Effects of Home-based Virtual Reality on Upper Extremity Motor Function for Stroke - An Experimenter Blind Case Study

Jung-Ah Lee[1], Sujin Hwang[2] and Chiang-Soon Song[3*]

[1]**Department of Motor and Cognitive Rehabilitation, Korea National Rehabilitation Center Research Institute**
[2]**Department of Physical Therapy, Nambu University**
[3]**Department of Occupational Therapy, Chunnam-Techno College**

가정–중심 가상현실이 만성뇌졸중환자의 팔 운동기능에 미치는 영향 – 실험자 맹검 단일실험연구

이정아[1], 황수진[2], 송창순[3*]
[1]국립재활원 재활연구소 운동인지재활과, [2]남부대학교 물리치료학과, [3]전남과학대학 작업치료과

Abstract　The purpose of this study was to investigate the effect of the home-based virtual reality (VR) on upper extremity motor function in hemiparetic stroke patients. Two matched subjects with left hemiplegia were volunteered to participate in this study. One subject received the home-based VR whereas the other subject recovered a modified home-based constraint-induced movement therapy (CIMT). Both interventions were given for 4 hours x 5 times a week for 4 weeks. Outcome measures included Fugl-Meyer Assessment (FMA), Motor Activity Log (MAL), and Wolf Motor Function Test (WMFT). The VR-trained subject showed considerable improvement in all the tested motor functions when compared with the home-based CIMT. Specifically, the FMA measure demonstrated that the VR subject showed 17% enhancement whereas the CIMT subject showed 5% increase. Similarly, Amount of Use (AOU) and Quality of Movement (QOM) of the MAL scores of the VR subject showed 40% and 20% increase whereas the CIMT subject showed 0% and 20% increase, respectively. The WMFT scores of the VR subject and CIMT subject showed 20% increase. Our home-based VR was effective in upper extremity motor recovery of chronic hemiparetic patients even when compared with the well-established CIMT approach in stroke victims.

요 약　본 연구의 목적은 만성 편마비 뇌졸중 환자를 대상으로 상지 운동기능 회복을 위하여 적용한 가상현실 가정 운동프로그램의 가능성을 알아보기 위함이다. 만성 뇌졸중 환자 2명을 대상으로, 한 명의 참여자는 가상현실운동프로 그램을 가정운동프로그램으로 처방하여 실행하였고, 다른 한 명의 참여자는 강제-유도운동치료를 가정운동프로그램으 로 처방하여 실행하였다. 치료기간은 4주간으로 1주일에 총, 5회로 1회에 4시간씩 실시하였다. 평가는 뇌졸중 기능회 복평가(Fugl-Meyer Assessment; FMA), 운동활동척도검사(Motor Activity Log, MAL), 그리고 울프운동기능검사(Wolf Motor Function Test; WMFT)를 이용하였다. 가상현실 운동프로그램을 가정운동프로그램으로 실시한 대상자가 모든 운동기능평가에서 상당한 기능적 회복을 보여주었다. 특히, FMA 점수는 가상현실프로그램을 사용한 대상자는 17% 향상된 반면, 강제유도운동치료를 가정운동프로그램으로 실시한 대상자는 5% 증가하였다. 또한, MAL 점수의 환측 상지를 이용하는 양(Amount of Use; AOU)와 움직임의 질(Quality of Movement; QOM)점수에서도 가정중심 가상현실 프로그램을 이용한 대상자가 각 40%, 20% 향상된 반면, 강제유도운동치료를 받은 대상자는 각각 0%, 20% 증가하였 다. 가상현실 프로그램을 사용한 대상자와 강제유도운동치료를 받은 대상자의 WMFT 점수가 모두 20%증가하였다. 본 연구결과, 만성 편마비 뇌졸중 환자의 상지 운동 기능 향상을 목적으로 가정운동프로그램을 설계할 때 가상현실 운동프로그램이 강제-유도운동치료보다 더욱 효과적인 것으로 사료된다.

Key Words : Arm motor function; Stroke; Virtual reality

1. Introduction

Hemiparetic stroke is a major leading cause of physical impairments and disabilities associated with upper extremity (UE) motor function such as reaching and grasping [1]. Such UE motor tasks are essential for independent activities of daily living (ADLs) and quality of life [1,2]. It has been suggested that UE motor dysfunction may result from underutilization of the affected limb following stroke [3]. For example, a hemiparetic stroke patient may attempt to use the affected limbs, but fail to perform motor tasks due to the underlying pathophysiology during the initial period of diaschisis [4]. Then the subject develops learned nonuse phenomenon where the subject does not utilize the affected limb rather compensate with the unaffected limbs. This learned nonuse assumption was elucidated by an empirical neuroimaging study which highlighted cortical suppression in the motor representation of the paretic hand that was underutilized [4, 5].

To address chronic UE motor dysfunction after stroke, various therapeutic interventions including neurofacilitation techniques [6], strengthening with functional electrical stimulation [7], biofeedback [8], constraint-induced movement therapy (CIMT) [9, 10], and virtual reality (VR) [4] have been used to promote functional motor recovery, but outcome studies have produced inconsistent results [1]. Among these interventions, the CIMT and center-based VR were found to yield meaningful neuroplastic changes and associated upper extremity motor recovery in hemiparetic stroke patients. CIMT focuses on increasing or forcing the amount of use in the paretic arm to improve UE motor function in hemiparetic stroke patients [9]. Patients must practice functional hand motor tasks with the paretic hand while the intact hand is restricted by a customized mitten or a splint for 6-8 hours to prevent any compensation at a laboratory setting [11]. Virtual reality (VR) involves an interactive, enjoyable, and motivating exercise games that can be systematically curtailed based on the patient's baseline motor performance and premorbid sports or recreational activity such as soccer or cooking. VR is a simulation of a real world environment that is generated by sophisticated computer software and human-machine interface technology. Most commercialized VR systems are center

(or laboratory)-based, which often used at laboratory and clinical settings [12, 4]. Therefore, CIMT can poise multiple practical issues of cost-effectiveness, safety, and compliance, whereas a center-based VR may have limitations in terms of portability and carry-over effects at home environments.

Extending our previous studies in a laboratory-based VR experiment [12, 13, 14], we have developed the home-based CIMT and VR paradigms where the patients can receive the interventions at home for 4 weeks. The purpose of this case study was to investigate the effect of the home-based VR interventions on UE motor performance and recovery in hemiparetic stroke patients. This case study was also to compare the effects of the home-based CIMT and home-based VR interventions on UE motor performance for stroke patients. Our basic premise was that the home-based VR trained subject would show greater improvement in the UE motor recovery after training. Our other premise was that the VR trained subject would show greater improvement in the UE motor recovery than the CIMT trained subject because enjoyable and realistic VR games may promote greater motivation and compliance than CIMT, which in turn help enhancing functional motor skills of the upper extremity and helping to overcome learned nonuse.

2. Methods

2.1 Subjects

Two age, gender, and lesion matched patients with left hemiplegia participated in this experiment. All subjects provided informed consent prior to the participation of this study. The patients were right-hand dominant and were diagnosed with right hemisphere stroke about 4 years ago. The patients were recruited through visits to a local public health center and met the following inclusion criteria: (1) a history of a single stroke, at least 1 year before the start of the study; (2) a minimum of 20 degrees of active wrist extension and at least 10 degrees of metacarpophalangeal (MP) joints extension; (3) ability to walk indoors without a cane. Exclusion criteria encompassed severe aphasia, visual and cognitive impairments (Mini-Mental State Examination score ≥24);

severe spasticity or tremor [15].

SJS was a 53-year-old woman who was independent in ambulation and had no apparent medical problems. Diagnostic MRI showed that she had a right cerebral infarct with resulting left hemiparesis. Before the stroke, she lived with her family and her occupation was a hair designer. Upon the admission to a local hospital, she had received intensive physical therapy 4 times a week for 3 months and followed by outpatient physical therapy 2 times a week for 9 months. At the time of her discharge from the outpatient rehabilitation center, she was unable to reach fully and grasp an object. Hence, she predominantly used her unaffected left hand for reaching and grasping tasks. She was able to put her clothes, but required assistance with fastener and zippers. When she attempted to wash dishes and cut cabbage, she failed to stabilize dishes or cabbage with her affected hand. However, she was able to ambulate indoors independently.

LYH was a 48-year-old woman who had a right cerebral infarct with resulting left hemiparesis 4 years previously. She received treatment for 3 months as an inpatient in a rehabilitation center. She was a manager in buffet restaurant, lived with her family, and had no a past medical history. She needed to ambulate outdoors with cane and a molded ankle-foot orthosis (MAFO), and required supervision for descending at night. She was able to perform all ADL tasks except bathing.

[Table 1] Clinical and demographic characteristics of the study participants

(N=2)

Characteristics	SJS	LYH
Age, yrs	52	48
Lesion	right temporal, premotor	right temporal, premotor, corona radiata infarct
Diagnosis	Moyamoya disease	right cerebral infarct

2.2 Procedure

This study was an experimental blind design where the therapists who provided the intervention did not know whether or not the patients were being investigated for the study. Pre and post-tests included motor function tests, Fugl-Meyer assessment (FMA), motor activity log (MAL),

Wolf motor function test (WMFT), and post-questionnaire about motivation and compliance. The pretest implemented before the 4-week intervention, followed by the post-test. Outcome measures were emphasized on the shoulder, elbow, and hand movement because both interventions were designed to improve gross movement of the upper extremity.

Intensive, functional, and home-based CIMT and VR interventions were administered 4 hours a day x 5 times a week for 4 weeks at each patient's residence. The experienced therapists provided the established intervention protocols.

2.3 Intervention

2.3.1 Modified Home−Based CIMT (Constraint−Induced Movement Therapy)

The modified home-based CIMT was designed to help the patient overcome the nonuse phenomenon at home and was conceptually based on the models validated to be effective with experimental research with primates [3, 10]. Specifically, the modified home-based CIMT involved intensive, repetitive, and functional motor task retraining of the affected upper extremity while the less involved limb was constrained by a mitten. Functional motor tasks included brushing teeth, washing face, folding a towel and cloth, answering phone, and cooking. The patient was instructed to use the affected upper extremity.

2.3.2 VR−Game Intervention

The home-based VR exercise games were used to facilitate the utilization of the effected upper extremity motor performance. The home-based SONY Playstation II virtual reality system (SONY corporation) are interactive, play-based exercise games. The system requires a television monitor, a videoplayer system requires a television, a video camera, virtual reality software (eye toy). The video camera is used to capture and track movement and immerse the patient inside the VR scene. The VR games included soccer, table-tennis, boxing, cooking, secret worker, remodeling, and Kungfu. These games were interfaced with virtual environments to facilitate range of motion, mobility, and strength which are important elements in developing functional upper extremity motor skills. Each game was played five times and depending on the game, within each game there were

three levels comprising a range of 88 to 131 opportunities to perform the exercise per game. A detailed description of the VR intervention protocol is available in the SONY corporation (http://www.sony.net).

2.4 Outcome Measures

The upper limb subtest of the Fugl-Meyer assessment (FMA) was used to examine sensation, range of motion, reflexes, synergy, muscle strength, and movement speed and coordination. Each item is graded on a 3-point ordinal scale (0=cannot perform; 1=can perform partially; 2=can perform fully). The score ranges from 0 to 66 (normal). Test-retest reliability and construct validity were reported to be significantly high, ranging from r=.98 to r=1.00 (P <0.05) [16, 17].

The modified motor activity log (MAL) was used to determine the amount of use and quality of movement of the patient's affected upper limb during activities of daily living (ADL). The score ranges from 0 to 5 (normal). The test-retest reliability and convergent validity for MAL was excellent, r=0.91 at P<0.01 [17, 18].

The Wolf motor function test (WMFT) was used to measure 17 items of upper extremity performance, 2 of which involve strength measures and 15 of which involve timed performance on various tasks. Performance time (up to 120 s), quality of motor function (score raging from 0 to 5, normal), and force are assessed. Test-retest reliability, interrater reliability, and internal consistency coefficients for the functional ability scale were 0.95, 0.88, and 0.92, respectively. Corresponding coefficients for the performance time scale were 0.90, 0.97, and 0.92. [18, 19, 20].

2.5 Statistical Analysis

Pre and post-test was used to examine the difference in the FMA, MAL, and WMFT between the home-based VR-game subject and home-based constraint-induced movement therapy subject.

3. Results

Descriptive statistics of functional motor scores pre- and post-intervention are presented in Table 2. For the CIMT trained patient, before the modified CIMT the patient had no functional use of the affected hand from which information was obtained. After the intervention, the FMA score improved from 13 to 16.

The MAL test showed that the quality of movement (QOM) and amount of movement (AOM) of the affected hands slightly improved from 0 to 1 and from 1 to 1 respectively, indicating minimal to negligible change of the affected hand. The average WMFT score increased from 1 to 2, suggesting slight functional change. For the VR trained patient, before the VR training the patient had no functional use of the affected hand from which information was obtained. After the intervention, the FMA score improved from 31 to 42. The MAL test showed that the use of the affected hand and amount of use slightly improved from 1 to 2 and from 1 to 3 respectively, suggesting increased utilization and utilization of the affected hand. The average WMF score increased from 2 to 3, suggesting slight functional hand motor improvement (Table 2, 3).

The relative interval changes in motor performance between the CIMT-trained patient and VR-trained patient are presented in Table 4. The interval changes in FMA for the CIMT-trained patient and VR-trained patient were 5% and 17%, respectively. Similar enhancement in AOM and QOM in the MAL test was 0% and 20% for the CIMT-trained patient and 40% and 20% for VR-trained patient, respectively. The relative interval changes in WMF for both patients were equally 20%. These results suggest that the VR trained patient showed more improvement in upper extremity motor recovery, function, and amount and quality of movement of the affected hand during daily activities of living.

[Table 2] Motor Function Test in CIMT-trained Patient

Test		Pre-test	Post-test
Upper limb in FMA		13	16
MAL	AOU	1	1
	QOM	0	1
WMFT		1	2

AOU, Amount Of Use; CIMT, Constraint-Induced Movement Therapy; FMA, Fugl-Meyer Assessment; MAL, Motor Activity Log; QOM, quality of movement

[Table 3] Motor Function Test in VR-trained Patient

Test		Pre-test	Post-test
Upper limb in FMA		37	42
MAL	AOU	1	3
	QOM	1	2
WMFT		2	3

AOU, Amount Of Use; FMA, Fugl-Meyer Assessment; MAL, Motor Activity Log; QOM, Quality Of Movement; VR, Virtual Reality

[Table 4] The difference of Improvement in Motor Function Test

Test		Improvement (%)	
		CIMT-trained patient	VR-trained patient
Upper limb in FMA		5	17
MAL	AOU	0	40
	QOM	20	20
WMFT		20	20

AOU, Amount Of Use; FMA, Fugl-Meyer Assessment; MAL, Motor Activity Log; QOM, Quality Of Movement; VR, Virtual Reality

4. Discussion

Our finding in FMA measures showed that relative improvement between the pre and post-VR was greater than those of CIMT. This was consistent with the previous studies that investigated the effect of center-based [13, 14] and home-based VR [21, 22] exercise in patients with chronic stroke. However, our VR program was less expensive and conducive to the patient at home. The patient who received CIMT also showed improvement in FMA, especially. This finding further strengthens the previous finding that examined the effect of CIMT or mofofied home based at the center.

The aim of this study was to determine the effects of the modified home-based CIMT versus home-based VR intervention in adults with hemiparetic stroke patients. In this study, each patient showed improvement in a subset of variables. Although LYH who performed modified home-based CIMT did not transfer this improvement to functional activities, SJS who performed home-based VR game showed improvement in the use of her affected hand to functional ADL tasks after intervention. From several studies, positive changes in functions such as manual dexterity, sensory discrimination, and limb coordination were reported after stroke in the laboratory. Wolf et al. represented the first systematic application of CIMT of the hemiplegia at least 1 year after stroke or traumatic brain injury (TBI) to quantitatively assess changes in speed or muscle force using a series of 21 functional tasks from gross to fine motor skill several hours a day for 2 weeks. They purposed that the motor deficiency was not linked to the paralysis but to learned nonuse reversible by relearning the functional activities through use of existing sensory-motor neural circuitry overcame a learned nonuse. Alberts et al. (2004) examined to determine the effects of an immediate or delayed 2-week CIMT intervention on the force-producing capabilities of the hemiparetic hand during the performance of a functional dexterous task in 10 subacute stroke patients [23]. They suggested that 4 of the 5 patients in the immediate CIMT, compared to the delayed group, showed significant clinical improvements in hand function, increased maximum precision grip force, improved force and torque regulation, and reduced variability in rate of force production during task performance. However, almost all current CIMT is directed toward improving movement that is observed in the laboratory and testing concentrates almost exclusively on that domain [24]. The intensity of the CIMT and restraint components also makes the protocol less clinically feasible and not reimbursable. In this study, we performed modified home-based CIMT which is composed of functional activities of living and repetitive daily tasks to focus primary on improving real world function. But this intervention had not enough motivation for though treatment time. Page et al. (2002) studied to determine the opinions of stroke patients and therapists about CIMT using self-report questionnaire [2]. They reported that 68% of patients with stroke would not want to participate in CIMT, and 65% of the patients would participate in CIMT agreed that they were somewhat or extremely unlikely to adhere to the CIMT protocol. They also reported that most therapists replied that development of an engaging, challenging 6-hour protocol would be difficult. In reference to the CIMT restrictive device schedule, therapists were concerned with compromises in

independent activities and safety because the CIMT protocol endangered patients impaired by balance. In this study, LYH was unlikely to adhere to the 4-hour CIMT protocol, and was uncomfortable in CIMT protocol with less-affected limb restricts.

The VR has the capability of creating a virtual rehabilitation scene where the intensity of practice and sensory feedback can be systematically manipulated to provide the most appropriate, individualized, real-life motor retraining. You et al. (2005) investigated the effects of VR intervention on cortical reorganization and associated locomotor recovery in ten chronic stroke patients with hemiparesis [4]. They reported that VR could induce cortical reorganization from aberrant insilateral to contralateral SMC activation, and cortical reorganization might play an important role in recovery of locomotor function in chronic stroke. In this study, the subject was enjoy and amused herself by doing modified VR game. We were used to VR game because it is cheap. VR game has only visual feedback, and has not proprioceptive feedback. So this VR game is not able to do appropriately motor relearning. However, commercial VR intervention program is so expensive.

Our limitation, we cannot be generalized in all stroke patient. Hence, this study should be examined to involve larger numbers of subjects in future research.

We recommend two descriptions. First, clinicians have had to develop less expensive VR intervention program. VR intervention is only enjoying training for patients with motor disabilities. If less expensive VR intervention program, it will be used extensively in rehabilitation unit. Second, CIMT protocol is modified more enjoy and engage.

5. Conclusion

The home-based VR training program was effective when compared to the home-based CIMT training program in stroke. Our results suggest that the VR trained patient showed more improvement in upper extremity motor recovery, function, and amount and quality of movement of the affected hand during daily activities of living. However, the subjects participated in this study were not matched such as functional level and neurological injury areas.

References

[1] A. S. Merians, D. Jack, R. Boian, et al, Virtual reality-augmented rehabilitation for patients following stroke. Phys Ther, 82, 898-915, 2002.

[2] S. J. Page, S. A. Sisto, & P. Levine, Modified constraint-induced therapy in chronic stroke. American J Physl Med Rehab, 81, 870-875, 2002.

[3] S. C. Deluca, K. Echols, S. L. Raney, & E. Taub, Pediatric costraint-induced movement therapy for a young child with cerebral palsy: Two episodes of care. Phys Ther, 83(11), 1003-1013, 2003.

[4] S. H. You, S. H. Jang, SH,. Y. H. Kim, et al, Virtual reality-induced cortical reorganization and associated locomotor recovery in chronic stroke. Stroke, 36, 1166-1171, 2005.

[5] J. M. Andre, J. P. Didier, J. Paysant, Functional motor amnesia instroke and learned non-use phenomenon. J Rehabil Med, 36, 138-140, 2004.

[6] S. Lennon, & A. Ashburn, The Bobath concept in stroke rehabilitation: A focus group study of the experienced physiotherapist's perspective. Disabil Rehab, 22(15), 665-674, 2000.

[7] J. S. Knutson, T. Z. Hisel, M, Y, Harley, et al, A novel functional electrical stimulation treatment for recovery of hand function in hemiplegia: 12-week pilot study. Neurorehabil Neural Repair, 23(1), 17-25, 2009.

[8] F. Eser, G. Yavuzer, D. Karakus, et al, The effect of balance training on motor recovery and ambulation after stroke: A randomized controlled trial. European J Phys Rehab Med, 44(1), 19-25, 2008.

[9] S. J. Page, S. A. Sisto, R. Levine, R. E. McGrath, Efficacy of modified constraint-induced movement therapy in chronic stroke: A single-blinded randomized controlled trial. Archives of Physical Medicine and Rehabilitation, 85, 14-18, 2004.

[10] E. Taub, G. Uswatte, R. Pidikiti, Constraint-induced movement therapy: A new family of techniques with broad application to physical rehabilitation. J Rehab Resear Develop, 36(3), 237‑251, 1999.

[11] H. J. Freund, M. Jeannerod, M. Hallett, & R Leiguarda. Higher-order motor disorders: from neuroanatory and neurobiology to clinical neurology. Chapter 25: Cortical plasticity and motor disorders, pp. 455-473, New York, MD: Oxford University Press Inc, 2005.

[12] J Broeren, L. Claesson, D. Goude, et al. Virtual rehabilitation in an activity centre for community-

dwelling persons with stroke: The possibilities of 3-dimensional computer games. Cerebrovasc Dis, 26(3), 289-296, 2008.

[13] A. Henderson, N. Korner-Bitensky, & M. Levin, Virtual reality in stroke rehabilitation: A systematic review of its effectiveness for upper limb motor recovery. Top Stroke Rehabil, 14(2), 52-61, 2007.

[14] S. Subramaniam, L. A. Knaut, C. Beaudoin, et al, Virtual reality environments for post stroke arm rehabilitation, J Neuroeng Rehabil, 22(4), 20, 2007.

[15] J. H. Van Der Lee, H. Beckerman, G. J. Lankhorst, L. M. Bouter, The responsiveness of the action research arm test and the Fugl-Meyer assessment scale in chronic stroke patients. J Rehabil Med, 33, 110-113. 2001.

[16] A. R. Fugl-Meyer, L. Jääskö, Leyman et al. The post-stroke hemiplegic patient. II. Incidence, mortality, and vocational return in Goteborg, Sweden with a review of the literature, Scand J Rehabil Med, 7, 13-31, 1975.

[17] A. Shumway-Cook, M. H. Woollacott, Motor Control: Translating research into clinical practice 3rd ed. pp. 175-230, Philadelphia, Lippincott Williams & Wilkins, 2007.

[18] G. Uswatte, E. Taub, D. Morris, et al, The motor activity log-28: Assessing daily use of the hemiparetic arm after stroke. Neurology, 67, 1189-1194, 2006.

[19] E. Taub, N. E. Miller, T. A. Novack, et al, Technique to improve chronic motor deficit after stroke. Arch Phys Med Rehabil, 174(4), 347-354, 1993.

[20] S. L. Wolf, D. E. Lecraw, L. A. Barton, et al, Forced use of hemiplegic upper extremities to reverse the effect of learned nonuse among chronic stroke and head-injured patients. Exp Neurol, 104(2), 125-132, 1989.

[21] M. K. Holden, T. A. Dyar L. Dayan-Cimadoro, Telerehabilitation using a virtual environment improves upper extremity function in patients with stroke. IEEE Trans Neural Syst Rehabil Eng, 15(1), 36-42, 2007.

[22] M. Rydmark, J. Broeren, R. Pascher, Stroke rehabilitation at home using virtual reality haptics and telemedicine. Stud Health Technol Inform, 85, 434-437, 2002.

[23] J. L. Alberts, A. J. Butler, S. L. Wolf, The effects of constraint-induced therapy on precision grip: a preliminary study, Neurorehabil Neural Repair, 18(4), 250-258, 2004.

[24] E. Taub, G. Uswatte, V. W. Mark, et al. The learned nonuse phenomenon: Implications for rehabilitation.

Eura Medicpphys. 42(3), 241-256, 2006.

Jung-Ah Lee   [Regular member]

- Feb. 2005 : Yonsei Univ., PT, MS
- Feb. 2008 : Yonsei Univ., PT, PhD
- Mar. 2007 ~ Feb. 2009 : Yonsei Univ., Dept. of Physical Therapy, a part-time lecturer
- Dec. 2008 ~ current : Korea National Rehabilitation Research Institute, Dept. of Motor and Cognitive Rehabilitation, Research Officer

<Research Interests>
NeuroRehabilitation

Sujin Hwang   [Regular member]

- Feb. 2006 : Yonsei Univ., PT, Msc
- Aug. 2009 : Yonsei Univ., PT, PhD
- Mar. 2010 ~ Feb. 2012 : Yonsei Univ., Institute of Health Science, Researcher
- Mar. 2012 ~ Current : Nambu Univ., Dept. of Physical Therapy, Professor

<Research Interests>
Motor Control & Learning, Neurologic Rehabilitation

Chiang-Soon Song   [Regular member]

- Feb. 2005 : Yonsei Univ., OT, Msc
- Aug. 2011 : Chosun Univ., SC, PhD
- Mar. 2008 ~ Current : Chunnam-Techno College, Dept. of Occupational Therapy, Professor

<Research Interests>
Assistive Technology, Geriatric Occupational Therapy