one cohort receiving attention training subacute (< 4 months) or post-acute (4–12 months) and in one cohort with two different training methods, a process-based and an activity-based method respectively.**

***Patients*: 100 patients were recruited from our earlier RCT study. They had mild to moderate stroke or traumatic brain injury with relatively limited symptomatology, and all had moderate to severe attention impairment.**

***Methods*: A questionnaire-based interview: EuroQol 5 dimensions, Occupational Gaps Questionnaire, Work Ability Index, self-assessed work status, self-reported employment conditions, sick leave, and experienced cognitive limitations in work performance.**

***Results*: An advantage for patients receiving subacute attention training regarding daily activities, work ability and returning to work.**

***Conclusion*: The results indicate that subacute rehabilitation with attention training (< 4 months) is preferable compared to post-acute intervention (4–12 months). There were only minor differences between the training methods.**

Key words: acquired brain injury; cognitive rehabilitation; early rehabilitation; attention dysfunction; attention process training; activity and participation.

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Correspondence address: Gabriela Markovic, Karolinska Institutet, Department of Clinical Sciences (KIDS), Division of Rehabilitation Medicine, Danderyd Hospital, SE-182 88 Stockholm, Sweden. E-mail: gabriela.markovic@ki.se

LAY ABSTRACT

Previously, in the context of interdisciplinary rehabilitation, we have subjected patients with stroke or traumatic brain injury to additional intensive rehabilitation of attention using two different training methods, a process-based and an activity-based method. The specific attention training commenced either during the first four months after injury or between four and 12 months after injury. In the current study, we report data collected by a telephone interview two years later regarding quality of life and possible limitations in activities of daily life and work. The results show an advantage for patients receiving early rehabilitation regarding daily activities, capacity for work and return to work. Further, there were some minor advantages for patients in the early group, receiving process-based training. Still, the two methods had no significant outcome differences after two years. Thus, the importance of early rehabilitation needs to be considered in organizing rehabilitation services.

Attention difficulties are common cognitive sequelae of acquired brain injury (ABI) (1, 2). Attention supports other cognitive functions and, as such, it is a core component of cognitive skills underlying human activities. Small changes in attention might significantly impact a person's daily life by affecting learning skills, daily functioning, and work (3, 4).

There are a variety of approaches for rehabilitation of attention impairments depending on injury severity and the specific nature of the attention impairment, with interventions that are either restorative, designed to improve underlying cognitive processes, or compensatory, improving performance and allocating attention resources (5–7). One of these approaches is systematic, hierarchical training with attention process training (APT) (8). This method targets the different aspects of attention, i.e., focused, sustained, selective, alternating, and divided into tasks of increasing difficulty and complexity. APT is a successful method post-ABI for adults (9–11) and children (12). APT is recommended in several guidelines (6, 7) and is considered an evidence-based method in the chronic stage after ABI. Most studies report these favourable effects from a post-intervention perspective. In contrast, long-term studies are scarce (4, 13), with only 2 studies focusing on the long-term effect of APT intervention in terms of strategy use (14) and maintenance of functional level (15). Therefore, the current study focuses on long-term aspects.

Activity-based attention training (ABAT) is a performance-skills and metacognitive strategy training emphasizing the importance of conscious cognitive processes in initiating, performing, and controlling attention-demanding activities, such as cooking and studying (5, 10, 16, 17).

Previously, we conducted a series of RCT studies investigating the short-term effects of attention training within the first year after ABI (18), comparing the effects of APT and ABAT in combination with an interdisciplinary inpatient and outpatient rehabilitation programme in 2 cohorts (18–20). Patients from the 2 largest diagnostic groups with ABI, stroke, and traumatic brain injury (TBI) were included in the study, following the same inclusion and exclusion criteria. The results of this short-term rehabilitation suggested an advantage for patients receiving APT (20–22). The current study examines long-term effects of the choice of rehabilitation intervention.

The definition of time intervals for rehabilitation of subacute ABI, compared with chronic ABI, varies, but the first year after ABI is usually considered an early stage (23). However, the path of spontaneous recovery of cognitive functions after ABI is described as non-linear during that timeframe, with different physiological mechanisms and a steeper curve during the first 3–4 months (24). Consequently, data were collected from 2 cohorts (18) since, during the past decade, several studies have reported positive effects of subacute cognitive rehabilitation (< 3 months) after ABI (25–32). These studies reported substantial changes during inpatient rehabilitation. Although effect sizes subsided over time, significant improvements were maintained up to 3 months after discharge. Thus, the choice of the starting time-point for attention-improving interventions is relevant.

People of working age with stroke or TBI are expected to live with a lifelong disability affecting both well-being and health-related quality of life (HRQoL). Active coping strategies (33) and return to work (RTW) have proved to be of importance for well-being after ABI (34–36), while cognitive impairment is associated with worse HRQoL (37) and attention dysfunction specifically (38–41) more likely results in failure to RTW. The possibility of RTW (42) depends not only on medical and psychological pre-and post-injury factors (43), but also on workplace-related circumstances (44). Several studies have highlighted the importance of investigating the long-term effects of cognitive rehabilitation (4, 36, 45, 46) along with the need to measure these changes in terms of changes in activity and participation (47), since those measures are assumed to reflect closer real-life changes in, for example, personal independence and work situation (48). With this background, the current study examines the patients' working ability and RTW 2 years after rehabilitation.

This study describes the activity status, participation, perceived work ability, and HRQoL in participants (18) receiving intensive attention training within the first year post-ABI. The study aimed to compare the long-term effects of: (*i*) subacute start of attention training with post-acute start; and (*ii*) 2 different attention interventions, process-based and activity-based. Based on our previous demonstration of an advantage of APT training within 4 months post-injury (21, 49) and a positive effect on work-performance within 4–12 months post-injury (20), one of the current study hypotheses was that the long-term effectiveness of APT training would be greater than that of the ABAT form of attention training in patients studied 2 years after the initial training.

METHODS

Study design

Participants from the previous RCT study (ClinicalTrials.gov. trial registration NCT02091453) (18, 50) were recruited 2 years after the initial rehabilitation intervention. Comparisons were made in 1 cohort that had undergone attention training either subacute (SA) (< 4 months post-ABI) or post-acute (PA) (4–12 months post-ABI) and in a second cohort that had undergone 1 of 2 different training methods, a process-based method (APT) and an activity-based method (ABAT).

Participants

The participants had had either a mild-to-moderate stroke or TBI with relatively homogenous symptomatology, no aphasia, psychiatric symptoms, or neglect. Satisfactory levels of logical reasoning, memory, and fine motor functions were required to participate in the APT programme. Attention impairment was moderate to severe, measured by the APT test (8) preceding the attention training. Demographic characteristics are shown in Table I. Injury-related characteristics (lesion localization and

Table I. Sociodemographic characteristics at follow-up (median = 22 months post-intervention; 95% confidence interval (95% CI) 21–24 months) for participants ($n = 100$) in interdisciplinary rehabilitation after acquired brain injury

Variable	Total sample
Age, years, mean (SD)/median	49 (10)/52
Age range, *n* (%)	
19–29 years	6
30–49 years	36
50–64 years	58
Sex, female, *n*	49
Marital status, *n*	
Married/co-habitant	76
Single	22
With parents	2
Education[a], *n*	
≤ 12 years	31
13–15 years	44
> 16 years	25
Employment (time of injury), *n*	
Working or studying	81
Not working	19

[a]Completed years of education, from elementary school to higher education.
SD: standard deviation.

distribution) are shown in Table II: a rehabilitation physician and a neuropsychologist classified lesion distribution and related features.

Procedure

An experienced research nurse, who was unfamiliar with the participants and blinded to intervention, contacted the participants, and performed data collection by telephone. All participants ($n=120$) from the previous RCT (18) were contacted by letter and a subsequent telephone call. Of these, 16 did not respond, 3 did not have a contact address, and 1 was deceased; therefore, the final number of respondents was 100. After signing informed consent, the participants received the questionnaires by post, and the research nurse interviewed them within 1 week.

Outcome assessments

The current study selected outcome measures (51) guided by a philosophy that outcome research in ABI should focus on function and participation in daily life. This study describes the status of the participants in relation to a healthy reference group according to each measure's standard outcome.

Health-related quality of life EuroQol-5 dimensions questionnaire (3L). EQ-5D, a generic, patient-reported HRQoL instrument, consists of 5 dimensions (mobility, self-care, usual activities, pain/discomfort, and anxiety/depression) and 3 severity levels (no problems, moderate problems, severe problems) (52). A single-index value can be derived for each dimension. The dimensions are converted into an index value (−0.594 and +1.000) (53), anchored at 1 (total health) and 0 (dead). Swedish normative health index is 0.898 for men and 0.886 for women (54). The EQ-5D is a valid measure of quality of life (QoL) after stroke (55).

Occupational Gaps Questionnaire. The OGQ, version 1.1, measures perceived participation in everyday occupations (56). An occupational gap (OG) occurs when the individual: (*i*) does not perform an activity that they want to (OG 1); or (*ii*) performs an activity that they do not want to (OG 2). This study considers only OG 1. OGs were examined for 28 activities, including 8 instrumental ADLs, 6 social activities, 10 leisure activities and 4 work-related activities. Higher scores correspond to higher restrictions. The scale is dichotomous, distinguishing situations with no OG from conditions with OGs. The results are presented regarding the distribution of OGs in relation to a healthy reference group (56).

Table II. Lesion distribution at follow-up of participants ($n=100$) in interdisciplinary rehabilitation after acquired brain injury

Variable	Total sample
Aetiology, *n*	
Stroke[a]	79
Traumatic brain injury[b]	21
Lesion side, *n* (%)	
Left/right hemisphere	42/31
Bilateral	27
Lesion distribution, *n* (%)	
Focal/multifocal (≥2)	47/53
Lesion localisation, *n* (%)	
Anterior	25 (29)
Posterior	16 (19)
Subcortical	35 (41)
Global	9 (11)

[a]Of which strokes 61% were thrombosis, 27% haemorrhage, 10% subarachnoid haemorrhage, and 2% thrombosis and haemorrhage. [b]Eight participants had haematoma, 4 had contusions, and 9 had both haematoma and contusions. Traumatic brain injury was a result of traffic accidents ($n=9$), falls ($n=8$), sports ($n=3$) and assault ($n=1$).

Work ability. The Work Ability Index (WAI) (57) measures work ability in 7 dimensions: current work ability (WAS) compared with lifetime best (score 0–10), work ability concerning job demands (score 2–10), number of medical diagnoses (score 1–7), impaired work performance (score 1–6), sickness absence in the last 12 months (score 1–5), expected work ability in the forthcoming 2 years (score 1–7), and mental resources (score 1–4). Scores are summed with (range 7–49) and without the diagnosis list (range 6–42). High numbers indicate better self-reported work ability. The number of diagnoses was based on medical records at inclusion. Results are presented in relation to a healthy reference group (58). The total WAI score can be grouped into 4 classes of work ability: 1: "poor" (need to restore); 2: "moderate" (need to improve); 3: "good" (need to support); and 4: "excellent" (need to maintain) (59). Self-rated work ability score (WAS) is based on the first question: "Current work ability compared with the lifetime best" (0=complete work disability, 10=best work ability). Previous studies demonstrate a strong association between WAS and the complete WAI. Therefore, WAS has been recommended as a simple, reliable indicator of work ability (60).

Self-reported employment conditions, sick leave, and experienced cognitive limitations in work performance. A structured questionnaire developed by the research group covered self-reported employment conditions, sick leave, and experienced cognitive limitations in work performance. Eight questions concerning employment conditions could be answered with "yes" or "no". Nine options were presented for the nature and extent of the actual work situation and sickness allowance/sickness compensation (0, 1/4, ½, ¾, or total compensation). The participants could select more than 1 option. Questions ($n=17$) concerning experienced limitations in work performance due to the ABI could be answered with "yes", "sometimes", and "no". The questions focused on cognitive and behavioural difficulties in work due to attention dysfunction, such as concentration demands, understanding and completing work tasks, forgetfulness, error-proneness, problems initiating and structuring work tasks, and the need for technical and emotional support.

Previous interdisciplinary rehabilitation and attention training

All subjects in the current study had participated in intensive (6 h/day, 4–5 day/week for 8–12 weeks) interdisciplinary rehabilitation, which was completed 2 years prior to the start of the current study. The rehabilitation was provided by rehabilitation physician, nurse, physiotherapist, occupational therapist, neuropsychologist, speech and language therapist, and social worker. Cognitive interventions were based on the work of the Cognitive Rehabilitation Task Force (CRTF) of the American Congress of Rehabilitation Medicine (10, 61). In addition to the regular rehabilitation, the participants received a total of 20 h of attention training, 3–5 times/week, for 5–6 weeks. The attention training was randomized into APT or ABAT.

The APT (8) is a process-oriented, theoretically and hierarchically based, individualized attention-training programme considered a "practice standard" treatment for attention deficits after brain injury (10, 61). It comprises repetitive exercises with increased difficulty and meta-cognitive strategy training for improved and more flexible use of strategies in daily life (generalization), insight, and motivation. The APT is a direct structured neuropsychological intervention. A neuropsychologist performs the training session individually (45–90 min/session), improving performance on training tasks and immediate measures of global attention (10).

The ABAT is an occupational therapy intervention comparable to the Cognitive Orientation to Occupational Performance (CO-OP) (62, 63) aiming at functional skills training on activity level and metacognitive strategies to improve performance on trained tasks. An occupational therapist conducted ABAT involving attention-demanding everyday activities in personal care, household activities, work, leisure, and social activities (60–120 min/session) (20).

Statistical analysis

Pearson χ^2 test was used to analyse sex, marital status, education, and injury-related data. A parametric *t*-test was used to compare groups on age, timing and length of intervention, the timing of follow-up, results of psychometric testing, and level of attention dysfunction. Descriptive statistics (frequencies, mean, median, standard deviations, percentiles, and confidence intervals) were calculated for the telephone interview questionnaires. Group comparison was analysed with the Pearson χ^2 test. Statistical differences between groups and subgroups were analysed for self-rated health expressed in EQ-5D dimensions (Pearson χ^2) and EQ-5D index (Mann–Whitney *U* test).

For the OGQ, this study presents data on OG 1 (i.e., "does not perform an activity that he/she wants to"). The proportion of reported OGs in the study population was compared with a Swedish age-matched reference population of 811 persons (56).

Between-group comparisons were made for the start of attention training, subacute group (SAG) vs post-acute group (PAG) and type of intervention (APT vs ABAT), as well as combined for the start of attention training and type of intervention (SAG-APT, SAG-ABAT, PAG-APT, PAG-ABAT). One-way analysis of variance (ANOVA) and Tukey-Kramer post hoc analyses were used to compare subgroups for all outcome measures. Effect sizes (ES) (64) were calculated according to Cohen's d (ES D) (small=0.2, medium=0.5, large=0.8). Levene's Test for Equality of Variances measured the homogeneity of variances within groups. The statistical significance level was set at $p<0.05$ 2-tailed for all analyses. IBM Corp. Released 2013. IBM SPSS Statistics for Windows version 22.0 Armonk, NY: IBM Corp. was used for statistical analysis.

Ethics

The study was approved by the Karolinska Ethics Committee (2014/1270-32) and was performed according to the principles of the Declaration of Helsinki.

RESULTS

No differences were found between the SAG and PAG groups, nor between APT and ABAT regarding age, marital status, education, employment, or injury-related characteristics. There was a sex difference, with more men in the SAG group than the PAG group (Pearson χ^2 5.725, df=1, $p=0.017$) and more women in the APT group than the ABAT group (Pearson χ^2 4.944, df=1, $p=0.026$). The initial APT test performance was lower for PAG than for SAG (t(98)=3.367, $p=0.001$). No differences in the APT test were found between the APT and ABAT groups. No impacts of sex and performance on the APT test were found on analysis of co-variance.

Health-related quality of life (EuroQol 5 dimensions)

There were no statistically significant differences in EQ-5D index values between SAG and PAG groups nor between APT and ABAT (Mann–Whitney *U* test) groups. Equal variances within groups are not assumed (F(3,96)=3,60, $p=0.016$) with SAG-APT showing less within-group variability (t(52)=2.120, $p=0.039$). The EQ-5D index values for the subgroups according to timing and type of intervention are shown in Fig. 1. SAG-APT had the highest mean HRQoL (0.80) and PAG-APT had the lowest (0.66).

Examination of differences regarding type and timing for the individual variables in EQ-5D indicated that participants from SAG reported fewer problems doing usual activities, χ^2 (1, N=100)=6.578, $p=0.016$).

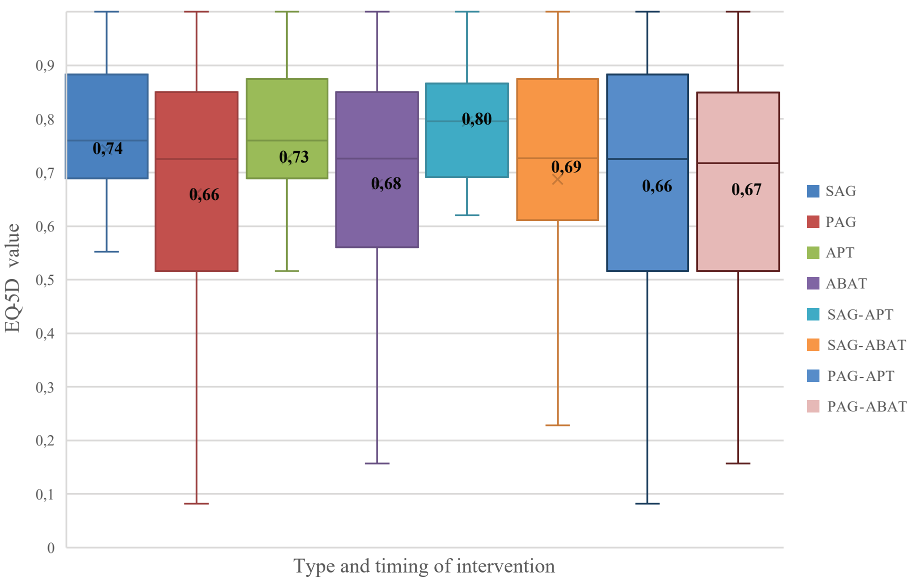

Fig. 1. EuroQol 5 dimensions (EQ-5D) index values for timing and type of intervention. Boxplots represent the distribution between the first and third quartile within each group, with the median as centreline and inserted mean values. Swedish reference data for EQ-5D index values in mean (standard deviation; SD) for a healthy population ($n=25,867$; aged 30–104 years) is 0.898 (0.112) for men, and 0.886 (0.116) for women (54). SAG (subacute group), PAG (post-acute group), APT (attention process training), ABAT (activity-based attention training).

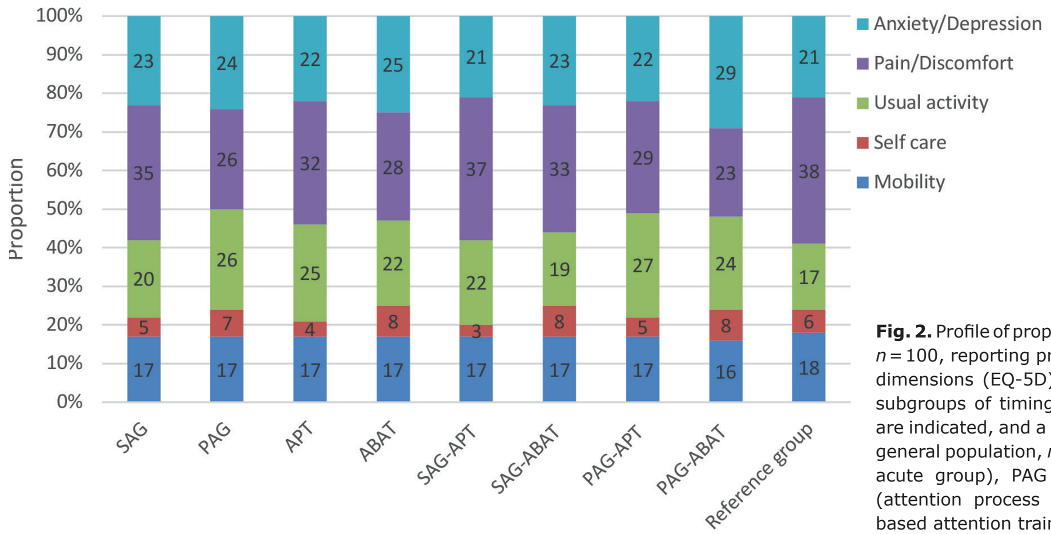

Fig. 2. Profile of proportions of participants (%), $n=100$, reporting problems in the 5 EuroQol 5 dimensions (EQ-5D) dimensions. Groups and subgroups of timing and type of intervention are indicated, and a reference group of healthy general population, $n=25,867$ (54). SAG (sub-acute group), PAG (post-acute group), APT (attention process training), ABAT (activity-based attention training).

Eighty-eight percent of the participants did not have problems with self-care, and 60% of the group reported an HRQoL corresponding to a healthy population. Proportions of participants reporting problems in the 5 EQ-5D dimensions are shown in Fig. 2.

Occupational Gaps Questionnaire

The number of OGs varied between the 4 subgroups (Table III). In the SAG group, there were significantly more participants with no OGs ($t(98)=2.008$, $p=0.047$) than in the other 3 subgroups, including reporting fewer OGs ($t(98)=-2.531$, $p=0.031$) than the median of an age-corrected healthy population. Conversely, PAG ($t(98)=-2.252$, $p=0.027$) and PAG-APT groups reported significantly more OGs ($F(3,98)=-2.054$, $p=0.045$) than other subgroups. There was no significant difference in OGs reported by the APT and ABAT groups.

The same frequency pattern of reported OGs (Fig. 3) was found in Instrumental ADL, Leisure activities, Social Activities, and Work- or work-related activities between SAG and PAG groups. The same was true for APT and ABAT groups. The highest frequency of OGs concerned cleaning, performing heavy household tasks, cultural activities and reading. Fewer problems were reported in grocery shopping, transport, meeting relatives and friends and taking care of and raising children. The SAG group reported fewer OGs in the domain of Leisure activities: "Participating in sports" ($t(1)=5.08$, $p=0.024$) and "Reading a newspaper" ($t(1)=3.348$, $p=0.004$) as compared to other subgroups. No other differences were found between study arms. The distribution of OGs in order of prevalence for all participants is shown in Appendix S1.

Self-reported employment conditions

The SAG group (Pearson $\chi^2=11.926$, df$=1$, $p=0.001$) reported a higher prevalence (47%) of successful RTW, defined as gainful employment at ≥75%, compared with the PAG group (22 %). The SAG-ABAT group reported successful RTW (Pearson $\chi^2=13.354$, df$=3$, $p=0.003$), compared with subgroups. There were no differences in RTW between APT and ABAT.

Employment conditions for the subgroups are shown in Table IV. The proportion of participants reporting working at the same work having the same or adapted work tasks varied greatly between subgroups (35–74%), with more participants in SAG, APT and SAG-APT groups, respectively, reporting the same or adapted work (63–74%). Fourteen participants reported having no gainful employment, and 17 had changed jobs due to health reasons.

Table III. Numbers and percentages of participants ($n=100$), according to their number of occupational gaps (OG) in relation to median number of OGs in an age-matched healthy reference group (86)

	Timing of intervention		Type of intervention		Type and timing of intervention			
Occupational gaps (OGs)*	SAG *n* (%)	PAG *n* (%)	APT *n* (%)	ABAT *n* (%)	SAG-APT *n* (%)	SAG-ABAT *n* (%)	PAG-APT *n* (%)	PAG-ABAT *n* (%)
Participants with no gaps	7 (13)	4 (9)	8 (15)	3 (7)	5 (19)	2 (8)	3 (11)	1 (5)
Participants with 1 OG up to the median number of gaps	23 (43)	11 (23)	22 (41)	15 (32)	12 (44)	12 (42)	7 (26)	4 (20)
Participants with greater than the median number of gaps	23 (43)	32 (68)	24 (44)	28 (61)	10 (37)	13 (50)	17 (63)	15 (75)

*Median number of OGs in the reference population were age 20–29 years = 5 OGs, age 30–49 years = 4 OGs, age 50–64 years = 2 OGs, age >65 years = 1 OG. For the reference population as a total, median number of OGs = 3.
SAG: sub-acute group; PAG: post-acute group; APT: attention process training; ABAT: activity-based attention training.

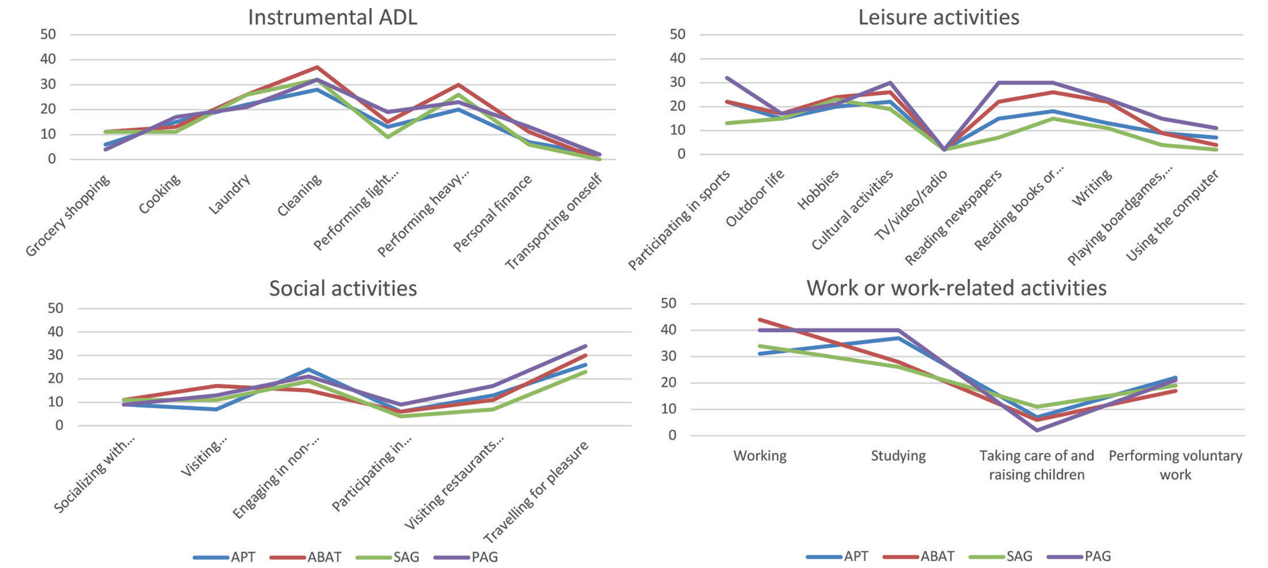

Fig. 3. Frequency of reported occupational gaps (limitations in activity) in the Occupational Gaps Questionnaire in the different domains of activities/participations for type and timing of intervention, respectively. Distribution is presented in percentage. Low percentage signifies a better functional level. SAG: sub-acute group; PAG: post-acute group; APT: attention process training; ABAT: activity-based attention training.

Forty-six percent of all participants self-reported receiving sickness benefits or sickness compensation to some degree, 70% of whom ($n=33$) received full payment due to disability. In Sweden, if a person has an RTW less than full-time, they can receive sickness compensation for the remainder up to 100%. No significant difference existed between groups and subgroups for the self-reported degree of sick leave, sickness allowance or sickness compensation.

Work Ability Index

The mean WAI Total score for the different subgroups varied between 29 and 33 points, corresponding to moderate work ability, implying a "need to improve" work ability.

SAG reported better work ability (WAI Total Score; independent sample Mann–Whitney U test, $p=0.00$) with a strong ES D (Cohen's d=–0.92) and higher self-rated work ability (WAS=t(92)3,338, $p=0.001$) (Table V) than PAG.

There were no differences in the WAI Total Score or the WAS, depending on the interventions APT or ABAT only. However, SAG-APT reported better outcome on the WAI Total Score (F(3,76)=4,755, $p=0.004$) and the WAS (F(3,90)=3,802, $p=0.013$).

The total WAI score (Table VI) grouped the participants into 4 classes, which showed that SAG (62%) self-assessed their work ability to be "good" or "excellent" to a higher degree than PAG (19%) (Fisher's χ^2 test, $p=0.001$; post hoc independent-sample Mann–Whitney U test, $p=0.000$). No statistical differences

Table IV. Self-reported employment conditions at follow-up for timing and type of intervention

	Timing of intervention		Type of intervention		Type and timing of intervention			
Variable	SAG $n=53$ n (%)	PAG $n=47$ n (%)	APT $n=54$ n (%)	ABAT $n=46$ n (%)	SAG-APT $n=27$ n (%)	SAG-ABAT $n=26$ n (%)	PAG-APT $n=27$ n (%)	PAG-ABAT $n=20$ n (%)
Actual work situation								
Employed or self-employed	32 (60)	21 (45)	28 (52)	25 (54)	16 (60)	16 (62)	12 (44)	9 (45)
Employee 75–100%[a]	25 (47)	7 (22)	16 (30)	16 (35)	11 (41)	14 (54)	5 (19)	2 (10)
Not in gainful employment	5 (9)	9 (19)	8 (15)	6 (13)	2 (7)	3 (12)	6 (22)	3 (15)
Work retraining	2 (4)	2 (4)	5 (9)	5 (11)	2 (7)	6 (23)	4 (15)	5 (20)
Working at the same work (same work tasks)	21 (40)	15 (32)	23 (43)	13 (28)	13 (48)	8 (31)	10 (37)	5 (20)
Working at the same work (adapted work tasks)[b]	14 (26)	6 (13)	11 (20)	9 (20)	7 (26)	7 (27)	4 (15)	2 (10)
Changed job due to health reasons	7 (13)	10 (21)	6 (11)	11 (24)	1 (4)	6 (23)	5 (19)	5 (20)
Sick benefit or activity compensation								
No sickness benefit or activity compensation	44 (83)	35 (74)	47 (87)	32 (70)	24 (89)	23 (88)	20 (74)	12 (60)
Sickness benefit or activity compensation 25–50%	1 (2)	5 (12)	4 (7)	2 (8)	1 (4)	2 (8)	0 (0)	5 (20)
Sickness benefit or activity compensation ≥75%	7 (15)	6 (13)	3 (5)	10 (22)	2 (7)	1 (4)	5 (26)	5 (20)

[a]Participants ($n=5$) working at 75% also receive activity compensation at 25%. [b]Participants on work retraining ($n=17$) are included in this group.
The participants could select more than 1 option in the questionnaire.
SAG: sub-acute group; PAG: post-acute group; APT: attention process training; ABAT: activity-based attention training.

Table V. Performance on Work Ability Index, showing mean (standard deviation; SD) and median for timing and type of intervention for all participants, for Total Score and for sub-dimensions separately

	Reference*	Timing of intervention		Type of intervention	
	n = 1,786 Mean	SAG (*n* = 53) Mean (SD)/md	PAG (*n* = 47) Mean (SD)/md	APT (*n* = 54) Mean (SD)/md	ABAT (*n* = 46) Mean (SD)/md
WAI Total Score (*n* = 74)[1]	41.53	36 (8)/38	29 (9)/29	33 (9)/33	33 (9)/34
Individual resources					
a. Current WA compared with estimated best (WAS)	8.25	6 (3)/8	4 (3)/5	5 (3)/6	5 (3)/6
b[1]. WA in relation to physical demands (current work)	4.29	4 (1)/4	4 (1)/4	4 (1)/4	4 (1)/4
b[2]. WA in relation to mental demands (current work)	4.23	4 (1)/4	3 (1)/4	4 (1)/4	4 (1)/4
f. Own prognosis of WA (2 years)	6.64	6 (2)/7	5 (2)/7	5 (2)/7	6 (2)/7
g. Enjoying daily activities (mental resources)	2,9	3 (1)/3	3 (1)/3	3 (1)/3	3 (1)/3
WAI Individual Health Factor[2]					
c. Number of medical diagnoses	5.82	4 (1)/4	3 (1)/3	4 (1)/4	4 (1)/4
d. Estimated WA impairment due to diseases	5.24	3 (1)/3	2 (1)/2	3 (1)/3	2 (1)/3
e. Sick leave (last 12 months)	4.15	3 (1)/3	3 (1)/2	3 (2)/2	3 (2)/2

[1]Total score for the WAI dimensions a, b[1], b[2], f, g; [2]Total score for WAI dimensions c, d, e; *Values of reference from a healthy general population (58).
SAG: sub-acute group; PAG: post-acute group; APT: attention process training; ABAT: activity-based attention training; SD: standard deviation; md: median.

were found between the APT and ABAT groups. When comparing the subgroups, the SAG-APT group reported a higher self-assessed level of work ability (t(3) = 4.996, p = 0.003).

Experienced limitations in work performance

Participants in the different groups reported cognitive and behavioural problems (Table VII), the most frequent issues concerned being more easily disrupted at work, more easily getting tired, experiencing work tasks taking longer, and concentration problems at work. The PAG group reported more problems with work tasks taking longer time than expected (Pearson χ^2 = 10.361, df = 2, p = 0.006). Participants receiving the APT reported fewer problems due to forgetting things at work (Pearson χ^2 = 6.428, df = 2, p = 0.040) and keeping the workplace tidy (Pearson χ^2 = 6.887, df = 2, p = 0.032). The SAG-APT group (t(3) = 15.910, p = 0.013) reported fewer problems keeping their workplace tidy.

All study participants experienced support from their co-workers, and 92% reported having supportive managers.

DISCUSSION

An important finding was that participants starting attention training within 4 months post-ABI reported significantly higher outcomes on HRQoL and work participation and fewer activity limitations. However, only minor differences were found for a specific intervention programme, favouring the advantage of APT within 4 months post-injury.

The results strengthen earlier findings concerning the importance of cognitive rehabilitation within the first year after ABI for functional outcome (27, 28, 32), psychological well-being (30), and vocational functioning (29, 65). Our data strongly support cognitive rehabilitation within the first 3–4 months after ABI for patients with attention impairment.

Furthermore, the subacute group perceived fewer restrictions in everyday occupations (43% vs 68%). No study was found in the literature review for the current study comparing a subacute vs a post-acute intervention group on the results of limitations in daily occupations. The time intervals between rehabilitation and follow-up in existing studies, deviate too much from our study to enable comparisons (56, 66, 67, 68).

The subacute and post-acute groups followed the same pattern when reporting restrictions in different daily occupations (Fig. 3). However, our subacute group reported fewer restrictions for "hobbies" (15%) in contrast to our post-acute group (32 %) and to Bergstrom's study (32%) (68). The results showed that sub-acute cognitive rehabilitation resulted in higher self-rated work ability (e.g., index value), especially for those receiving APT. Work ability seems linked to functional impairments, attitudes towards disability,

Table VI. Distribution of participants sorted into 4 levels of working ability (poor, moderate, good, excellent) based on the total score according to the Work ability Index (WAI) Manual and in relation to timing and type of intervention respectively

		Timing of intervention		Type of intervention		Type and timing of intervention			
WAI, %	Levels of working ability	SAG *n* = 42 %	PAG *n* = 32 %	APT *n* = 37 %	ABAT *n* = 37 %	SAG-APT *n* = 21 %	PAG-APT *n* = 16 %	SAG-ABAT *n* = 21 %	PAG-ABAT *n* = 16 %
Poor work ability	(7–27)	14	41	27	24	14	44	14	38
Moderate work ability	(28–36)	24	41	30	32	19	44	28	38
Good work ability	(37–43)	48	13	30	35	48	6	48	19
Excellent work ability	(44–49)	14	6	14	8	19	6	10	6

SAG: sub-acute group; PAG: post-acute group; APT: attention process training; ABAT: activity-based attention training.

Table VII. Experienced limitations in work performance at follow-up for timing and type of intervention. Experienced limitations are presented in order of prevalence for all participants

	Timing of intervention		Type of intervention		Timing and type of intervention			
Single questions related to experienced limitations at work, *n* (%)	SAG *n* = 45 *n* (%)	PAG *n* = 33 *n* (%)	APT *n* = 40 *n* (%)	ABAT *n* = 38 *n* (%)	SAG-APT *n* = 22 *n* (%)	PAG-APT *n* = 18 *n* (%)	SAG-ABAT *n* = 23 *n* (%)	PAG-ABAT *n* = 15 *n* (%)
I easily get disturbed at work	32 (71)	30 (91)	31 (78)	31 (81)	15 (68)	16 (89)	17 (74)	14 (93)
I easily get tired	31 (69)	28 (85)	31 (78)	28 (74)	15 (68)	16 (89)	16 (70)	12 (80)
Work tasks take longer time	30 (67)	26 (79)	30 (75)	26 (68)	16 (73)	14 (82)	14 (61)	12 (80)
It is difficult to concentrate on work tasks	25 (56)	22 (67)	23 (58)	24 (63)	12 (55)	12 (67)	14 (61)	10 (67)
I make careless mistakes	22 (50)	20 (61)	23 (58)	19 (51)	10 (45)	13 (72)	12 (52)	7 (47)
I forget to do things at work	18 (40)	19 (58)	16 (40)	21 (55)	7 (32)	9 (50)	11 (48)	10 (67)
I find it difficult initiating/ structuring my work	18 (40)	18 (54)	14 (35)	22 (58)	6 (27)	8 (44)	12 (52)	10 (67)
Relationships with co-workers have changed	16 (36)	15 (48)	16 (42)	15 (41)	8 (36)	8 (44)	8 (35)	7 (47)
I misunderstand instructions	13 (29)	12 (36)	11 (28)	14 (37)	5 (23)	6 (33)	8 (35)	6 (40)
I have difficulties in keeping up with time	14 (31)	11 (32)	16 (40)	9 (24)	9 (41)	7 (39)	5 (22)	5 (27)
I have difficulties keeping my workplace tidy	10 (22)	14 (42)	7 (18)	17 (45)	1 (5)	6 (18)	9 (39)	6 (40)
Pain affects my work performance	11 (24)	10 (30)	13 (33)	8 (21)	6 (27)	7 (39)	5 (22)	3 (20)
I have problems performing my work tasks	5 (11)	7 (21)	5 (13)	7 (20)	2 (9)	3 (17)	3 (14)	4 (27)

Results are presented in number (%) of answers reported as "yes" and "sometimes". SAG: sub-acute group; PAG: post-acute group; APT: attention process training; ABAT: activity-based attention training.

and motivation to work (69) and depends on the person's insight into injury-related problems that might influence work performance (70). In an earlier study on the management of attention (14) we found that increased self-awareness, paired with coping strategies at an early stage, potentially mitigates expedience in performance despite disability and perceived limitations in activity, which could account for the findings of higher WAI for the APT group. However, we can only hypothesize why the impact seems greater with sub-acute rehabilitation.

The comparisons showed a higher prevalence of successful RTW in patients receiving sub-acute intervention than post-acute intervention. RTW is essential for QoL (34) and is a realistic goal for many working-age patients with ABI. Thus, RTW rates are of interest in rehabilitation research, even if the interpretation beyond the usual individual functioning level needs to be careful since societal factors influence it to varying degrees. When comparing RTW rates in studies from different countries, comparisons need to respect the differences in each country. The RTW rate of 47% for gainful employment ≥ 75% is well within the range of earlier reports (43, 71–73). No study has been found comparing the sub- vs post-acute attention-training long-term outcome on RTW. Regarding RTW, the current study results do not support selecting one training method above the other. Cognitive function (38, 74–76), independence in ADL, together with pre-injury factors, such as education and type of job, and perceived work ability (76) are identified as predictive factors (75, 77) for successful RTW. Although attention dysfunction has proven to have a significant impact on RTW within 18 months post-onset (38), studies identifying the potential impact of specific cognitive disability on RTW (78) or outcome of RTW post rehabilitation (74) are scarce. No study has been found comparing the 2 attention-training methods' effects on long-term RTW.

In the current study, there were only minor statistical differences between the 2 attention interventions using measures of activity and participation, which was unexpected. Previously, our research group reported the advantage of APT on a neuropsychological outcome measure, Paced Auditory Serial Addition Test (21), using a statistical process method (49). On the level of activity and participation, using a standardized office-work task and evaluated according to the Assessment of Work Performance measure (AWP) (79, 80), significant differences were found, favouring APT post-intervention and at a 3-month follow-up for some process skills (Mental Energy, Knowledge, Temporal Organization, Adaptation and Physical Energy) (20). AWP assesses an individual's observable skills during work performance, i.e., how efficiently and appropriately a client performs a work activity. These skills are subserved by executive and attention functions trained in the programme, suggesting some transfer effects of the training from body to activity levels. For other outcome measures, such as the WAI, a significant improvement was observed after intensive rehabilitation of attention. However, there were no differences between the 2 training methods, as observed in the current study for WAI.

It should be noted that the minor differences observed in the current study supporting APT, and particularly in the subacute group (SAG-APT has the highest QoL, highest successful RTW, better outcome on WAI Total Score and fewer problems in organizing their workplace). In addition, APT patients reported fewer memory problems at work. The only discrepant result was significantly more OGs for PAG-APT.

The results of the current study can be interpreted in several contexts: (*i*) differences between process-based and activity-based attention training might disappear gradually. As time passes, practical behavioural elements, strategies and skills acquired in activity-based training get individually incorporated into everyday behaviour according to situations, needs and preferences. This slow process might smooth out early differences in the effects of training methods in the long-term. Patients utilize rehabilitation programmes differently due to their strengths and weaknesses, leading to a gradual absorption of the newly learned behavioural elements or performance skills in daily life. This process makes the effects of underlying cognitive training in one area (attention) challenging to discern. In our earlier interview study with participants receiving a multidisciplinary rehabilitation programme and APT (14), we provided examples of how patients apply APT training after discharge from rehabilitation. (*ii*) Conceptual differences in measures may be another reason for the different results. Earlier studies found low to moderate correlations between measures for cognitive tests (body-function level) and the Assessment of Motor and Process Skills (AMPS) activity level (81). As discussed previously (80), some outcome measures on activity level, such as QoL and work ability, are global measures primarily assessing the impact of a disease without referring to specific behaviours. The effects of a directed cognitive intervention might not be easily detected in such a context.

Another category of outcome measures on activity level is performance skills, defined as small observable units of behaviour used to perform a specific task (82) and offer higher conceptual proximity to variables in a neuropsychological test situation. However, these behavioural units, such as time management and structuring one's workstation, require attentional support to varying extents. Improvements in attention, a cognitive function, are thus differentially reflected in activity changes as a function of task requirements and individual qualifications. Furthermore, these measurement instruments, such as AMPS and AWP, allow the selection of different tasks or activities. Hence, differences in types of activities make group comparisons more problematic.

An additional group of activity-based measures are functionally based standardized performance-based instruments directly relevant to clinically meaningful outcomes (6). Our standardized office-task targeting skills in attention, organization, and processing skills is an example of this approach (80). The task follows a formalized procedure with standardized scoring according to predefined criteria and values for a healthy comparison group.

Due to earlier criticism regarding the lack of evidence in the generalization of cognitive training to real-life activities (83) and to answer the calling of earlier reviews (84, 85) we have selected outcome measures on the level of activity and participation in the current study. Our varying results suggest a need to distinguish between different subcategories and choose measures closely related to the target of rehabilitation, i.e., performance-based measurements, as recommended (6).

When relating the current study results to healthy reference groups for each measure, the results indicate that the subacute group rates their QoL at the same level as the healthy population and has few restrictions in daily occupations. However, participants in the current study rated their work ability (mean WAI total score) as "moderate" work ability (need to improve) in contrast to a healthy reference group ranking theirs as "good" work ability (59). The lower ratings may be interpreted as that, after 2 years, the patients still needed measures to improve their work ability, especially the 26% of the participants who experienced poor work ability.

Study limitations

First, due to the recommendation for homogeneous groups (50) the current study participants showed a restricted range of clinical symptoms, excluding patients with comorbidities, including higher severity of injury and aphasia. The current results are based on patients with mild to moderate deficits post-ABI, so the results do not apply to patients with more severe injuries and complexity in cognitive impairment.

The dropouts from the current study had lower results on logical thinking at the time of intervention, which we consider having minimal influence on the conclusions.

These results are based on self-report data regarding the working situation and social support. A third limitation thus concerns the choice of measures, as self-reports are not always reliable, due to the complexity of these measures. Independent data sources, such as registered data from insurance agencies, are recommended to give as correct data as possible on sick leave days and sickness compensation extent and periods. However, no such resources were available. A strength of the current study was the telephone-based follow-up for completing the reports, circumventing the most common confounders in self-reports, i.e., missing data and the influence of next-of-kin.

Conclusion

This study followed up working-age patients on daily activities, RTW and work ability 2 years after they had undergone intensive attention training for moderate attention impairment post-ABI. The results emphasize the importance of subacute (≤4 months) over post-acute (4–12 months) start of rehabilitation. When comparing attention training interventions, no differences could be distinguished except for a few minor advantages that could be demonstrated for APT in the group who underwent subacute rehabilitation. Valid measurements of how impaired functions influence activities and participation in the long term are complex and require further research.

Clinical implications

The results of this study provide information concerning long-term outcomes of subacute intensive attention training regarding QoL and aspects of working capacity for patients with ABI of working age. These results contribute to the accumulating body of knowledge concerning the importance of early rehabilitation. According to current clinical practice, patients are mobilized and activated during the acute inpatient and rehabilitation phases and then, after housing adaptation, often discharged to home-based rehabilitation. However, the resources of the teams providing home-based rehabilitation are not sufficient to meet the requirements of intensive attention training. These results indicate the need for providing more patients with shorter periods of intensive sub-acute outpatient rehabilitation.

Differences between training methods seemed to attenuate over time. However, the clinician should note that both APT and ABAT were accompanied by extensive metacognitive training and tasks focusing on attention-demanding activities, as recommended by several guidelines (6, 7, 45).

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