ORIGINAL ARTICLE

The efficacy of computerized cognitive rehabilitation in improving attention and executive functions in acquired brain injury patients, in acute and postacute phase

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ABSTRACT

BACKGROUND: Cognitive deficits, particularly executive dysfunction is common following acquired brain injury (ABI) and has detrimental effect on functional status and autonomy in daily life. Among various cognitive training methods, computerized cognitive rehabilitation (CCR) has been investigated as an alternative method to therapist-driven cognitive rehabilitation (TCR). However, previous studies have shown conflicting results on the superiority or inferiority of CCR and TCR.
AIM: To investigate the efficacy of TCR and CCR in improving executive function in patients with acute-to-subacute ABI.
DESIGN: A prospective, assessor-blinded randomized controlled trial.
SETTING: Hospitalized care setting in the department of rehabilitation in a university hospital.
POPULATION: Thirty-two acute-to-subacute (less than 3 months after onset) ABI patients with executive dysfunctions were included in this study. The mean time after injury was 25.1±18.1 days.
METHODS: Participants were assigned to the TCR group (N.=14) or the CCR group (N.=18). Each group performed TCR or CCR for 30 minutes each day for two weeks in addition to routine rehabilitation. Neurocognitive function tests to assess complex attention, executive function, general cognitive function (mini-mental status examination [MMSE] and Montreal Cognitive Assessment [MoCA]), and functional evaluations [modified Barthel Index, MBI]) were performed at baseline (T0) and at the end of treatment (T1).
RESULTS: The TCR and CCR groups showed significant improvements in the MMSE (P=0.004, 0.000), MoCA (P=0.003, 0.006), and MBI (P=0.000, 0.000) scores. TCR and CCR groups both showed significant improvements in some of the complex attention tests (trail-making test A, P=0.002, 0.005) and executive function tests (trail-making test B, P=0.016, 0.016). The TCR group showed significant improvements in the additional executive function tests (phonemic fluency test, P=0.004, semantic fluency test, P=0.001), while the CCR group showed significant improvements in the additional complex attention tests (symbol search, P=0.02, digit symbol coding, P=0.002). In the intergroup comparison of the changes from pre- to postintervention, only the TCR group showed a significant improvement in the phonemic fluency test (P=0.013).
CONCLUSIONS: TCR might be more effective than CCR in improving frontal lobe-related executive function in ABI patients. CCR might be beneficial for improving psychomotor speed and working memory.
CLINICAL REHABILITATION IMPACT: TCR or CCR should be chosen according to the targeted domain of cognitive dysfunction in acute-to-subacute ABI patients.

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KEY WORDS: Cognitive disorders; Therapy, computer-assisted; Executive function; Brain injuries.

Acquired brain injury (ABI), which refers to the damage to the brain in nonprogressive nature, includes hemorrhagic stroke, ischemic stroke, and traumatic brain injury and results in a significant burden on the individual and community.[1] Persistent cognitive deficits are common following ABI, particularly deficits in executive function-

ing, attention, and learning.[2, 3] These *sequalae*, together with other motor dysfunctions following ABI, have a detrimental effect on functional status and may decrease individuals' autonomy in daily life.[4] Stroke survivors with mild or severe cognitive dysfunction are 3.17 or 12.20 times more likely to have self-care problems and 3.31 or 16.61 times more likely to have problems performing daily activities.[5] Among the various domains of cognitive function, executive function in particular is considered to be a strong predictor of recovery from disability in patients with acute stroke.[4, 6]

Executive functions are higher-order cognitive regulatory processes that include inhibitory control, working memory, planning, decision-making, and error correction, which enhance a patient's capacity to problem-solve and sustain goal-oriented exploration.[7-9] Executive dysfunction hampers individuals' capacity to adapt to diverse situations and prevents them from acquiring independent living skills, thereby preventing their successful community re-entry after ABI.[10]

Therefore, individuals with ABI may require the restoration of not only basic cognitive function but also executive function to perform complex and adaptive tasks.[11] On the other hand, improvement in cognitive impairment after ABI mostly occurs in the first year after onset,[12, 13] and the largest magnitude of improvement occurs within the first 3 months after onset.[14] Furthermore, it has been stated that the recovery of cognitive functions occurs faster when interactive rehabilitation programs are practiced during the acute or subacute stroke stage.[15-17] Accordingly, it would be meaningful to investigate the optimal rehabilitative interventions for improving executive function in individuals in the acute-to-subacute phase after ABI.

Approaches to improve cognitive function, via cognitive rehabilitation, in ABI patients have long been researched. Cognitive rehabilitation approaches can generally be divided into two categories, restorative and compensatory approaches.[18] Restorative approaches aim to strengthen individuals' impaired cognitive function and improve their cognitive ability through repetitive training, while compensatory approaches focus on modifying patients' behavioral patterns and teaching them ways to cope with lost cognitive functioning.[19, 20]

Among the various cognitive training methods, computerized cognitive rehabilitation (CCR) has been investigated as an alternative or supplementary method to therapist-driven cognitive rehabilitation (TCR). Many CCR programs utilized in previous studies are included in restorative approaches composed of repetitive training programs to enhance cognitive function.[10, 18, 21-23] Even though the efficacy of CCR by itself in ABI patients has been observed,[3, 21-29] previous studies have shown conflicting results on the superiority or inferiority of CCR and TCR.[30, 31] In addition, a number of previous studies utilizing CCR did not focus on executive function[23, 26, 29, 32] or did not include an adequate control group for comparison[22, 23, 25] or only included patients in the chronic phase.[3, 21, 23-25, 27, 32-34] Thus, we thought that the efficacy of restorative TCR and CCR in improving executive function in acute-to-subacute ABI patient needs to be compared.

Consequently, the aims of this study were to investigate the effectiveness and efficacy of restorative TCR and CCR in improving executive dysfunction and to distinguish the benefits of the two methods in acute-to-subacute ABI patients.

Materials and methods

Participants

This study is a prospective, randomized controlled study with an assessor-blinded, two-arm parallel group design using a 1:1 ratio of allocation, in accordance with the CONSORT recommendations. Patients included in this study were the ones with non-coma ABI, including hemorrhagic stroke, ischemic stroke, and traumatic brain injury, who were admitted to the Department of Physical Medicine and Rehabilitation in a university hospital in Korea from August 2018 to March 2020 were included in this study. The patients were randomly assigned to one of two groups (TCR or CCR). An independent researcher used sequentially numbered containers for randomization. Either the patient or a relative of the patient was adequately informed about the study and provided written consent. This study was approved by the relevant institutional review board and research ethics committee (N. 2018-10-007) before experiment began. All methods were performed in accordance with the principles set forth in the Helsinki Declaration, relevant guidelines and regulations.

The inclusion criteria for the participants were as follows: 1) a diagnosis of ABI confirmed by brain imaging studies and clinical data; 2) ABI that developed fewer than 3 months prior; 3) the presence of cognitive impairment (Mini-Mental Status Examination [MMSE] score ranging from 10-26 or clinical dementia rating score of more than 0.5 points); 4) the absence of disabling sensory alterations, severe psychiatric and medical illness; and 5) an age older than 18.

The exclusion criteria were as follows: 1) having a severe cognitive comorbidity to participate in an adequate cognitive rehabilitation training (*e.g.* impaired alertness, sensory aphasia, neglect, amnestic syndrome interfering with treatment); 2) having a medically unstable condition (*e.g.* pneumonia, cardiovascular diseases); 3) being illiterate; and 4) having had severe cognitive, neurologic, muscular and mechanical problems before the onset of ABI.

Instrumentation

In the present study, the CCR software used was RehaCom (Hasomed GmbH; Magdeburg, Germany), which is a comprehensive program that uses computer systems for cognitive training. RehaCom includes a number of therapeutic modules that activate and stimulate specific cognitive domains: complex attention, working memory, visuomotor abilities, visual field, and other executive functionings.[35] The modules for each domain have different levels of complexity that can be automatically adjusted in response to whether the subject succeeds or fails in a given task.[23] The computer also gives the subjects auditory instructions and feedback on their performance in their own language. In each module, the number of errors and test completion time for each patient are recorded; the records can be reviewed at every successive training session as a reference value for planning further training.

Intervention

Comprehensive rehabilitation, including physical therapy and occupational therapy, for physical disabilities other than cognitive dysfunction was performed on the patients in both groups in the same manner with the same dose; 60 minutes of physical therapy and 30 minutes of occupational therapy were performed 5 days a week for 2 weeks. The physical and occupational therapy sessions were composed of various treatment approaches; biomechanical and neurophysiological approach, task-oriented training, strengthening exercise, and motor relearning for physical therapy; range of motion exercise, gross motor and fine motor exercise, and activities of daily living (ADL) training for occupational therapy.[36-38]

For the TCR group, in addition to routine rehabilitation, 30 minutes of cognitive training with a restorative approach was performed daily. The treatment was administered by 3 occupational therapists who were qualified in performing adequate cognitive rehabilitation. The therapeutic session was composed of manual tabletop activities that were designed to improve multiple neurocognitive domains including attention and executive functions. The therapists were allowed to intervene initiatively to any extent during the session in accordance with occupational and cognitive remediation principles and theories.[39-42]

For the CCR group, on the other hand, an additional 30 minutes of cognitive training using RehaCom was performed daily. Among the various training modules, we chose to focus on several specific modules that were closely related to the following domains of complex attention and executive functioning: divided attention, working memory, calculation and planning. One of three trained therapists was randomly assigned to supervise each patient. For every patient, the first time each module was performed, the therapist provided instructions on the training procedure. Afterwards, the therapist intervened only when the patient was unable to complete the module in an appropriate way and corrected only the technical or procedural aspects to maximize the role of CCR. The therapist took into account the information recorded from past sessions and gradually adjust the difficulty of the modules accordingly as the treatment progressed.

These additional TCR and CCR sessions for each group were performed 5 times a week for 2 weeks.

Outcome measures

Cognitive function was assessed in both groups at the time of enrollment (T0) and at the end of the 2 weeks of treatment sessions (T1) by the same experienced psychologist who was blinded to group allocation. Functional performance in ADL was assessed by occupational therapists who were also blinded to group allocation.

To assess cognitive dysfunctions according to various neurocognitive domains, we utilized the following assessment tools. We used subtests included in the third edition of the Wechsler Adult Intelligence Scale; working memory index tests, including the digit span forward and backward (DSF, DSB, respectively) tests; and processing speed indexes, including the digit symbol coding (DSC) and symbol searching (SS) tests. In addition, the following specific tests were also included; the trail making test A and B (TMT-A, TMT-B, respectively) and controlled oral word association test (COWAT). To specify the utilities of each used measurement tools, DSF and DSB measure immediate and sustained verbal working memory; DSC, SS, and TMT-A measure complex attention (processing speed and selective attention); TMT-B and DSB measure executive function (mental flexibility and executive control of attention).[43-46] The COWAT was used to assess the efficiency of

retrieval strategies, self-monitoring and inhibition of inappropriate responses. The COWAT is composed of the phonemic (letter) fluency test (PFT) and semantic (category) fluency test (SFT) and is widely used to assess frontal and temporal lobe executive dysfunction.[47, 48] When undergoing the PFT or SFT, the subject is asked to name as many items as possible under a time constraint of 1 minute. In the PFT, the subject is asked to name words with specific initial letters in sequence (normally C, F, and L in the English language; "[giyeok]," " [ieung]," and "[siot]" in the Korean language). In the SFT, the subject is asked to name objects in given categories (animals, fruits, and vegetables).

For the assessment of general cognitive function, the total score and subscores of the MMSE and Montreal Cognitive Assessment (MoCA) were recorded. We utilized the MoCA as well as the MMSE because it contains several more items for assessing executive function.[49] Moreover, MoCA is known to be a more sensitive test in detecting mild cognitive dysfunction and is more indicative of functional impairments in patients with stroke.[50] The functional performance in ADL was measured by the Modified Barthel Index (MBI) at T0 and T1. The primary outcome measures of this study were the test results of executive function assessment; DSB, TMT-B, and COWAT (PFT and SFT).

Statistical analysis

The statistical analyses were performed using the Statistical Package for the Social Sciences, version 19 (IBM Corp.; Armonk, NY, USA), for Windows. We compared the demographic and clinical characteristics and initial neuropsychological assessment results between the TCR and CCR group with independent t-tests, 2-tailed Mann-Whitney U tests, χ^2 tests, and Fisher's Exact tests, as appropriate. Additionally, as some data were not normally distributed according to Shapiro-Wilk test results, nonparametric tests were also used to evaluate the intragroup and intergroup differences. The paired t-tests and Wilcoxon signed-rank test were used to analyze the intragroup changes over time, while the two-tailed Mann-Whitney test was used to compare the intergroup differences in the magnitude of improvement from T0 to T1.

Data availability

The data associated with the paper are not publicly available but are available from the corresponding author on reasonable request.

Results

Between August 2018 and March 2020, 133 participants with ABI were assessed for eligibility. Ninety-eight participants were excluded because they did not meet the inclusion criteria (severe cognitive impairment ([MMSE<10] [N.=50] or intact cognitive function [MMSE>26] [N.=13]), unwillingness to participate (N.=34), or medically unstable status (N.=1). After randomization, there were 3 dropouts because they were discharged early from the hospital. Finally, 14 patients in the TCR group and 18 patients in the CCR group were included. There were no harmful or unintended effects reported during the study (Figure 1).

Thirty-two acute-to-subacute ABI patients with a mean age of 64.7±15.2 years (time after onset: 25.1±18.1 days) were included. Among the participants, 53.1% (N.=17) had ischemic stroke; 37.5% (N.=12) had hemorrhagic stroke, including intracerebral hemorrhage and subarachnoid hemorrhage; and the remaining 9.4% (N.=3) had traumatic brain injury. There were no statistically significant differences between the two groups in the baseline demographic and clinical characteristics (Table I).
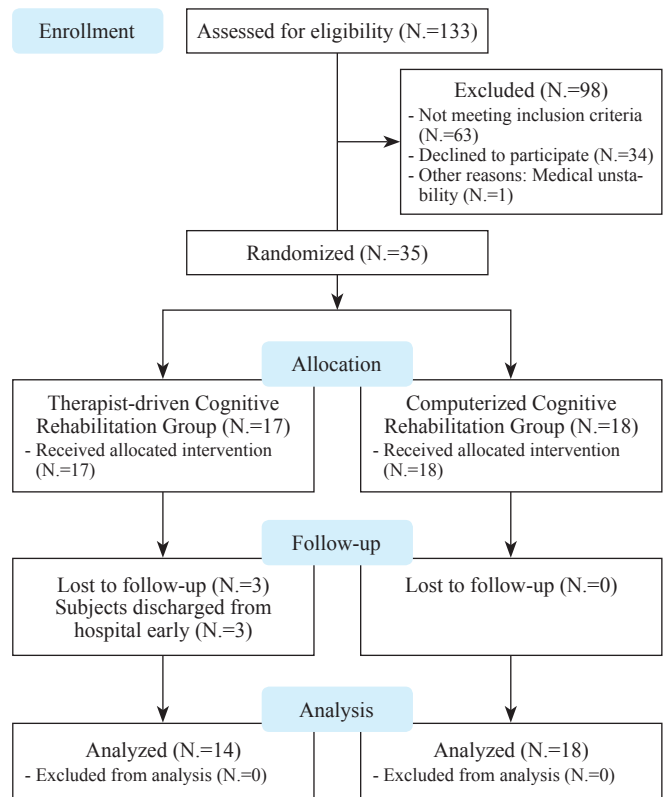

Figure 1.—Flow diagram of the study.

TABLE I.—*Demographic and clinical characteristics of the study participants.*

Variables	Therapist-driven cognitive rehabilitation group (N.=14)	Computerized cognitive rehabilitation group (N.=18)	P
Age (y)	62.5±16.4 [19-84]	66.4±14.4 [27-86]	0.488
Education (y)	10.1±3.5 [6-16]	8.7±5.2 [0-17]	0.536
Sex			0.221
Male	10 (71.4)	9 (50.0)	
Female	4 (28.6)	9 (50.0)	
Lesion			0.706
Right	8 (57.1)	12 (66.7)	
Left	5 (35.7)	6 (33.3)	
Both	1 (7.1)	0 (0.0)	
Type of injury			0.665
Ischemic stroke	8 (57.1)	9 (50.0)	
Hemorrhagic stroke	4 (28.6)	8 (44.4)	
Traumatic brain injury	2 (14.3)	1 (5.6)	
Time after injury	22.9±14.6 [8-60]	26.9±20.6 [8-89]	0.613
Acute	5 (35.7)	5 (27.8)	
Subacute	9 (64.3)	13 (72.2)	
MBI	30.0±16.3 [4-56]	30.1±19.3 [0-60]	0.986
MMSE	22.9±4.8 [15-28]	21.7±3.9 [14-30]	0.462
MoCA	16.3±6.1 [7-24]	15.4±5.4 [7-29]	0.684
CDR	1.2±0.7 [0.5-2.0]	1.3±0.7 [0.5-3.0]	0.442
GDS	6.1±4.9 [1-13]	5.1±5.1 [0-14]	0.556

Data are given as mean±SD [minimum-maximum value] or N. (%).
MBI: modified Barthel Index; MMSE: mini-mental status examination; MoCA: Montreal cognitive assessment; CDR: clinical dementia rating; GDS: Geriatric Depression Scale.

The neuropsychological function test results measured at T0 are given in Table II. There were no significant differences in any of the test results at baseline between the two groups.

TABLE II.—*Baseline scores of neurocognitive function tests.*

Variables	Therapist-driven cognitive rehabilitation group (N.=14)	Computerized cognitive rehabilitation group (N.=18)	P
DSF	5.2±1.3	5.6±1.4	0.416
DSB	2.9±1.2	3.1±1.1	0.750
TMT-A	119.2±120.8	120.2±110.9	0.697
TMT-B	185.2±120.7	211.8±119.8	0.728
SS	8.6±9.4	6.2±7.1	0.570
DSC	17.2±17.5	17.2±19.1	0.860
SFT	9.6±4.9	9.2±6.3	0.442
PFT	3.3±3.2	5.0±4.7	0.249

Data are given as mean±SD.
DSF: digit span forward; DSB: digit span backward; TMT-A: trail making test-A; TMT-B: trail making test-B; SS: symbol search; DSC: digit symbol coding; SFT: semantic fluency test; PFT: phonemic fluency test.

In the intragroup comparison between T0 and T1, as shown in Table III, the patients in both groups exhibited significantly improved outcomes in the MBI, MMSE, MoCA, TMT-A, and TMT-B scores but not in the DSF, DSB scores. Moreover, only the participants in the TCR group showed significant improvements in the COWAT results (SFT and PFT [P=0.001 and .004, respectively]), while only the CCR group showed significant improvements in the SS and DSC test results (P=0.023 and .002, respectively). As shown in Table IV, which presents the mean differences in the outcomes between T1 and T0 for both groups, only the PFT results in the TCR group showed a statistically significant difference in improvement from T0 to T1 (P=0.013). The MBI scores improved by 22.6±16.6 and 16.6±13.4 in the TCR and CCR groups, respectively (P=0.220), indicating improvement in functional performance in ADL.

TABLE III.—*Test scores of pre- and postintervention with intragroup comparisons.*

Variables	Therapist-driven cognitive rehabilitation group (N.=14)			Computerized cognitive rehabilitation group (N.=18)		
	Pre	Post	P	Pre	Post	P
MBI	30.0±16.3	52.6±17.1	<0.001***	30.1±19.3	46.7±19.4	<0.001***
MMSE	22.9±4.8	25.1±4.1	0.004**	21.7±3.9	24.2±4.3	0.000***
MoCA	16.3±6.1	19.3±5.1	0.003**	15.4±5.4	17.8±5.6	0.006**
DSF	5.2±1.3	5.4±1.4	0.437	5.6±1.4	5.6±1.1	10.00
DSB	2.9±1.2	3.0±1.0	0.635	3.1±1.1	3.3±1.4	0.625
TMT-A	119.2±120.8	56.4±72.1	0.002**	120.2±110.9	95.1±113.3	0.005**
TMT-B	185.2±120.7	126.9±114.4	0.016*	211.8±119.8	184.0±130.7	0.016*
SS	8.6±9.4	11.4±8.9	0.064	6.2±7.1	8.6±10.0	0.023*
DSC	17.2±17.5	21.6±16.6	0.082	17.2±19.1	23.6±24.4	0.002**
SFT	9.6±4.9	11.9±4.8	0.001**	9.2±6.3	10.6±6.5	0.102
PFT	3.3±3.2	5.1±3.3	0.004**	5.0±4.7	5.5±4.5	0.221

Data are given as mean±SD.
Statistically significant difference: *P<0.05; **P<0.01; ***P<0.001.
MBI: modified Barthel Index; MMSE: mini-mental status examination; MoCA: Montreal Cognitive Assessment; DSF: digit span forward; DSB: digit span backward; TMT-A: trail making test-A; TMT-B: trail making test-B; SS: symbol search; DSC: digit symbol coding; SFT: semantic fluency test; PFT: phonemic fluency test.

TABLE IV.—*Intergroup comparison of pre- to postintervention difference.*

Variables	Therapist-driven cognitive rehabilitation group (N.=14)	Computerized cognitive rehabilitation group (N.=18)	P
MBI	22.6±16.6	16.6±13.4	0.220
MMSE	2.3±2.5	2.4±2.0	0.842
MoCA	3.0±3.5±	2.3±3.2	0.925
DSF	0.21±0.89	0.00±0.97	0.694
DSB	0.14±1.10	0.17±0.92	0.925
TMT-A	-62.79±101.18	-27.61±36.61	0.587
TMT-B	-58.36±103.49	-34.89±80.95	0.613
SS	2.79±8.00	1.72±4.31	0.955
DSC	4.36±14.36	4.67±8.56	0.319
SFT	2.29±2.13	0.83±3.57	0.189
PFT	1.86±1.96	0.22±1.87	0.013*

Data are given as mean±SD.
Statistically significant difference: *P<0.05.
MBI: modified Barthel Index; MMSE: mini-mental status examination; MoCA: Montreal Cognitive Assessment; DSF: digit span forward; DSB: digit span backward; TMT-A: trail making test-A; TMT-B: trail making test-B; SS: symbol search; DSC: digit symbol coding; SFT: semantic fluency test; PFT: phonemic fluency test.

Discussion

The present study investigated and compared the efficacy of restorative TCR and CCR in restoring executive function in acute-to-subacute ABI patients. Our study results showed that both TCR and CCR significantly improved general cognitive function (MMSE, MoCA), selective attention and psychomotor speed (TMT-A, B), and performance in ADL (MBI). However, the two treatment methods showed different strengths in some cognitive domains. Only the CCR group showed significant improvements in the SS and DSC test results, while only the TCR group showed significant improvements in the COWAT (SFT and PFT) results. In the intergroup comparison, TCR was significantly more efficacious than CCR in improving PFT.

The COWAT is known to be a sensitive test for executive functions, including cognitive flexibility, strategy utilization, interference suppression, and response inhibition.[51, 52] Furthermore, the PFT is known to be more useful in assessing frontal lobe function, which is related to the switching of ideas, than is the SFT, which is more sensitive in assessing temporal lobe function.[53, 54] Hence, we suppose that TCR accompanied by active assistance by trained therapists, including suggesting problem-solving strategies or providing goal-oriented encouragement in an interactive way, might be more effective in improving frontal lobe function. Especially for ABI patients with decreased autonomy in problem solving and strategy switching, we suppose that more goal-oriented and constructive approaches are more helpful than repetitive, task-oriented, trial-and-error training. Moreover, considering that the SS and DSC results improved only in the CCR group, CCR might be more beneficial for improving psychomotor speed, visual perception, and working memory.[55, 56] Performance in ADL, which was measured by the MBI, improved significantly after treatment in both groups. Since executive function is closely related to ADL performance,[50] we suggest that this finding is the consequence of the improvement in executive function, as evidenced by the test results.

In previous studies, greater improvements due to TCR than due to CCR, as shown in our study, were rarely reported.[24, 26, 28, 57] However, in some elaborate studies by Spikman *et al*. and Poulin *et al*., which utilized therapist-driven cognitive training methods on executive function, it was suggested that customized therapy is a better option than CCR for improving executive function and related ADL performance in ABI patients.[33, 58] Considering the benefits of both TCR and CCR, De Luca *et al*. and Baltaduoneine *et al*. investigated the advantages of combining these methods in improving executive function in ABI patients.[26, 28]

In the present study, we tried to distinguish the TCR and CCR treatment methods by modulating the interventions provided by the therapists. Although the TCR method used in our study is not exactly the same as those used in Spikman and Poulin's studies, interventions with trained therapists might have a positive impact on setting treatment goals and establishing problem-solving strategies for the patients.

Additional consideration is needed in interpreting our study results because the mean age of the participants in the present study (64.7±15.2) was higher than that of participants from previous similar studies, who were most commonly in their 30's and 40's.[21, 22, 27, 28] According to research on smartphone ownership in 2018, Korea showed the highest prevalence among all global countries, with a prevalence of 95% in the overall population and nearly 80% in the group of individuals older than 60 years.[59, 60] Due to this prevalence, the difficulty of using computerized apparatuses may be lower in elderly people in Korea than in other countries. However, considering that there have been reports of elderly participants who intended to refuse CCR due to unfamiliarity with interactive devices,[26] the older mean age of the study population might have led to TCR being more efficacious than CCR.

Strengths and limitations of the study

One of the strengths of this study compared to most previous studies is that we included acute-to-subacute ABI patients specifically.[21, 23-25, 27, 28, 32, 58] Although patients' cognitive function spontaneously recovers in this phase of ABI, we distinguished the difference in improving neurocognitive domains between the TCR and CCR groups. These findings showed that each cognitive rehabilitation method may impact on cognitive recovery differently in the acute-to-subacute rehabilitation period. Thus, this study might provide some evidence useful in choosing a cognitive rehabilitation method for ABI patients.[15-17]

Our study presents several limitations to consider. First, the sample size of our study was small, and a control group without an intervention was lacking. However, we thought that including a no-intervention group and preventing ABI patients in the acute-to-subacute phase from receiving cognitive therapy would be unethical. Additionally, we did not analyze the acute phase (<2 weeks after injury) and subacute phase patients sample separately because of the small size of the acute phase sample. Further studies with larger sample sizes should be conducted to determine whether the efficacy of two methods differs in the acute phase patients from subacute phase patients. Second, the treatment dose of intervention for both groups (10 times of 30-minute sessions) was relatively low compared to the one used in previous studies.[21-23, 25-27, 33, 57] However, we thought that 10 treatment sessions lasting 30 minutes each would be enough for acute-to-subacute ABI patients with cognitive dysfunction, whose attention span may be short. Third, we did not evaluate long-term effects; thus, it was impossible to determine the sustained advantages of intensive training in the acute-to-subacute phase. Last, improvements in motor impairment could have influenced the improvements in ADL performance, as evaluated by the MBI, because the participants were in the acute-to-subacute ABI phase, which is when motor functions tend to improve considerably.

Conclusions

In conclusion, our study shows that TCR and CCR have distinct strengths in improving different domains of executive function in acute-to-subacute ABI patients and that TCR may be more effective in improving frontal lobe-related executive function.

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