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# Determining the Effects of a Horticultural Therapy Program for Improving the Upper Limb Function and Balance Ability of Stroke Patients

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***Abstract*. The objective of this study was to assess the physical and psychological effects of an 18-session horticultural therapy (HT) program based on task-oriented training in stroke patients and investigate patient satisfaction. The HT program consisted of horticultural activities including the motions such as reaching–grasping, squatting, stepping, and stooping. A total of 31 stroke inpatients (16 males, 15 females) at B rehabilitation hospital in Seongnam, South Korea, participated in this study. Fourteen stroke patients participated in a thrice weekly HT program (6 weeks, ≈60 minutes per session) between Aug. and Sept. 2016, whereas another 17 stoke patients comprised the control group. At the completion of the 18-session HT program, upper limb function [manual function test (MFT)], grip strength (hydraulic hand dynamometer), pinch force (hydraulic pinch gauge), fine motor skills (9-hole pegboard), balance [Berg Balance Scale (BBS)], and activities of daily living (Modified Barthel Index) were evaluated in both groups. In addition, depression [The Korean version of the short form of Geriatric Depression Scales (SGDS-K)], rehabilitation stress (Rehabilitation Stress Scales), rehabilitation motivation (Rehabilitation Motivation Scales), and fall efficacy (The Korean version of the Falls Efficacy Scale) were evaluated. Stroke patients in the HT group showed significantly improved upper limb function, hand force, balance, fall efficacy, activities of daily living, and decreased depression ($P < 0.05$). By contrast, no significant change was noted in the control group. In addition, 85.7% of the stroke patients in the HT group reported being very satisfied or satisfied with the HT program. In conclusion, the HT program based on task-oriented training improved the patients' physical and psychological function after stroke rehabilitation. These study results suggest that implementing an HT program in a rehabilitation hospital will effectively contribute to functional recovery after stroke.**

Stroke is a very common and serious neurologic disease that affects about one in six people worldwide and ≈800,000 Americans each year (Mozaffarian et al., 2015). In South Korea, the number of stroke patients increased from 521,000 in 2011 to 538,000 in 2015, an increase of 3.2% (National Health Insurance Service, 2016). An estimated 80% of stroke survivors experience serious long-term disabilities such as hemiplegia, motor impairment, psychological and cognitive disabilities, and restricted daily living activities (Sturm et al., 2002).

The recovery of upper limb function and posture control are the most essential components that lead to independent daily living for stroke patients (Langhorne and Legg, 2003). Upper limb function is required for most daily activities such as drinking, eating, and dressing (van Andel et al., 2008). Posture control is the ability to maintain and recover balance in any activity. The impairment of lower limb function caused by stroke results in an imbalance in the body's center of mass (COM), asymmetry of the pressure distribution under the feet, and an increase in body sway, thereby reducing balance ability and posture control (Eng and Chu, 2002; Pang and Eng, 2008; Pollock et al., 2000). It also limits walking ability and increases the risk of falls (Yavuzer et al., 2006).

The most effective treatment method for recovering the upper limb function and posture control of stroke patients is relearning the motor skills required to perform functional tasks that are basic motions in daily living activities (Shepherd, 2001; Willingham, 1998). Task-oriented training is known to be an effective treatment for stroke rehabilitation in which one repeatedly performs a specific functional task on the affected side to enable motor learning (Carr and Shepherd, 2003; Yang et al., 2006).

The brain has neuroplasticity that fluidly changes the brain function and structure by learning through repetitions of motion (Dimyan and Cohen, 2011; Murphy and Corbett, 2009). The training method in task-oriented training based on neuroplasticity has a therapeutic mechanism that leads to the relearning of motor skills in the upper and lower limbs by activating neuroplasticity in the cerebral cortex and central nervous system (Harvey, 2009; Hubbard et al., 2009). For example, reaching–grasping training, as a task-oriented training to improve upper limb, is commonly used (Rensink et al., 2009). The training comprises repeatedly reaching, grasping, transporting, and releasing objects. For balance-improving training, trunk-control training is repeatedly practiced using a sit–reach motion of reaching toward objects placed across a table to recover static balance, whereas specific functional tasks such as sit to stand, stepping, and stooping are repeatedly performed to recover dynamic balance (Dean et al., 2007; McCloskey and Bulecheck, 2000; Rensink et al., 2009).

Horticultural therapy uses horticultural activities for clients with special needs being treated by a professional therapist (Relf, 2008; Son et al., 2016). There are six positive effects of HT: physical, psychological, social, cognitive, behavioral, and educational (Park et al., 2016a). Various indoor and outdoor horticultural activities are considered low- to high-intensity aerobic exercises (Park et al., 2011, 2013a, 2014b), whereas weight-bearing exercises use both upper and lower limb muscles (Park et al., 2013b, 2014a). Specifically, the previous study compared the similarities of horticultural activity and task-oriented training through kinematic and kinetic analyses (Lee, 2017; Lee et al., 2016). Upper limb motions of indoor horticultural activities such as sowing seeds and planting a plant showed similar movement pattern to reaching–grasping training and daily living activities. Lower limb motions of outdoor horticultural activities such as digging, raking, transporting, weeding, and harvesting also showed similar movement patterns to specific functional tasks for balance-improving training such as stepping, squatting, and stooping. Thus, the physical therapeutic mechanisms of horticultural activity create the possibility of HT as a task-oriented training.

Therefore, the objectives of this study were to determine the effects of HT as

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a task-oriented training for improving upper extremity function and balance ability in stroke patients and investigate patient satisfaction with the HT to confirm its applicability as a rehabilitation therapy for stroke.

## Materials and Methods

### Participants and experimental design

Stroke inpatients were recruited from B rehabilitation hospital in Seongnam, South Korea, which specializes in brain–nervous system diseases, using a flyer with a description of the study and registration forms that were distributed in the hospital and a list of recommended patients from a rehabilitation medicine specialist. The stroke patients were provided descriptive information for all procedures to be used in the study. The participation criteria were inpatient status and the ability to perform horticultural activities. The physical and cognitive functions of the stroke patients who could perform horticultural activities were selected through discussion with three horticultural therapists, two rehabilitation medicine specialists, and one occupational therapist. The physical function was based on our previous study findings of range of motion and movement characteristics through a motion analysis of the horticultural activities (Lee, 2017; Lee et al., 2016). Participation was limited to patients who had the physical function to voluntarily perform 65% of the horticultural activity motions (Timmermans et al., 2010): 1) Brunnstrom recovery stage >3; 2) MFT score >4; and 3) ability to move in a wheelchair. Cognitive function was limited to patients with mild cognitive impairment (score >18) and no difficulty with simple communication. In addition, participation was limited to patients with individual caregivers and who were at risk of falling during therapy. Finally, a total of 31 stroke patients who volunteered to participate and receive consent from caregivers of the patients participated in the study.

Fourteen stroke inpatients participated in the 18-session HT program. Another 17 stroke inpatients comprised the control group. The following demographic information was obtained for each of the patients through the hospital medical records: age, gender, diagnosis, duration from brain injury onset, brain damage type, hemiplegia side, health status (e.g., Brunnstrom recovery stage, gait function, communication function, cognitive function, and depression), and other treatment participation information. This study was conducted over a total of 8 weeks during Aug. to Sept. 2016. This study featured a quasi-experimental design with a nonequivalent control group. Both groups were subjected to physical and psychological rehabilitation function assessments before and after the HT program. Each participant in the control group received an incentive (equivalent to $5) at the study completion. This study was approved by the institutional review board (7001355-201608-HR-126 and 2016BMI-1).

### HT program design

The 18-session HT program consisted of indoor and outdoor horticultural activities. The HT program involved three weekly sessions for a mean duration of 60 min per session. Treatment frequency and time were based on the previous study information about task-oriented training in stroke and HT for physical rehabilitation (Duff et al., 2013; Turton et al., 2013; Wolf et al., 2006). A height-adjustable table ($4.6 \times 1.5$ m) and a garden plot ($18 \times 4.5 \times 0.3$ m) were installed in an occupational therapy room and rooftop garden of B Hospital, respectively, for this project. Each participant in the HT group was provided an individual garden ($1.5 \times 1.5$ m).

The HT program in this study consisted of a therapeutic technique of task-oriented training that was repeatedly performed involving specific functional tasks for physical rehabilitation after stroke (Timmermans et al., 2010) (Table 1). The HT program comprised horticultural activity motions of specific functional tasks such as reaching–grasping, squatting, stepping, and stooping that were similar movement patterns of horticultural activities in the task-oriented training. Specifically, studies conducted by Lee et al. (2016) and Lee (2017) provided kinetic and kinematic data of various indoor and outdoor horticultural activities. Reaching–grasping and sitting–reaching were performed repetitively to improve upper limb function and static balance ability, respectively. It was based on culture-focused indoor activities such as sowing seeds (*Brassica campestris* spp. *Pekinensis* and *Lactuca sativa* L.), cutting (*Peperomia*), and planting plants (*Ardisia pusilla*, *Crassula ovata* '*Gollum*', *Cupressus macrocarpa*, *Echeveria* '*Prolifica*', *Fittonia verschaffeltii*, *Fittonia v.* var. *argyroneura*, *Orostachys japonicas*, *Pelargonium inquinans*, *Scindapusus aureus*, *Spathiphyllum*, *Syngonium*, and *Zinnia elegans*).

Squatting, stepping, and stooping, which were weight-shifting motions for balance ability training, were performed repetitively in outdoor horticultural activities such as designing a garden, making garden plots, transporting plants (*Callistephus chinensis*, *Capsicum annuum*, *Chrysanthemum morifolium*, *Gomphrena globose*, *Impatiens*, *Hedera helix*, *Lilium longiflorum*, *Mentha piperita*, *Mentha species Mentha*, *Pelargonium rosium*, *Petunia hybrid*, *Ramat*., *Rosmarinus officinalis*, and *Tagetes erecta*), and performing garden maintenance.

The HT program was developed by the application of essential factors such as progressive training and patient-customized training load in standard task-oriented training (Timmermans et al., 2010) (Table 1; Fig. 1). It is important to perform progressive training from distributed practice to total skill practice of the horticultural activity motions for motor learning in stroke patients. The HT program consisted of the following four steps: 1) distributed practice in reaching–grasping training, 2) distributed practice in balance ability training, 3) total skill practice in reaching–grasping training, and 4) total skill practice in balance ability training (Table 1; Fig. 1).

Increasing the difficulty of motion by changing the distance, size, and height of horticultural materials and number of repetitions of horticultural activity motions to provide the training load through the HT gradually increased the stroke patients' physical abilities (e.g., muscle activation, range of motion, and combined exercise). Therefore, the horticultural therapist set the goal and range of individual treatment considering each patient's physical condition based on the patient-customized training load factor (Timmermans et al., 2010).

The biomechanical practice model (Kielhofner, 2009) was used to ensure that the stroke patients could practice correctly. The horticultural therapist conducted a one-on-one HT to correct posture based on the kinematic and kinetic characteristics of each horticultural activity (Lee, 2017; Lee et al., 2016) and provided the patient with posture feedback (Timmermans et al., 2010). For example, the maximum shoulder abduction was higher in the task of watering with a watering can ($67.21° \pm 8.81°$) than in other tasks such as positioning a pot ($34.40° \pm 8.36°$), filling a pot with soil ($38.74° \pm 0.97°$), and planting a plant in a pot ($32.48° \pm 6.85°$). In each activity, the horticultural therapists corrected the subject's posture.

Digging and raking while making a garden plot required maximal hip flexion of 69.4° and 89.7° and maximal left knee flexion of 27.8° and 43.5°, respectively (Lee, 2017). Thus, raking required larger joint movements in the lower limbs when compared with digging, and these characteristics were considered to correct the posture. When performed during horticultural activities, the horticultural therapist corrected and supported the posture of each stroke patient to align their waist, hip joints, and ankle joints to allow them to better perform the exercise strategies and recover the balance instability caused by sudden leaning of COM.

This therapy program was primarily managed by the horticultural therapist and 14 assistant horticultural therapists, all of whom were certified by the Korean Horticultural Therapy and Wellbeing Association. The primary therapist provided on-board training to the assistant therapists to implement the HT movements based on the kinetic and kinematic characteristics of the horticultural activity and each participant's physical condition.

### Rehabilitation functional assessments

*Physiological function.* Assessments of upper limb function, hand function, balance, and daily living activities were conducted before and after the 18-session HT program by an occupational therapist and a physical therapist on staff at the hospital (Fig. 2).

The MFT was developed as a tool for evaluating upper limb motor function in stroke patients and measures physiologic parameters using range of motion of the

Table 1. The 18-session horticultural therapy rehabilitation program for increasing upper limb function and balance ability of brain injury patients.

| No. | Step | Goal | Target functional motion[z] | Horticultural activity |
|---|---|---|---|---|
| 1 | 1. Reaching–grasping training (distributed practice) | 1. Improvement of upper limb function | 1. Phases division of reaching–grasping motion[y] | Planting plants |
| 2 | | 2. Improvement of static balance ability | 2. Reaching training by position of horticultural materials (e.g., changing torso distance and horticultural materials; 40, 45, 50, 55 cm) | Planting plants |
| 3 | | | 3. Grasping pattern training (e.g., tray: lateral prehension; seeds: fingertip prehension; plants: palmar prehension; watering can: cylindrical grasp; soil: ball grasp)[y] | Planting plants |
| 4 | | | 4. Number of repetitions: 30 per session | Hydroponics |
| 5 | | | | Sowing seeds and sticking cutting |
| 6 | 2. Balance-improving training (distributed practice) | 1. Improvement of dynamic balance ability | 1. Phases division of stepping, squatting, and stooping[y] | Design garden and making garden plots |
| 7 | | | 2. Therapy method by gait function (e.g., independent and with support: standing–stepping, standing–squatting, standing–stooping; unable to walk: sitting–stooping on a wheelchair) | Making flower garden beds |
| 8 | | | 3. Number of repetitions: 30 per session | Making herb garden beds |
| 9 | | | | Making herb garden beds |
| 10 | 3. Reaching–grasping training (total skill practice) | 1. Improvement of upper limb function | 1. Combination performance reaching–grasping | Planting plants |
| 11 | | 2. Improvement of static balance ability | 2. Transportation and releasing training by position change of pot [e.g. adjusting height and width of pot using fence designed for horticultural therapy program (1.7 × 1.0 m)][x] | Planting plants |
| 12 | | | 3. Number of repetitions: 45 per session | Planting plants |
| 13 | | | | Planting plants |
| 14 | | | | Planting plants |
| 15 | | | | Planting plants |
| 16 | 4. Reaching–grasping training (total skill practice) | 1. Improvement of dynamic balance ability | 1. Combination performance of stepping, squatting, and stooping | Planting transplants |
| 17 | | | 2. Number of repetitions: 40 per session | Planting transplants |
| 18 | | | | Planting transplants |

[z]The application of task-oriented training components (Timmermans et al., 2010).

[y]Reaching–grasping in the upper limb motion is divided into six phases: reaching, grasping, back transporting, forward transporting, watering, and releasing (Lee et al., 2016). Stepping, squatting, and stooping in the lower limb motion are divided into four or three phases: stepping: 1) stepping forward with the left foot, 2) reaching the target spot, 3) performing the horticultural task, 4) stepping back with the left foot; and squatting: 1) standing-squatting, 2) reaching the target spot, 3) performing horticultural task, 4) squatting-standing; and stooping: 1) stooping back and reaching the target spot, 2) performing the horticultural task, and 3) stretching back (Lee, 2017).

[x]Range of motion improvement training was performed using extension (30°–140°) and adduction-abduction (45°–160°) exercises of the shoulder joint that occurred within performed fence height and width range position on the chair with the back in front of the fence.

arm and manipulative tasks such as reaching, grasping, transporting, and releasing in medical rehabilitation (Nakamura and Moriyama, 2000). The MFT comprises eight assessment items (Nakamura and Moriyama, 2000): 1) forward elevation of the arm, 2) lateral elevation of the arm, 3) touching the occiput with the palm, 4) touching the back with the palm, 5) grasping and releasing, 6) pinching, 7) carrying cubes, and 8) manipulating a pegboard. The MFT kit (SOT-5000; Sakai Iryo Co, Tokyo, Japan), a standardized measurement tool designed for this assessment, was used. Each subtest included three test repetitions and the score was the maximum scores achieved. Total scores range from 0 to 32. The test–retest reliability of this instrument was 0.99 by Nakamura and Moriyama (2000) and 0.99 in this study.

Grip strength, pinch force, and fine motor skill were measured using a Jamar hydraulic hand dynamometer (5632-13; Sammons Preston, Bolingbrook, IL), Jamar hydraulic pinch gauge (081504265; Sammons Preston), and Jamar 9-hole pegboard (5309; Sammons Preston), respectively. Grip strength and grip force were evaluated as the average value (kg) after three test repetitions. Fine motor skills were evaluated using two test repetitions and the score was taken as the shortest task performance times (in seconds) achieved.

Balance ability was measured using the BBS, which is commonly used to assess patient function in the hospital (Berg et al., 1992; Blum and Korner-Bitensky, 2008; Jung et al., 2006). This test was developed as a tool for evaluating the static balance, dynamic balance, and fall risk and measures the patient's ability to maintain balance to perform specific motions during the test. BBS comprises 14 assessment items (Berg et al., 1992): 1) sitting to standing, 2) standing unsupported, 3) sitting unsupported, 4) standing to sitting, 5) transferring, 6) standing with eyes closed, 7) standing with feet together, 8) reaching forward with an outstretched arm, 9) retrieving an object from the floor, 10) turning to look behind, 11) turning 360°, 12) placing alternate feet on a stool, 13) standing with one foot in front of the other foot, and 14) standing on one foot. Total scores range from 0 to 56 (Berg et al., 1992). A score ≥41 indicates good balance, 21–40 indicates balance impairment, and ≤20 indicates a balance disorder. The test–retest reliability of this instrument was 0.98 by Chou et al. (2006) and 0.96 in this study.

The daily living activities of stroke patients were measured using the Korean Modified Barthel Index (K-MBI) (Jung et al., 2007), which comprises 10 activities of daily living: 1) personal hygiene, 2) bathing, 3) feeding, 4) toileting, 5) going up/down stairs, 6) dressing, 7) defecating, 8) voiding, 9) ambulating, and 10) transferring to/from bed. Each question uses a 10-point Likert scale, and the total scores range from 0 to 100. The test–retest reliability of this instrument was 0.84 by Jung et al. (2007) and 0.99 in this study.

*Psychological function.* Assessments of depression, rehabilitation stress, rehabilitation motivation, and fall efficacy were conducted through individual interviews with


Fig. 1. Therapeutic horticultural activity motions for the rehabilitation of upper limb function and balance ability of a stroke patient: (**A**) reaching–grasping to object distance, (**B**) reaching–grasping to pot location, and (**C**) motion for balance ability (stepping–reach, squatting–reach, and stooping–reach).

researchers in both groups before and after the 18-session HT program (Fig. 2). This assessment used a highly reliable questionnaire that is widely used in clinical settings.

To evaluate depression in stroke patients, the SGDS-K was used (Kee, 1996; Yesavage and Sheikh, 1986). This scale consists of 15 questions, and a higher score indicates more severe symptoms of depression. A score $\leq$5 indicates normal condition, 6–9 indicates moderate depression, and $\geq$10 indicates severe depression. Cronbach's *a* coefficient of the survey was 0.88 by Kee (1996) and 0.80 in this study.

Rehabilitation stress was assessed using a rehabilitation stress survey developed based on Neuman's stressor (1982) by Park (1988). This survey includes a total of 25 questions about stress related to the physical limitations of stroke patients. The 5-point Likert scale consists of three subcategories including internal stress (15 questions), interpersonal stress (six questions), and external stress (four questions). Total scores range from 25 to 125. A higher score indicates a higher degree of stress. Cronbach's *a* coefficient of the survey was 0.94 by Kim et al. (1995) and 0.91 in this study.

To assess the rehabilitation motivation of the stroke patient subjects, a rehabilitation motivation survey was developed based on the self-determination theory (Ryan and Deci, 2000) by Han and Lim (2002). The survey comprises a total of 27 questions with the following subcategories: task-oriented motivation (eight questions), compulsory

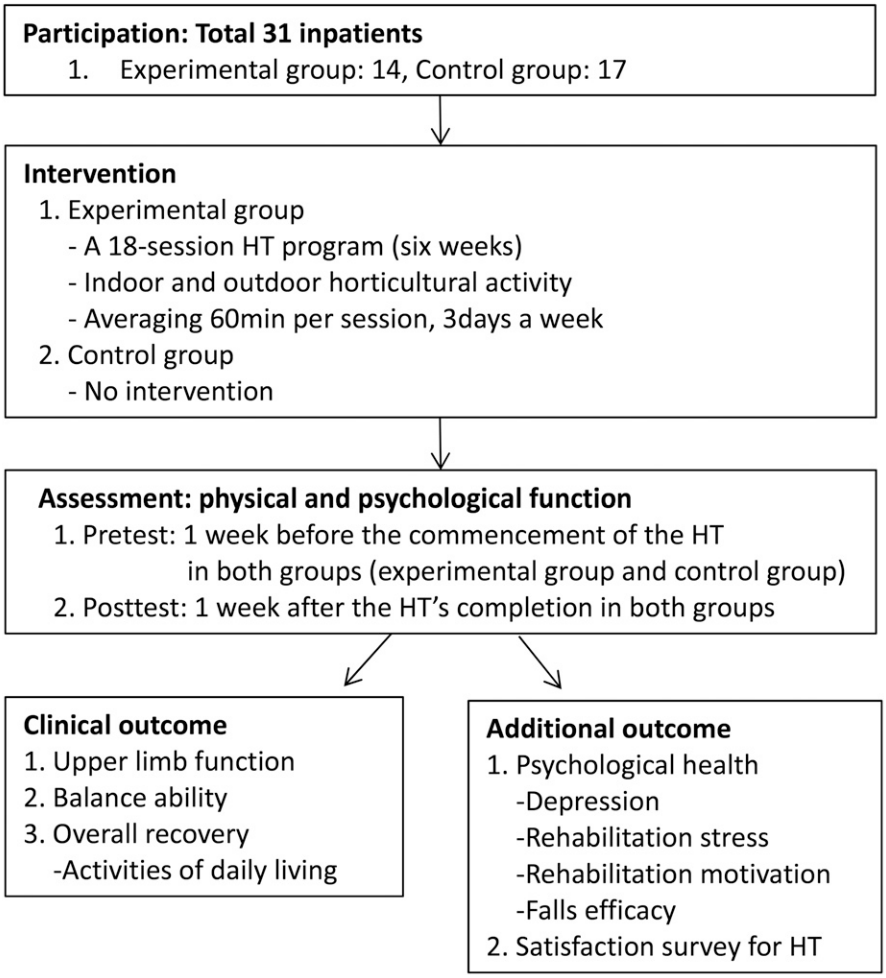


Fig. 2. Experimental process of horticultural therapy (HT) for the rehabilitation of upper limb function and balance ability of brain injury patients.

motivation (four questions), internal motivation (four questions), change-directed motivation (seven questions), and amotivation (four questions). Total scores range from 1 to 88, and a higher score indicates higher rehabilitation motivation. Cronbach's *a* coefficient of the survey was 0.85 by Han and Lim (2002) and 0.79 in this study.

The Korean version of the Falls Efficacy Scale (Choi et al., 2003; Tinetti et al., 1990) was used to evaluate the degree of self-confidence of stroke patients that they will not fall while performing 10 activities of daily living. Each question uses a 10-point Likert scale from 1 (not at all scared) to 10 (very scared) to determine the fear of falling in each activity. Total scores range from 10 to 100, and a lower score indicates a higher fall efficacy. Cronbach's *a* coefficient of the survey was 0.84 by Choi et al. (2003) and 0.92 in this study.

In addition, a satisfaction survey for the HT program was revised and tailored appropriately for this study (Park et al., 2015, 2016b) and performed by the stroke patients in the HT group after the 18-session HT program. This satisfaction survey was composed of a total of nine questions: overall satisfaction with the HT, duration per HT session, frequency of HT, benefits of HT, preference for performed HT activities, wish to continue participating in the HT, intent to recommend the HT to other stroke patients, intent to pay for HT, and willingness to pay for HT.

### Analytical methods

To compare the physical and physiological rehabilitation effects of the HT program in the HT and control group, the Wilcoxon signed-rank test was performed using SPSS software (version 24 for Windows; IBM, Armonk, NY). Demographic information and satisfaction with the HT program were analyzed using Excel software (Microsoft Office 2007; Microsoft Corp., Redmond, WA). Furthermore, the chi square test using SPSS software was leveraged to compare the demographic data between the two groups. Values of $P < 0.05$ were considered statistically significant. To analyze test–retest reliability of instruments used in this study, Pearson correlation analysis was conducted for MFT, BBS, and K-MBI. Cronbach's *a* coefficient of surveys such as SGDS-K, Rehabilitation Stress Scales, Rehabilitation Motivation Scales, and the Korean version of the Falls Efficacy Scale used in this study was obtained by the reliability analysis.

## Results and Discussion

*Demographic characteristics.* The stroke patients who participated in the HT and control groups had mean ages of 53.4 ± 12.6 ($n$ = 14; six males and eight females) and 56.1 ± 10.0 years ($n$ = 17; 10 males and seven females), respectively.

There were significant intergroup differences in hemiparetic side and duration from brain injury ($P < 0.05$; Table 2). Quadriplegia patients existed only in the HT group, but the horticultural therapist conducted intensive training by choosing the more injured parts of the brain through interviews with them. Symptoms of stroke represent differences in neurological and psychological characteristics depending on the side of lesion (American Heart Association, 2017; Foerch et al., 2005). Left hemiparetic, which appears as right-sided damage, mainly exhibits a vision problem and a fast, curious behavior pattern. Right hemiparetic, which appears as a left-sided injury, has a slow and cautious behavior pattern with speech and language problems (American Heart Association, 2017). The medical attention and subsequent management of the left hemiplegic patient was reported to be higher than the right hemiplegic patient (Foerch et al., 2005).

The HT and control groups had mean durations from brain injury onset of 2.0 ± 0.9 and 1.4 ± 0.7 years, respectively. In general, the longer the onset of illness, the slower was the recovery rate of function and the lower was the physical and psychological health (Aström et al., 1993; Broeks et al., 1999). The recovery of function in stroke patients is mostly seen at the first week after the onset, and the maximum recovery is achieved at 3–6 months after the onset of the stroke, after which patient function remains the same or weaker (Kwakkel et al., 2004; Meyer et al., 2015). This study also showed that patients in the HT group with a long stroke duration tended to have lower physical, psychological, and cognitive function than those in the control group.

However, there were no significant differences between the HT and control groups in gender, age, brain damage type, stroke recovery stage, gait function, depression, communication function, and cognitive function of stroke patients (Table 2). As treatment services in rehabilitation hospital, both groups were equally provided occupational and physical therapy that involved fifth-weekly sessions for a mean duration of 60 min per session. The therapy attendance rate among stroke patients in the HT group was 92.9% ± 8.2%, and poor physical condition and absence from the hospital were cited as reasons for absence.

*Physiological function assessments.* Stroke patients in the 18-session HT program exhibited significant improvement of upper limb, grip strength, pinch force, balance ability, and daily living activities ($P$ = 0.05;

Table 3), whereas the control group did not differ significantly in any of the physical parameters. According to the MFT, the mean upper limb function of stroke patients in the HT group was significantly improved from 12.6 ± 9.7 (pre-therapy) to 13.7 ± 9.9 (post-therapy, $P$ = 0.05). However, there was a slightly increased tendency of upper limb function scores in the control group, but the differences were insignificant. Stroke patients in the HT group exhibited significant increases in grasp force from 4.2 ± 2.3 kg (pre-therapy) to 5.2 ± 2.2 kg (post-therapy, $P$ = 0.05) as well as lateral pinch force of 2.1 ± 0.9 kg (pre-therapy) to 2.5 ± 0.8 kg (post-therapy, $P$ = 0.05). There was no significant difference in the fine motor skills. Meanwhile, there was no statistically significant changes in hand function between pre- and post-therapy in stroke patients in the control group. In the post-physical function assessments, most of the stroke patients in the control group were absent because of poor physical condition and absence from the hospital. The improved function of the upper limbs in the HT group is suggested to be the result of the repetitive reaching–grasping motion of the horticultural activities based on the task-oriented training method.

Table 2. Comparisons of subjects' demographic information during improvement of upper limb function and balance of brain injury through 18-session horticultural therapy (HT) using chi-square and Mann–Whitney $U$ tests.

| Variable | HT ($n$ = 14) N (%) | Control ($n$ = 17) N (%) | $P$ |
|---|---|---|---|
| Gender | | | |
| Male | 6 (42.9) | 10 (58.8) | 0.376^NS^ |
| Female | 8 (57.1) | 7 (41.2) | |
| Brain damage type | | | |
| Cerebral hemorrhage | 7 (50.0) | 11 (64.7) | 0.446^NS^ |
| Ischemic stroke | 6 (42.9) | 6 (35.3) | |
| Traumatic brain injury | 1 (7.1) | — | |
| Hemiparetic side | | | |
| Right | 5 (35.7) | 6 (35.3) | 0.047* |
| Left | 5 (35.7) | 11 (64.7) | |
| Quadriplegia | 4 (28.6) | — | |
| Gait function | | | |
| Independent | 3 (21.4) | 2 (11.8) | 0.501^NS^ |
| With support | 7 (50.0) | 12 (70.6) | |
| Unable to walk | 4 (28.6) | 3 (17.6) | |
| Communication function | | | |
| Normal | 9 (64.3) | 13 (76.5) | 0.457^NS^ |
| Speech and language disorder | 5 (35.7) | 4 (23.5) | |
| Depression | | | |
| Normal | 10 (71.4) | 10 (58.8) | 0.465^NS^ |
| Disorder | 4 (12.9) | 7 (41.2) | |
| | Mean (SD) | | |
| Age (years) | 53.4 (12.6) | 56.1 (10.0) | 0.633^NS^ |
| Duration from brain injury onset (years) | 2.0 (0.9) | 1.4 (0.7) | 0.049* |
| Brunnstrom recovery stage | 3.5 (0.7) | 3.1 (0.3) | 0.125^NS^ |
| Cognitive function (score) | 25.8 (6.5) | 26.4 (4.0) | 0.739^NS^ |

The chi square test was used to compare values at $P$ < 0.05 for sex, brain damage type, hemiparetic side, gait function, communication function, and depression, whereas the Mann–Whitney $U$ test was used to compare means at $P$ < 0.05 for age, Brunnstrom recovery stage, and cognitive function.

NS, *Nonsignificant or significant at $P$ < 0.05, respectively.

Table 3. Wilcoxon test comparisons of upper limb function, balance ability, and daily living activities of brain injury patients before and after horticultural therapy (HT).

| Variable | | | HT | Control |
|---|---|---|---|---|
| Manual functional test[z] | | Pretest | 12.6 (9.7)[y] | 8.6 (6.5) |
| | | Posttest | 13.7 (9.9) | 9.3 (7.7) |
| | | $P$ | 0.016* | 0.157^NS^ |
| Hand function | Grasp force | Pretest | 4.2 (2.3) | — |
| | | Posttest | 5.2 (2.2) | |
| | | $P$ | 0.046* | |
| | Lateral pinch force | Pretest | 2.1 (0.9) | — |
| | | Posttest | 2.5 (0.8) | |
| | | $P$ | 0.043* | |
| | Hand dexterity | Pretest | 40.0 (16.1) | — |
| | | Posttest | 37.0 (12.5) | |
| | | $P$ | 0.080^NS^ | |
| Berg Balance Scale[z] | | Pretest | 40.5 (9.4) | 40.6 (8.0) |
| | | Posttest | 42.2 (8.7) | 39.8 (8.0) |
| | | $P$ | 0.020* | 0.705^NS^ |
| | | Pretest | 64.4 (18.8) | 61.5 (15.5) |
| Modified Barthel Index[z] | | Posttest | 65.5 (17.9) | 62.9 (16.8) |
| | | $P$ | 0.041* | 0.201^NS^ |

[z]Test–retest reliability of instrument was 0.99 for manual functional test, 0.96 for Berg Balance Scale, and 0.99 for Modified Barthel Index in this study by the Pearson correlation analysis.

[y]Values are means ± SD. The Wilcoxon test was used to compare pre- and posttest means in each group at $P$ < 0.05.

NS, *Nonsignificant or significant at $P$ < 0.05, respectively.

Meanwhile, the reaching–grasping of stroke patients showed compensatory action that the waist excessively bends forward because of limited upper limb function (Cirstea and Levin, 2000). To make reach–grasp training more effective, the therapist needs a trunk-restraint skill that deliberately limits their waist movement (Michaelsen et al., 2006); thus, in this study, the horticultural therapist corrected the posture so that the stroke patients could restrict the waist movement when performing the horticultural activity. Michaelsen et al. (2006) reported significantly improved combination pattern of upper limb and trunk control that affected the balance ability of 30 stroke patients throughout the 15-session reaching–grasping training (5 weeks for 60 min per session) with the application of the trunk-restraint skill compared with the standard reaching–grasping training.

The improvement of grip strength and pinch force gained by this HT program seems to be due to repeated practice with the grasping pattern through the horticultural activity. Patterns required for grasping the soil and watering can were the ball grasp and the cylindrical grasp, respectively (Lee et al., 2016). These were the grasping patterns required to hold the hand dynamometer during grip strength test. To grasp a tray, seeds, and a plant, grasping patterns required lateral prehension, fingertip prehension, and palmar prehension, respectively (Lee et al., 2016). These were also the grasping patterns may have required to hold the pinch gauge in the pinch force test.

Meanwhile, the fine motor skill of HT group did not show statistically significant results because of the developmental process of hand function. This function requires elaborate and complicated movements with the adjustment of small muscle movements that both involve the synchronization of hands and fingers with the eyes (Barnsley and Rabinovich, 1970; Fleishman, 1972). The Motor Assessment Outcome model (Haley, 1992) explained that improvement of the fine motor movement was preceded by improvement of the sensorimotor components such as grip strength, stereognosis, and dexterity (Li-Tsang, 2003). Therefore, if the HT program in this study were used for a longer period, the hand function of stroke patients in the HT group would be expected to demonstrate improved sensory motor components and fine motor skills. In a previous study, a 3-month HT program as treatment for a longer term compared with 6-week HT program in this study demonstrated significant improvement in fine motor skills of participants (Kim et al., 2010).

The balance ability of stroke patients in the HT group was significantly increased as evidenced by an increased mean BBS score from 40.5 ± 9.4 (pre-therapy) to 42.2 ± 8.7 (post-therapy, $P = 0.05$). By contrast, stroke patients in the control group exhibited no significant difference between pre- and posttest scores. Thus, the HT group experienced progressing posture control level from balance disorder to balance impairment, whereas the control group remained at the balance disorder state (Table 3). The HT groups exhibited improved static and dynamic balance. In the BBS, the subtest scores of static balance such as standing with the feet together ($n = 4$, 33.3%), standing unsupported ($n = 3$, 25.0%), and standing with eyes closed ($n = 1$, 8.3%) tests were increased, and the sitting to standing test ($n = 4$, 33.3%) findings of dynamic balance were also increased.

Trunk rehabilitation for stroke patients is very important to recovering balance ability. Trunk control is closely related to body movements such as balance ability, walking ability, and upper limb function (Hsieh et al., 2002; Verheyden et al., 2006). Rehabilitation therapists generally use a training method that maintains dynamic stability against postural instability caused by abrupt body COM movements during trunk movements such as flexion, extension, lateral flexion, and rotation for trunk rehabilitation (Eng and Chu, 2002; Kim et al., 2012). Sitting and reaching to grasp an object is combined with the trunk and upper movement limb according to the object spot as the neutralization of the movement of the upper limb in stroke patients (Shaikh et al., 2014). Improved balance ability is considered the result of repetitive performed trunk control motions such as sitting–reaching, squatting–reaching, stooping–reaching, and stepping–reaching, all of which are used to grasp horticultural materials (Lee, 2017).

Previous studies have reported positive effects of balance improving tasks as task-oriented training on body balance that are similar to this study findings. For example, Chan et al. (2015) reported improved static balance, trunk strength, and trunk control function among 37 stroke patients after balance improving training (6 weeks for 60 min per session) included sit–reach and trunk-control motions. Moreover, 12 stroke patients (mean age, 52.4 ± 10.1 years) who participated in 16-session balance improving training (four times a week, 30 min per session) as extra therapy reported significantly improved balance and gait ability (Kim et al., 2009).

Overall, the same effect such as improving upper limb function and balance ability of task-oriented training through the HT program using the task-oriented training was shown in this study. These results were expected at the time of developing the HT program for this study. These study results support findings of previous studies (Lee, 2017; Lee et al., 2016) that reported similar kinetic and kinematic characteristics of motions in horticultural activity and functional tasks in task-oriented training. In conclusion, the repetitive horticultural activity motions such as reaching–grasping, squatting, stepping, and squatting activated the brain's plasticity, caused reorganization of new neural networks in the damaged brain tissue, and finally enabled the relearning of motor skill in stroke patients (Harvey, 2009; Hubbard et al., 2009).

In the daily living activities, the HT group experienced an increase in the K-MBI score from 64.4 ± 18.8 (pre-therapy) to 65.5 ± 17.9 (post-therapy; $P = 0.05$). However, the control group showed no significant difference in the pre- and post-tests (Table 3). The daily living activities in stroke patients are mainly affected by the motor ability of the upper limb, lower limb, and trunk (Fujita et al., 2015; Oliveira et al., 2006; Verheyden et al., 2006). Improved daily living activities were thought to have resulted in the improved motor function such as the upper limb, lower limb, and body balance among stroke patients in the HT group, thus further improving the daily living activities. The positive result achieved in this and a previous study (Kim et al., 2010) suggested that stroke patients experienced the improved motor function such as the upper limb, lower limb, and body balance through HT and eventually improved their daily living activities.

The increased tendency of physical function in the control group in this study seems to be treatment effect of the occupational and physical therapy provided in the hospital. This tendency was similar to those reported in previous studies that used HT to rehabilitate stroke inpatients (Kim et al., 2003, 2010).

*Psychological function assessments.* Stroke patients in the 18-session HT program experienced significantly decreased depression and improved fall efficacy ($P = 0.05$), whereas the control group did not show any significant difference in any of the psychological parameters scores between the pre- and post-therapy time points. The mean depression scores of stroke patients in the HT group decreased from 7.0 ± 4.5 to 4.6 ± 3.7, with symptoms recovering from moderate depression symptoms before the treatment period to normal at the end of the study ($P = 0.05$; Table 4). The depression scores in the control group tended to increase and remained in the moderate depression symptom range. HT is reportedly effective for reducing depression in patients with post-stroke depression (Kim et al., 2003, 2010, 2014; Park et al., 2015; Shin et al., 2016). Previous studies of HT programs for stroke patients also showed that depression levels improved from moderate to normal, consistent with the results of this study (Kim et al., 2010; Park et al., 2015). Stroke patients used green plants in HT, which provided emotional stability and a relaxation effect. Previous studies have reported the effects of visual stimulation by green plants on physiological and psychological relaxation (Park et al., 2016d; Son et al., 1998). Specifically, Park et al. (2017) reported that the reaching–grasping task with green plants showed a higher stabilizing effect on the autonomic nervous system such as cerebral blood flow and sympathetic nerve activity than the reaching–grasping task without a green plant. Therefore, performing functional tasks through horticultural activity can provide psychophysiological and psychological stabilization effects as well as the physical effects that are commonly obtained through the repetition of a functional task.

Stroke patients in the HT group exhibited decreased rehabilitation stress and increased rehabilitation motivation in the posttest, but this improvement was not significant. Meanwhile, stroke patients in the control group did not change during this period (Table 4). HT as a group therapy can have a positive impact on psychological health as it features group dynamics such as a self-help group formation and social support (Wevers et al., 2009). However, rehabilitation stress and rehabilitation motivation are influenced by individual psychological factors and external factors such as family, hospital, and community (Geelen and Soons, 1996; Wolff, 1969); therefore, professional support and intervention should be provided (Maclean et al., 2002; Matheson, 1995). Because the improvement

Table 4. Wilcoxon test comparisons of the psychological health of brain injury patients before and after horticultural therapy (HT).

| Variable[z] | | HT | Control |
|---|---|---|---|
| Geriatric depression scales (0 to 15 scale) (GDS-5/15) | Pretest | 7.0 (4.5)[y] | 6.5 (3.3) |
| | Posttest | 4.6 (3.7) | 7.4 (3.4) |
| | $P$ | 0.044* | 0.244[NS] |
| Rehabilitation stress | Pretest | 74.4 (20.6) | 78.8 (20.0) |
| | Posttest | 63.6 (18.6) | 77.8 (19.5) |
| | $P$ | 0.055[NS] | 0.754[NS] |
| Rehabilitation motivation | Pretest | 85.7 (28.3) | 95.5 (24.5) |
| | Posttest | 95.7 (23.6) | 98.6 (19.7) |
| | $P$ | 0.152[NS] | 0.780[NS] |
| Falls Efficacy Scale (0 to 100 scale) (K-FES) | Pretest | 69.0 (26.8) | 72.3 (16.9) |
| | Posttest | 44.4 (27.7) | 70.8 (16.2) |
| | $P$ | 0.006** | 0.859[NS] |

[z]Cronbach's $a$ coefficient of survey was 0.80 for GDS-5/15, 0.91 for rehabilitation stress, 0.79 for rehabilitation motivation, and 0.92 for K-FES in this study by the reliability analysis.

[y]Values are means ± SD. The Wilcoxon test was used to compare pre- and posttest means in each group at $P < 0.05$.

[NS, *, **]Nonsignificant or significant at $P < 0.05$, and significant at $P < 0.01$, respectively.

of physical function in stroke patients was a main therapeutic goal of this HT, the study results were considered that horticultural therapists' deliberate and therapeutic interventions to improve rehabilitation stress and rehabilitation motivation were poor. For improving rehabilitation stress and rehabilitation motivation through HT, intentional and wide intervention and support of the horticultural therapist for the stroke patient and caregivers are necessary.

Meanwhile, the main form of task-oriented training, the repetition of specific functional tasks, leads to a lack of initiative and motivation to treatment in patients by causing a loss of purpose awareness and treatment boredom (Gil-Gómez et al., 2011).

HT involves various factors that can increase treatment interest and motivation compared with traditional rehabilitation therapy: task-oriented and goal-oriented processes in horticultural activity, interest in continuously caring for living plants during seasonal variations and plant growth cycles, and the provision of outdoor HT activity as differentiated therapy from traditional rehabilitation (Department of Health, 2004; Lekies and Sheavly, 2007; Park et al., 2008a, 2008b, 2009). It can also be used to develop individual treatments that consider each patient's abilities by applying changed activity styles and a variety of horticultural activities (Söderback et al., 2004). Because of the high accessibility of horticultural activity in real life, HT can be linked to home training for rehabilitation or leisure activities even after the patient is discharged from the hospital (Söderback et al., 2004).

A significant improvement in fall efficacy was observed among stroke patients in the HT groups ($P = 0.01$; Table 4). Meanwhile, there was no significant pre- vs. posttest difference in the control group. Limiting movements because of their fear of falling reduces balance and walking ability, continually reduces physical function, and eventually leads to falling (Tinetti et al., 1994).

Improving the falling efficacy is closely related to the recovery of the patient's physical, psychological, and social functions (Bandura, 1998; Wood et al., 2010). This study results suggest that the HT program was conducted as a group therapy in a real-world environment (Morris et al., 2006; Pang et al., 2007; Wood et al., 2010). The HT using real-world environmental factors such as a table, a garden plot, and horticultural materials for operating therapy did not differ between the treatment environment and real life, so it is possible to acquire motor skills more effectively, apply the program in real life, and positively improve fall efficacy. Thus, the improved fall efficacy of stroke patients might help increase their activity due to decreasing the fear of falls (Weerdesteyn et al., 2008) and improving their balance ability.

*HT program satisfaction.* Stroke patients in the HT group reported being "very satisfied" (66.7%), "satisfied" (19.0%), "normal" (9.5%), and "not satisfied" (4.8%) with the HT. In the case of the patient who reported "not satisfied" ($n = 1$), he responded that the preference for plants was inherently low and his caregiver forced him to participate in the HT. Stroke patients were "very satisfied" (38.1%), "satisfied" (23.6%), "normal" (28.6%), "not satisfied" (4.8%), or "very not satisfied" (4.8%) with the 60-min treatment time per session. In the case of patients who reported feeling "not satisfied" or "very not satisfied" ($n = 2$), they responded that 30 and 90 min per HT session were adequate durations. Stroke patients were also "very satisfied" (38.1%), "satisfied" (23.6%), "normal" (6.5%), "not satisfied" (14.3%), and "very not satisfied" (9.5%) with a session frequency of third per week. In the case of patients who reported "not satisfied" or "very not satisfied" ($n = 5$), they responded that one session per week ($n = 1$), two sessions per week ($n = 1$), four sessions per week ($n = 1$), and five sessions per week ($n = 1$) were adequate session frequencies for HT. Regarding the benefits of gardening, stroke patients who participated in the HT responded "expectation for plant growth" (81.0%), "enjoyable treatment" (71.4%), "getting outcomes" (66.7%), "using living plants as therapy tools" (66.7%), and "therapy physical and psychological rehabilitation" (61.9%). The most preferred HT activities were ranked "transporting" (41.0%), "planting indoor plants" (25.6%), and "maintaining a garden" (22.2%). In addition, 76.2% stroke patients in the HT group reported that they wished to continue participating in the HT, whereas 81.0% of participants would recommend it to other stroke patients. A total of 76.2% participants in the HT group hoped to pay the treatment fee for HT in the hospital and were willing to pay \$17.4 (±\$23.2).

To verify the effectiveness of HT for rehabilitation, the HT program was developed to improve upper limb function and balance ability by applying task-oriented training methods based on kinetic and kinematic characteristics of horticultural activity motions and was delivered to stroke patients. In conclusion, stroke patients in the HT group who participated in all HT and existing rehabilitation therapy had more significant improvements (e.g., upper limb function, grip strength, pinch force, balance ability, and daily living activities) in their physical recovery when compared with those in the control group, who completed the standard rehabilitation therapy program ($P = 0.05$). In addition, stroke patients in the HT group exhibited significantly decreased depression and improved fall efficacy ($P = 0.05$). This result showed that HT can be used as a complementary and alternative medicine to ameliorate the lack of emotional recovery such as amotivation and lacking purpose in treatment, which is a limitation of rehabilitation therapy (Gil-Gómez et al., 2011; Saini et al., 2012). A future study should evaluate the effectiveness of HT rehabilitation in various rehabilitation patients such as those with spinal cord injury, cerebral palsy, or neuromuscular disorders.

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