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Adherence of stroke patients with an online brain training programme: the role of health professionals' support.

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1 **Abstract**

2 *Background.* Computer-based cognitive rehabilitation (CBCR) is used to improve cognitive
3 functioning after stroke. However knowledge on adherence rates of stroke patients is limited.

4 *Objective.* To describe stroke patients' adherence with a brain training programme using two
5 frequencies of health professionals' supervision.

6 *Methods.* This study is part of a randomized controlled trial comparing the effect of the brain
7 training programme (600 minutes playtime with weekly supervision) with a passive intervention
8 in patients with self-perceived cognitive impairments after stroke. Patients randomized to the
9 control condition were offered the brain training after the trial and received supervision twice (vs
10 weekly in intervention group). Adherence was determined using data from the study website.

11 Logistic regression analyses were used to examine the impact of supervision on adherence.

12 *Results.* 53 patients allocated to the intervention group (group S8; 64% male, mean age 59) and
13 52 patients who were offered the intervention after the trial (group S2; 59% male, mean age 59)
14 started the brain training. The median playtime was 562 minutes (range 63-1264) in group S8 vs.
15 193 minutes (range 27-2162) in group S2 ($p < 0.001$, Mann Whitney U).

16 *Conclusions.* The overall adherence of stroke patients with a brain training was low and there are
17 some implications that systematic, regular interaction with a supervisor can increase training
18 adherence of stroke patients with a restitution-focused intervention performed at home.

19

20 **Keywords:** stroke, adherence, cognitive rehabilitation, supervision, support, brain training.

21

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24 **Introduction**

25 Although stroke mortality rates in the past two decades have decreased, according to the
26 World Health Federation stroke is still the second leading cause of death in the world. In 2010,
27 the absolute number of people with first stroke was 16.9 million and the number of stroke
28 survivors was 33 million [1]. Among the survivors of stroke, 22 to 50% [2,3] experience
29 cognitive impairment, such as aphasia, neglect, reduced processing speed and impaired attention
30 [4], with direct consequences for dependency in activities of daily living and functional
31 outcomes [5].

32 Neurorehabilitation after stroke is focused on compensational strategy training and
33 restitution-focused training [6]. Compensational training aims to compensate for the lost function
34 by using remaining intact functions. Restitution-focused treatments consist of frequent repetition
35 or stimulation of the affected function by high-intensity training [7,8]. Therefore, therapists often
36 prescribe intensive exercise regimes for patients [9]. However, a study found that only 31 percent
37 of patients actually performed exercises as recommended [10].

38 Recently, computer-based cognitive rehabilitation (CBCR) programmes, especially serious
39 brain games, have emerged as a tool for restitution-focused treatment in stroke patients. It is
40 expected that serious brain training helps patients in recovering from a stroke by making training
41 more fun, as monotony of repeated motions is decreased and direct feedback about performance
42 is provided [9,11,12]. However results about the effect of restitution-focused computer training
43 are still conflicting [13,14,15]. Studies are often hampered by low adherence rates [16,17,18,19],
44 although this is one of the main requirements for success of an intervention as well as improved
45 patient outcomes [20]. Laver et al. (2015) concluded in their review that studies should provide
46 more detail in their reporting of adherence of stroke patients with CBCR interventions [15].
47 Moreover, the impact of the extent of supervision on stroke patients' adherence with restitution-
48 focused interventions is unknown. It was found in a review of Kelders et al. (2012) that
49 frequency of interaction with a counselor was a significant predictor for adherence with web-
50 based health interventions in different patient groups ($p < 0.001$) [21].

51 The goal of this study was to contribute to a better understanding of the impact of
52 supervision on stroke patients' training adherence with restitution-focused interventions, as a
53 potential factor to increase adherence, ultimately leading to better treatment outcomes for those
54 recovering from stroke. The aim of the study was to describe stroke patients' adherence with a

55 home-based 8-week brain training programme (Lumosity Inc.®) by comparing two frequencies
56 of health professional's supervision. The hypothesis of the study was that a CBCR training with
57 more supervision would lead to higher training adherence in stroke patients [21].

58 **Materials & Methods**

59

60 *Study design*

61 The present study on adherence was part of a randomized controlled trial (RCT)
62 evaluating the effectiveness of an 8-week CBCR programme on cognitive functioning, quality of
63 life (QoL) and self-efficacy as compared to a passive intervention [22]. In this study no effect of
64 the CBCR programme were found on cognitive functioning, quality of life or self-efficacy when
65 compared to the control group, except for very limiting effects on working memory and speed. A
66 profile of the study is shown in Figure 1.

67 The current study compares patients in the original intervention group who received
68 supervision eight times during the CBCR intervention period (S8) vs. the original control group
69 who underwent the CBCR intervention after the original RCT and received supervision twice
70 during the intervention period (S2). For the present analysis the data from all patients who agreed
71 to take part in the programme were used.

72 Patients in the S2 group received weekly information about stroke during the period that
73 the S8 group received their intervention. The information provision was not interactive, it
74 provided unidirectional information about brain differences between men and woman, the
75 influence of stress on brain function and possible difficulties with living with a damaged brain.
76 No new information was provided in these brain facts that were not already extensively
77 addressed during previous rehabilitation treatment. Each week, during a period of 8 weeks, new
78 information (text or a video clip) was added to the website. The study was approved by the
79 Medical Ethical Review Board of The Leiden Medical Centre (P 12.190). The CONSORT
80 (Consolidated Standards of Reporting Trials) guidelines were used for adequate reporting of the
81 study [22].

82

83 [Figure 1 near here].

84 *Recruitment and inclusion*

85 Inclusion criteria for participation in the study were: age between 45 and 75 years,
86 diagnosed with stroke 12-36 months ago, having self-perceived cognitive impairments (extracted

87 from a checklist accompanying the recruitment letter), having access to the Internet, being able
88 to visit the rehabilitation centre and having time to participate. Exclusion criteria were:
89 antidepressant use; receiving actual treatment for cognitive impairments; severe aphasia; lack of
90 computer skills; not being proficient in Dutch; participants with psychological disorders in need
91 of treatment; patients with physical disorders known to impact cognition. Patients were recruited
92 from the participating rehabilitation centers.

93 The recruitment procedure is described in more detail in a previous report [23]. In total,
94 142 patients meeting the inclusion criteria were screened for eligibility, of whom 53 were
95 eventually randomised to the S8 group and 57 patients to the S2 group. 50 patients (94%) in the
96 treatment group and 57 patients (100%) in the control group completed the study. Of the S2
97 group, 52 accepted the offer to participate in the programme after the trial was completed. A
98 flow chart of the inclusion is shown in Figure 2.

99

100 ***Intervention***

101 The CBCR intervention was a home-based brain training programme with a duration of 8
102 weeks. The duration of 8 weeks for both the intervention and the follow-up were based on
103 clinical expertise by the research team and the health professionals involved in the project team.
104 All participants received a user identification and password to log on to a website providing
105 access to the brain training (www.spelenderwijsbeter.nl). The training software was supplied by
106 Lumosity Inc.®. This programme was selected because it targets multiple cognitive domains and
107 adapts the level of difficulty of games to a patients' own abilities. In total, 16 games were used
108 targeting five cognitive domains: attention, speed, memory, flexibility and problem solving.

109 The minimum requested total playtime was 600 minutes. Patients were encouraged to
110 complete at least one session a day (approximately 15-20 minutes) on at least 5 days per week.
111 Each session, random selections of three games were assigned to the participant, each game
112 lasting about five minutes. Patients were able to play longer after finishing the training session.
113 Furthermore, participants were instructed to complete an extra game session when they missed
114 one game session and/or were not able to play 5 days a week. With each game, all patients
115 started at the same level of difficulty. The difficulty level was then raised or lowered depending
116 on the performance in the previous round of the respective game. The software provided

117 feedback about game scores and how much games were completed. Patients could receive
118 reminders for training by e-mail or a text message for mobile phone.

119

120 *Supervision*

121 During the training period, patients from the S8 group received digital support by a
122 supervisor. Supervisors were three health care providers (a psychologist, physical therapist and
123 occupational therapist) from the two rehabilitation centers that participated in the study. The
124 supervision consisted of a short meeting with their own supervisor at the first assessment day in
125 the rehabilitation centre. Moreover, digital support was provided to patients weekly during the 8-
126 week training period by their supervisor by telephone if training adherence was lower than five
127 times a week.

128 A structured plan with instructions and a timeline was provided to the supervisors.
129 Moreover, during a meeting at the start of the intervention and evaluations during the
130 intervention these instructions were discussed with the supervisors. Supervisors were instructed
131 that contact was aimed at: (1) providing assistance needed to solve problems impairing a patient
132 to play (e.g. help with software problems, explaining game instructions, install a reminder for
133 training appointments, etc.), (2) providing strategies to achieve or improve adherence by using
134 the Plan-Do-Check-Act method and (3) encourage patients to increase training frequency by
135 using motivational interviewing. Moreover, patients were able to contact their supervisor
136 themselves by email or telephone anytime they needed assistance, for instance in case of
137 problems with training software or questions about a certain game.

138 Patients from the S2 group received supervision twice during the training period: a short
139 meeting with their supervisor at the start of the brain training and contact by telephone once,
140 after 4 weeks of training. They were encouraged to contact the supervisor by email or telephone
141 in case they experienced difficulties using the training.

142

143 *Assessments*

144 The main outcome of interest in the current study was training adherence during the intervention
145 period. Moreover, patient characteristics were used to determine which variables predict
146 adherence. These data were retrieved from medical records and online questionnaires.

147

148 *Adherence*

149 Training adherence was measured by registering the patients' frequency of logging on to the
150 website of the study during the total training period of 8 weeks and for each week. This was done
151 in order to determine whether patients played 40 times in total (five times a week during 8
152 weeks) as was required. Data were automatically recorded by the software of the website and
153 therefore gathered independently of the provider of the software. In addition, the patients'
154 playtime, expressed as the minutes played during the 8-week training period for all cognitive
155 domains together and for each cognitive domain (attention, memory, speed, flexibility, problem
156 solving) were registered. These data were provided by Lumosity Inc.®. Logging into the brain
157 training and not playing any game was not registered as playtime.

158

159 *Patient characteristics*

160 Demographic characteristics included gender, age (years) and level of education (low:
161 primary and lower vocational education; middle: secondary and middle vocational education;
162 high: higher vocational and university education) [24]. In addition, living situation
163 (alone/together with spouse or other(s)), daily functioning (dependent/independent) and
164 participation in paid work (yes/no) were recorded. Stroke characteristics included the affected
165 hemisphere (left/right/other), type of stroke (infarction/hemorrhage), time between stroke and
166 enrollment and length of stay in the rehabilitation center (in months).

167 Physical and psychological characteristics included Health related quality of life
168 (HRQoL), measured with a Dutch version of the short Stroke Specific Quality of Life
169 Questionnaire (SSQoL) with higher scores indicating better quality of life (range 12-60) [25],
170 self-perceived cognitive failures, measured with a Dutch version of the 25-item Cognitive
171 Failures Questionnaire (CFQ) with higher scores indicating less cognitive failure (range 0-100)
172 [26] and self-efficacy, measured with a Dutch version of the general self-efficacy scale (SES)
173 with higher scores indicating greater self-efficacy (range 10-40) [27,28].

174

175 *Analysis*

176 Patients' baseline characteristics and adherence with the CBCR programme were
177 analysed using descriptive analyses. Data were presented as the number with percentage, median
178 with the range or mean with SD. It was tested if variables were normally distributed by means of

179 the Kolmogorov-Smirnov normality-test. Differences between the S8 group and S2 group were
180 analysed with independent t-tests, Mann-Whitney U tests or Chi-square test, where appropriate.

181 Logistic regression analyses were used to examine the impact of the extent of supervision
182 on training adherence. Adherence (high and moderate versus low) was dichotomized to be used
183 as dependent variable. Moderate/ high adherence was defined as ≥ 300 minutes, as this was half
184 of the required amount of total playtime (600 minutes). Low adherence was defined as < 300
185 minutes of total playtime. All cognitive domains were included. The impact of supervision
186 (group S8/ group S2) was included as independent variable, while adjusting for the following
187 potential confounders: age, sex, educational level, type of stroke, affected hemisphere, cognitive
188 failure (CFQ), quality of life (QoL) and self-efficacy (SES). Moreover, multiple logistic
189 regression analyses with a stepwise backward selection procedure were executed in order to
190 determine which variables predict adherence. Variables with the highest P value were removed
191 one by one from the prediction model, until all remaining variables were $P < 0.05$. All analyses
192 were performed with the SPSS statistical software package (version 21).

193 **Results**

194

195 *Patient characteristics*

196 The analysis on adherence concerned 53 patients who were allocated to group S8 and 52 patients
197 in group S2, who agreed to participate in the CBCR programme after the trial ended (Figure 2).

198 Characteristics of the 105 patients included in the study are presented in Table 1. The mean age
199 of all patients was 59 (range 46-74) and 66 (63%) of the patients were male. Patient
200 characteristics were similar for group S8 (baseline) and group S2 (t=16 weeks), except for more
201 patients who had had a haemorrhage in group S8 (21/53; 40%) compared to group S2 (11/52;
202 21%) (p=0.04).

203

204 [Table 1 near here].

205

206 *Adherence*

207 A number of 21 out of the 105 (20%) included patients failed to complete any game.

208 Reasons for not playing at all, as recorded by the supervisor, were: technical problems with the
209 computer (n = 6), lack of motivation (n = 6), health problems (n = 4), vacation (n = 3), hospital
210 stay (n = 1), finding training too difficult (n = 1). From the remaining 84 patients who completed
211 at least one training session, 46 patients (87%) were in the S8 group and 38 (73%) in the S2
212 group (p<0.01, Chi-Square). Data about adherence for both groups are presented in Table 2.

213 The median total play time was 424 minutes (range 27-216; 71%) in the total population.
214 The median playtime in group S8 was 528 min (range 63-1264; 88%) vs. 193 min (range 27-
215 2162; 32%) in group S2 (p<0.001 Mann Whitney U). In the total group, 24 out of 84 patients
216 (29%) played ≥ 600 minutes. In groups S8 and S2, 19/53 (36%) and 5/52 (10%), of the patients
217 played ≥ 600 minutes (p<0.001, Chi-Square). The median frequency of logging into the website
218 during the training period was 66 (1-164) in group S8 and 47 (1-318) in group S2 (p<0.001
219 Mann Whitney U). A number of 7 patients from group S2 did not receive interaction with their
220 supervisor after 4 weeks of brain training, since they did not respond to any of the calls.

221 The Odds Ratio of being in the moderate and high adherence group was 3.4 [95% CI 1.98
222 – 5.96] (p=0.00) for patients who received weekly supervision (group S8), –0.9 [95% CI 0.86 –
223 1.02] (p=0.06) for older age (each year of life), 1.65 [95% CI 0.78 – 3.46] (p=0.19) for higher

224 self-perceived quality of life (SSQoL), 1.0 [95% CI 0.99 – 1.05] (p=0.26) for higher subjective
225 cognitive failure (CFQ), 1.1 [95% CI 0.92 – 1.08] (p=0.50) for higher self-efficacy (SES) and 1.8
226 [0.67 – 4.60] (p=0.25) for patients with a high educational level.
227
228 [Table 2 near here].

229 **Discussion**

230 The aim of this study was to compare two different types of support on training
231 adherence in chronic stroke patients. This study found that only 24 out of 105 patients (23%)
232 were able to complete the required amount of playtime (600 minutes) of brain training. Training
233 adherence was significantly higher for the patients in group S8 (median 528 minutes, range 63-
234 1264) compared to patients in group S2 (median 193 minutes, range 27-2162). A small
235 proportion of patients (5/52, 10%), who had interaction with a supervisor twice (group S2), were
236 able to complete the training. Therefore, there are some implications that systematic, regular
237 interaction with a supervisor can increase stroke patients' training adherence with a restitution-
238 focused intervention performed at home.

239 The observation of non-adherence to a CBCR training programme in patients with stroke
240 is in line with findings of other studies [16,17,18,19]. The adherence rate for all patients found in
241 the current study was 29% (36% in group S8 vs. 10% in group S2), but cannot be compared to
242 those studies because of lack of adequate reporting of training adherence [15]. Compared to an
243 average adherence rate of 50% found in a review of 101 publications about Web-based
244 interventions in different areas (chronic conditions, lifestyle and mental health) adherence was
245 low [21], which confirms non-adherence with CBCR programmes is a problem among patients
246 with stroke.

247 Although a number of patient characteristics were examined with respect to their
248 association with training adherence, apart from the extent of supervision, no other predictors
249 were found in the current study. Therefore it remains unclear for which patients with stroke a
250 CBCR programme in its current form is most suitable. The intensity of training (600 minutes
251 within 8 weeks) might be too demanding for stroke patients. It should be further investigated if
252 lower intensity of training can improve adherence among patients with stroke.

253 The current study has a number of limitations. First, patients in the S8 group were
254 allocated to the intervention group during the RCT and probably received in general more
255 attention (outside the weekly contact) compared to patients from group S2. Second, interactions
256 between the supervisors and patients were not logged (e.g. topics of conversation and duration of
257 contacts) and could therefore not be verified. It cannot be truly concluded that patients who
258 received more support from supervisors showed greater levels of adherence than those who
259 received very little support.

260 Third, there should be the same time difference between being informed about the study
261 and the start of the intervention in both groups. Patients in the S8 group started the training
262 straight away when it was still exciting and novel, while patients in the S2 group had to wait 16
263 weeks when excitement could have waned. On the other hand, those patients were probably still
264 motivated to participate in the brain training, given the option to start the training themselves
265 (self-selection). Moreover, the control group has been given some information about stroke at the
266 time when the intervention group was underwent the brain training procedure. This passive
267 intervention could have had limited impacts on the patients. But the information was very
268 general and previously received by patients during their rehabilitation process.

269 In conclusion, the overall adherence with an online brain training was low and it seems
270 that serious brain training is not suitable for all initially motivated chronic stroke patients.
271 Moreover, despite a number of methodological limitations in the study design, this study
272 provides ground to further investigate the effect of the extent of supervision on training
273 adherence of stroke patients with restitution-focused training. Although only little or no effects
274 were found on cognitive functioning, self-efficacy and quality of life of the restitution-focused
275 brain training in the overall study [23], this seems important since low adherence rates
276 undermine the effect of interventions. A future study is recommended comparing three groups
277 operating simultaneously with one intervention group receiving weekly support, a second
278 intervention group receiving only two episodes of support and a control group.

279 **Declaration of interest**

280 The authors report no declarations of interest. The authors alone are responsible for the content
281 and writing of the paper.

282 **References**

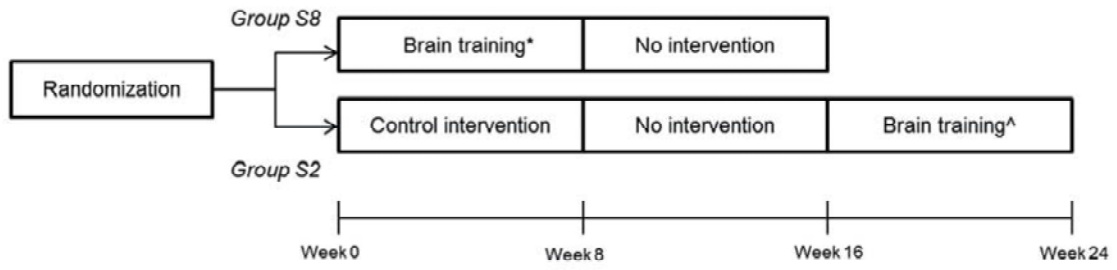
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360

361 **Figure 1. Study profile**
362



*Weekly contacts with a supervisor during the 8-week training period (S8)

^Contacts with a supervisor twice (S2)

363
364

365
366

367

368 **Figure 2. Flow of inclusion**

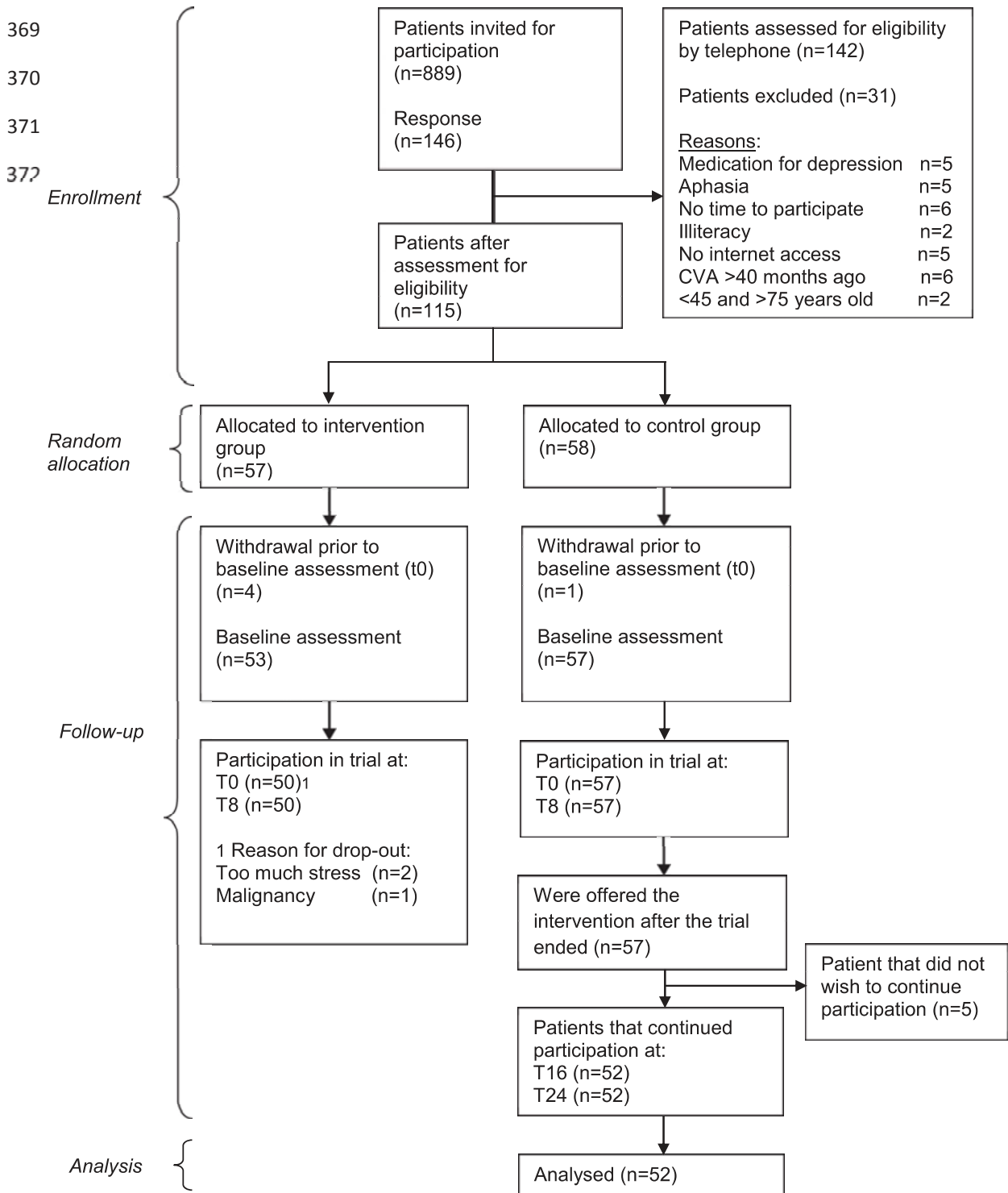


Table 1. Baseline characteristics of patients with stroke who participated in an 8-week CBCR programme, presented for all patients and per group.

	All patients (n=105)	Group 1 (n=53)	Group 2 (n=52)	Between groups (<i>P</i> -value)*
Age in years; median (range)	59 (46-74)	59 (46-74)	59 (46-73)	0.85
Sex, male;	66 (63)	34 (64)	32 (62)	
Type of stroke:				
Infarction, n (%)	68 (67)	29 (55)	41 (79)	
Haemorrhage, n (%)	34 (32)	21 (40)	11 (21)	0.04
Unknown ‡, n (%)	3 (6)	3 (5)	0 (0)	
Location of stroke:				
Hemisphere left, n (%)	50 (48)	23 (43)	27 (52)	
Hemisphere right, n (%)	50 (48)	26 (49)	24 (46)	0.21
Basal ganglia, n (%)	3 (3)	3 (6)	0 (0)	
Unknown ‡, n (%)	2 (2)	1 (2)	1 (2)	
Time from stroke onset to randomization in months; mean (SD)	25 (8.2)	26 (9.1)	25 (7.5)	0.32
Time spent in rehabilitation centre in months; mean (SD)	5.8 (3.6)	6 (3.6)	5 (3.4)	0.23
Educational status ¥:				
Low, n (%)	36 (34)	17 (32)	19 (36)	
Intermediate, n (%)	33 (32)	18 (34)	15 (29)	0.94
High, n (%)	36 (34)	18 (34)	18 (35)	
Living alone, n (%)	26 (25)	13 (25)	13 (25)	0.84
Independent in daily functioning, n (%)	101 (96)	52 (98)	54 (95)	0.35
Participation in paid work, n (%)	32 (31)	14 (26)	18 (35)	0.33
Subjective cognitive failure≠; median (IQR)	63 (20)	63 (19)	63 (20)	0.62
Quality of life~; median (IQR)	3.7 (2.5)	3.7 (2.4)	3.8 (2.4)	0.57
Self-efficacy^; median (IQR)	30 (15)	28 (14)	30 (15)	0.83

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*Differences between the groups were analysed with independent t-tests, Mann-Whitney U tests or Chi-square test, where appropriate.

‡ No data were available for medical status.

¥ Low: lower technical and vocational training; median: secondary technical and vocational training; and high: higher technical and vocational training and university.

≠ Measured with the Cognitive Failures Questionnaire (CFQ): range 0-100; higher scores indicating less cognitive failure.

~ Measured with the Stroke Specific Quality of Life Questionnaire (SSQoL): range 12-60; higher scores indicating better quality of life.

^ Measured with the General Self Efficacy Scale (GSES): range 10-40; higher scores indicating greater self-efficacy.

Table 2. Training adherence with an 8-week CBCR programme, presented for all stroke patients and per group*

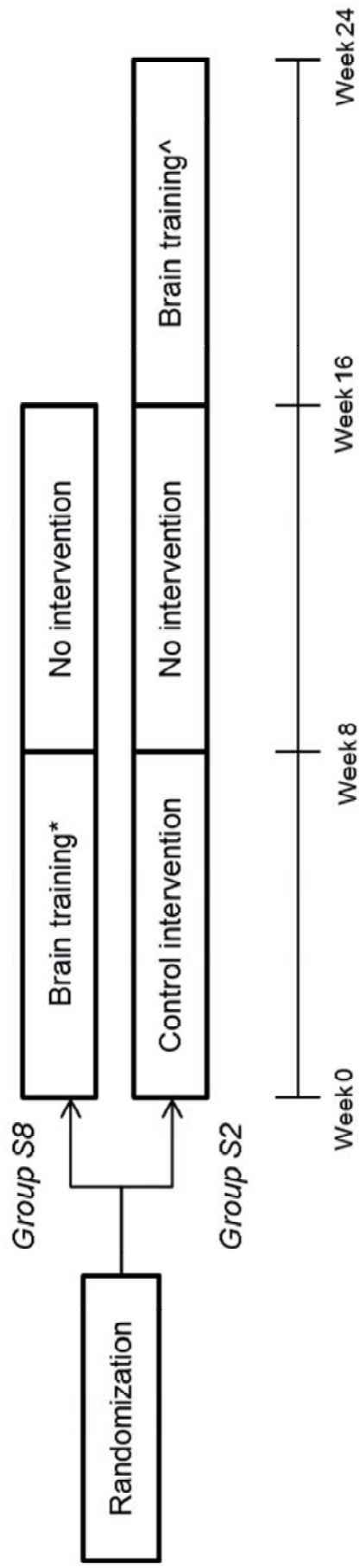
	All patients (n=84)	Group 1 (n=46)	Group 2 (n=38)	Between groups (P-value)[^]
Total time played (minutes):	424 (27-2162)	528 (63-1264)	193 (27-2162)	<0.001
Total time played per cognitive domain (minutes), %:				
Attention	58 (2-466) (14)	60 (3-408) (11)	37 (2-466) (19)	0.002
Speed	49 (1-139) (12)	53 (3-139) (10)	6 (1-48) (3)	<0.001
Memory	168 (4-646) (40)	232 (26-646) (44)	95 (4-645) (49)	<0.001
Flexibility	87 (4-1009) (21)	109 (6-349) (20)	50 (4-1009) (26)	0.001
Problem solving	53 (1-265) (13)	81 (1-265) (15)	7 (2-168) (3)	<0.001
Frequency of logging on to the website (number):	50 (1-318)	66 (1-164)	47 (1-318)	<0.001

385 *Presented as the median total play time (in minutes) with the range and percentage of the total play time,
386 unless indicated otherwise.

387 [^]Differences between the groups were analysed with independent t-tests, Mann-Whitney U tests or Chi-
388 square test, where appropriate.

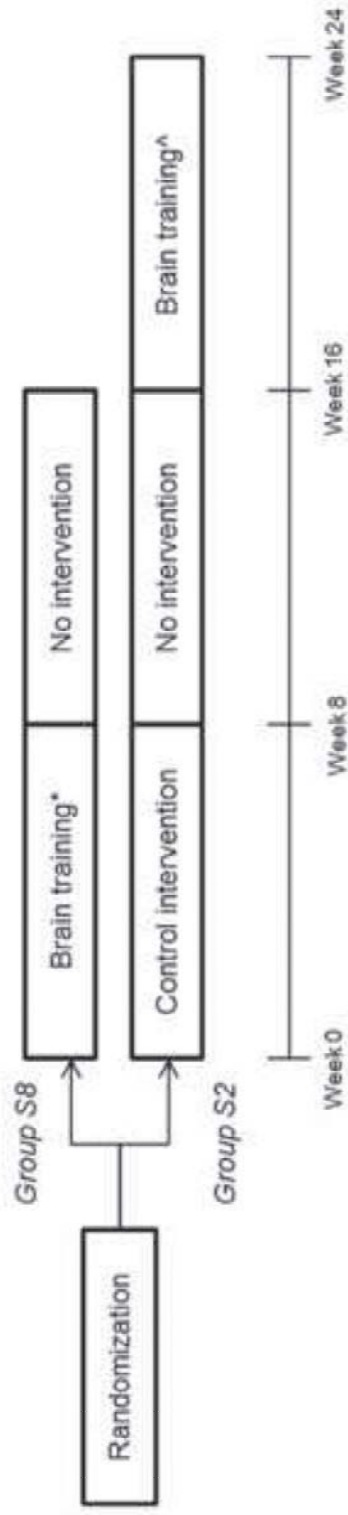
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Figure 1



*Weekly contacts with a supervisor during the 8-week training period (S8)

^Contacts with a supervisor twice (S2)



*Weekly contacts with a supervisor during the 8-week training period (S8)

^Contacts with a supervisor twice (S2)

Figure 2

Figure 2. Flow of inclusion

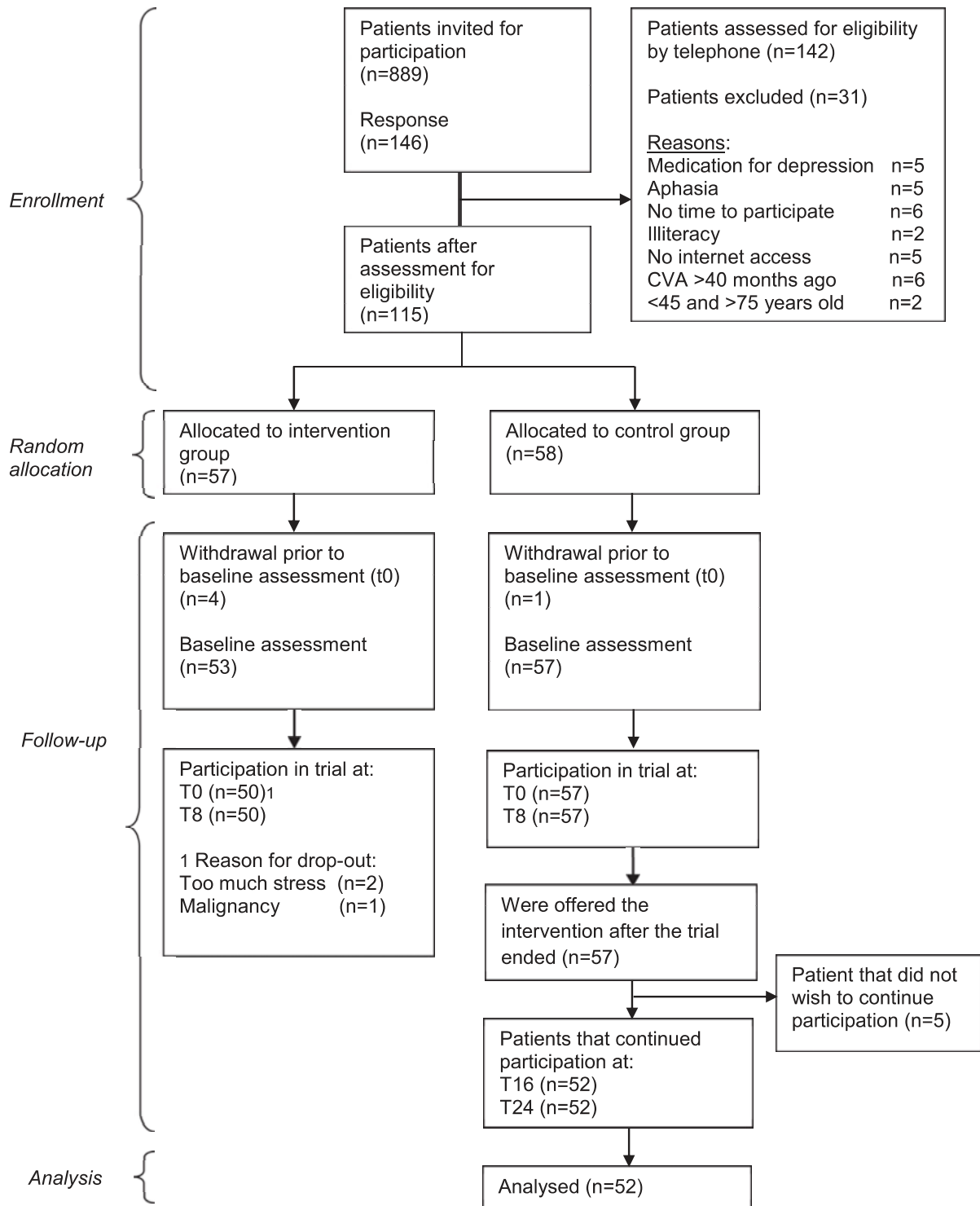


Figure 2

