Research-Based Evidence of Horticultural Therapy for Health

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**Horticultural Therapy**

- Intervention based on horticultural activities
- Diagnosed clients
- Therapeutic goal and objectives
- Trained professional

★ **Horticultural therapy expertise**: Maximizing the therapeutic effect by appropriately utilizing horticultural activities according to the subject's purpose
Key Tool of Horticultural Therapy

★ Horticultural activities (HAs)

- Energy expenditure
- Exercise intensity
- Muscle activation
- Heart rate variability
- Brain activation
- Cognitive ability
- Emotional condition
- Etc.
## Research-Based Evidence for HA

### Active participation

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<th>Analysis of HAs as a physical activity</th>
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<td>• Physical activity (Study 1-1,1-2,1-3)</td>
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<td>• Muscle activation (Study 2-1,2-2)</td>
</tr>
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<td>• Kinetic and kinematic motion (Study 3-1,3-2)</td>
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<td>• Prefrontal cortex activity (Study 4)</td>
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</table>
Analysis of HAs as a Physical Activity
Study 1: Determining Exercise Intensity of HAs

- **Physical activity**: any bodily movement produced by the contraction of skeletal muscle that results in energy expenditure

- **Exercise intensity of physical activity**: Metabolic equivalent (MET)
  - 1 MET = 3.5 ml of \( O_2/\)kg of body/min.
  - e.g. lying (1 MET), sitting (1.3 METs), walking (3.5 METs), Golf (4.5 METs), Jogging (7 METs)

- **Physical activity recommendation for health (CDC)**
  - Adults: at least 30 min of moderate intensity physical activity on most days of the week
  - Children and adolescents: 60 min or more of moderate to high intensity on each day
Study 1-1, 1-2, 1-3: Determining Exercise Intensity of HAs in Children, Adults, and Elderly

Study 1-1
- Date: 2012, Aug.
- Subject: 17 children aged 12.4±0.7 years
- Procedure: 10 gardening tasks, 5 min for each task

Study 1-2
- Date: 2012, Aug.
- Subject: 15 adults aged 24.7±1.4 years
- Procedure: 10 gardening tasks, 5 min for each task

Study 1-3
- Date: 2011, June
- Subject: 20 elderly aged 67.3±2.7 years
- Procedure: 15 gardening tasks, 5 min for each task

• Measurement: exercise intensity, oxygen uptake, and energy expenditure by a portable telemetric calorimeter (K4b²; Cosmed, Rome, Italy)
# Results of Study 1-1, 1-2, 1-3: Exercise Intensity of HAs

<table>
<thead>
<tr>
<th>Activity</th>
<th>Children</th>
<th>Adults</th>
<th>Elderly</th>
<th>Activity</th>
<th>Children</th>
<th>Adults</th>
<th>Elderly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digging</td>
<td>6.6 ± 1.6</td>
<td>6.3 ± 1.2</td>
<td>4.5 ± 1.2</td>
<td>Sowing</td>
<td>5.0 ± 1.1</td>
<td>4.3 ± 0.8</td>
<td>2.7 ± 0.6</td>
</tr>
<tr>
<td>Raking</td>
<td>6.2 ± 1.5</td>
<td>5.4 ± 1.0</td>
<td>3.4 ± 0.8</td>
<td>Harvesting</td>
<td>4.8 ± 0.6</td>
<td>4.2 ± 0.6</td>
<td>2.7 ± 0.6</td>
</tr>
<tr>
<td>Weeding</td>
<td>5.8 ± 1.1</td>
<td>5.0 ± 0.8</td>
<td>3.4 ± 0.6</td>
<td>Watering</td>
<td>4.6 ± 1.1</td>
<td>3.9 ± 0.4</td>
<td>2.8 ± 0.9</td>
</tr>
<tr>
<td>Mulching</td>
<td>5.5 ± 1.3</td>
<td>4.5 ± 0.8</td>
<td>3.3 ± 0.8</td>
<td>Mixing soil</td>
<td>4.3 ± 0.6</td>
<td>3.6 ± 0.5</td>
<td>2.4 ± 0.7</td>
</tr>
<tr>
<td>Hoeing</td>
<td>5.3 ± 0.7</td>
<td>4.4 ± 0.8</td>
<td>.</td>
<td>Planting</td>
<td>4.3 ± 0.5</td>
<td>3.5 ± 0.5</td>
<td>2.9 ± 0.9</td>
</tr>
</tbody>
</table>

Unit: METs

- **Study 1-1:** Park et al., *HortTechnology*, 2013
- **Study 1-2:** Park et al., *HortTechnology*, 2014
- **Study 1-3:** Park et al., *HortScience*, 2011

Gardening: low to high intensity physical activity
Study 2: Electromyographic Analysis of Upper and Lower Limb Muscles during HAs

- Electromyography (EMG): an electrical method used to measure the electrical signal produced by skeletal muscle, which results from muscular contraction
- Widely used to provide specific information on the functions of agonistic and antagonistic muscles, to detect medical abnormalities, or to biomechanically analyze human or animal movement
- Analyzing various movements of the human body to improve exercise techniques or apply rehabilitation
Study 2-1: Measuring Muscle Activation of Upper Limb and Hand Muscles during Indoor HAs

- Date: 2012, June
- Subject: 30 male adults aged 24.8±2.8 years
- Procedure: 15 indoor horticultural activities, 60-second for each task
- Muscles tested: 6 upper limb muscles and 2 hand muscles
- Measurement: a portable four channel EMG

Park et al., HortTechnology, 2013
Results of Study 2-1: Muscle Activation of Upper Limb and Hand Muscles

Park et al., HortTechnology, 2013

- Sticking cutting
- Filling a container with growing medium
- Transplanting plants
- Planting plant
- Making moss balls
- Removing leaves from plants
- Sowing seeds
- Dividing plants
- Watering
- Cutting stems
- Writing name tags
- Mixing growing medium
- Making moss balls
- Watering
- Cutting stems
- Higher muscle activation: upper trapezius, thenar eminence, hypothenar eminence
- Almost not used: triceps long head

(A) upper trapezius, (B) triceps—long head, (C) biceps brachialis, (D) flexor carpi ulnaris, (E) flexor carpi radialis, (F) brachioradialis, (G) thenar eminence, (H) hypothenar eminence
Study 2-2: Muscle Activation of Upper and Lower Limb Muscles

- Date: 2013, July
- Subject: 20 male adults aged 24.8±2.4 years
- Procedure: 5 gardening tasks, 20-second for each task
- Muscles tested: 16 muscles on upper and lower body
- Measurement: a portable 16 channel EMG
Results of Study 2-2: Muscle Activation of Upper and Lower Limb Muscles

Movement analysis

Digging

Raking

Troweling, Weeding

Hoeing

(A) right anterior deltoid, (B) right biceps brachialis, (C) right brachioradialis, (D) right flexor carpi ulnaris, (E) left anterior deltoid, (F) left biceps brachialis, (G) left brachioradialis, (H) left flexor carpi ulnaris, (I) right vastus lateralis, (J) right vastus medialis, (K) right biceps femoris, (L) right gastrocnemius, (M) left vastus lateralis, (N) left vastus medialis, (O) left biceps femoris, (P) left gastrocnemius
Study 3: Kinetic and Kinematic Analysis of Body during HAs

Kinetic and kinematic analysis
• Observed to have a more precise understanding of the human motions (velocity, joint angle, power, etc.)
• Broadly applied to analyze human motions in fields of medicine, rehabilitation, biomechanics, sports, etc.
• Kinematic factors: movement times, velocity, joint angles, grasping patterns
• Kinetic factors: muscle activation
Study 3-1: Kinetic and Kinematic Analysis of Upper Body during HAs

- Date: 2014, Feb.
- Subject: 20 male adults aged 26.2±2.0 years
- Procedure: 2 indoor horticultural tasks (sowing seeds, planting a plant)

Lee et al., Kor.J.Hort.Sci, 2016
Movement analysis

Two HAs

Eight tasks
- Positioning a tray
- Filling a tray with soil
- Sowing seeds in the tray
- Watering with a spray bottle

Six phases
- Reaching
- Grasping
- Back transporting
- Watering
- Forward transporting
- Releasing

Seed sowing

Planting plant
- Positioning a pot
- Filling a pot with soil
- Planting a plant
- Watering with a watering can

Lee et al., Kor.J.Hort.Sci, 2016
Results of Study 3-1: Kinetic and Kinematic Analysis of Upper Body during HAs

Two gardening activities

- Reaching- grasping motion
- Differences of Kinematic characteristics in types of gardening tools
- Commonly use shoulder girdle

Lee et al., Kor.J.Hort.Sci, 2016

Reaching- grasping training in gardening activities proves to have high potential to serve in physical therapy treatments
Study 3-2: Kinetic and Kinematic Analysis of Lower Body during HAs

- Date: 2016, June
- Subject: 20 male adults aged 23.3±2.9 years
- Procedure: 8 gardening tasks

Lee et al., 2017
Results of Study 3-2: Kinetic and Kinematic Analysis of Lower Body during HAs

**Taking one step**
- Raking
- Digging

**Squatting**
- Sowing
- Planting
- Weeding 1
- Weeding 2

**Bending**
- Harvesting 1
- Harvesting 2

Gardening for balance training

Lee et al., 2017
Measuring of Psychophysiological Responses of HA
Study 4: Comparison of Physiological and Psychological Relaxation for Tasks with and without Foliage Plants

- Date: 2015, Oct.
- Subject: 21 male adults aged 23.8±2.6 years
- Activity: Transferring pots with and without foliage plants
- Measurements: Prefrontal cortex activity (NIRS), heart rate variability, subjective indexes

Park et al., Intl. J. Environ. Public Health, 2017
Results of Study 4: Comparison of Physiological and Psychological Relaxation for Tasks with and without Foliage Plants

Park et al., Intl. J. Environ. Publich Health, 2017

N = 21, mean ± SE, *: p < 0.05 by paired t test (one-sided)

N = 21, mean ± SE, †: p < 0.10 by paired t test with Holm correction (one-sided)
N = 24, mean±SE, **: p < 0.01 by Wilcoxon signed-rank test (one-sided)

Park et al., Intl. J. Environ. Publich Health, 2017
N = 24, mean ± SE, *: p < 0.05, **: p < 0.01 by Wilcoxon signed-rank test (one-sided)

Park et al., Intl. J. Environ. Publich Health, 2017
Study 5: Comparison of Psychophysiologial Responses according to the Levels of Cognitive Demand of Horticultural Activity

- Subjects: 60 adults aged 20s years (25.2± 2.7 years)
- Activity: Performed two cognitive demand of soil-mixing activities for 2 min, respectively
- Measurements: Electroencephalography, electrocardiography

<table>
<thead>
<tr>
<th>Activity</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low level cognitive demand</td>
<td>Just mixing the pre-mixed soil with peat-moss, perlite, and water in the basin with both hands for 2 min.</td>
</tr>
<tr>
<td>High level cognitive demand</td>
<td>Putting peat-moss and perlite in an empty basin at a ratio of 7:3, pouring a certain amount of water (200mL) and mixing with both hands for 2 min.</td>
</tr>
</tbody>
</table>
Results of Study 5: Comparison of Psychophysiological Responses according to the Levels of Cognitive Demand of Horticultural Activity

- Increased concentration and improved cognitive performance when performing high difficulty cognitive demands
  - RLB (Relative low-beta power spectrum)
    - Significant increase during high level of cognitive demand in both frontal lobes
  - RFA (Relative fast-alpha power spectrum)
    - Significant increase during high level of cognitive demand in right frontal lobe
  - SDNN (Standard deviation of R-R intervals)
    - Significantly increase SDNN in women during high-level of cognitive demand
**Study 6: Effects of Horticultural Therapy Using FDG PET Imaging for Dementia**

- A case study
- HT programs: Every weekday for 14 days

<table>
<thead>
<tr>
<th>Alzheimer’s disease (AD) patient</th>
<th>Vascular dementia (VD) patient</th>
</tr>
</thead>
<tbody>
<tr>
<td>65 yr. Male, High-school dropped-out</td>
<td>76 yr. Male, High-school dropped-out</td>
</tr>
<tr>
<td>K-MMSE 10, CDR 3, Middle stage of dementia</td>
<td>K-MMSE 23</td>
</tr>
<tr>
<td>Low visuo-spatial functions (easily lost the way), Low ADL (impossible to bath by himself)</td>
<td>Low short-term memory, Sleep disturbance, Amotivation</td>
</tr>
</tbody>
</table>

SPM analysis of the Brain PET images in AD patient with horticultural therapy. This analysis shows increasing tendency in left parieto-temporal area.

SPM analysis of the Brain PET images in VD patient with horticultural therapy. This analysis shows increasing tendency in bilateral multiple fronto-temporal-parietal area after horticultural treatment.
Effects of Horticultural Therapy Program
Study 7: Horticultural Therapy for Improving Physical and Psychological Health of Elderly Women

- Date: 2015, Sep. – Nov.
- Subject: 50 elderly women aged over 70 years
- Design: a quasi-experimental design with a nonequivalent control group
- Place: a garden plot, senior center, Seoul, Korea
- Intervention: a 15-session Horticultural therapy program (twice a week)

Park et al., HortTechnology, 2016
Park et al., HortScience, 2017
A 15-session horticultural therapy program as low to moderate intensity

<table>
<thead>
<tr>
<th>Session</th>
<th>Gardening activity</th>
<th>Plant used</th>
<th>Estimated METs²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Design garden and making garden plots</td>
<td>-</td>
<td>3.4</td>
</tr>
<tr>
<td>2</td>
<td>Planting transplants</td>
<td>chives</td>
<td>3.7</td>
</tr>
<tr>
<td>3</td>
<td>Planting transplants</td>
<td>beet, chinese cabbage, radish, lettuce, crown daisy, kohlrabi</td>
<td>2.9</td>
</tr>
<tr>
<td>4</td>
<td>Making garden signs</td>
<td>-</td>
<td>2.8</td>
</tr>
<tr>
<td>5</td>
<td>Maintaining garden</td>
<td>golden pothos</td>
<td>2.3</td>
</tr>
<tr>
<td>6</td>
<td>Fertilizing</td>
<td>-</td>
<td>4.0</td>
</tr>
<tr>
<td>7</td>
<td>Making flower garden beds</td>
<td>crown of thorns, chrysanthemum, zinnia</td>
<td>2.5</td>
</tr>
<tr>
<td>8</td>
<td>Making vegetable beds</td>
<td>onion, lettuce</td>
<td>2.7</td>
</tr>
<tr>
<td>9</td>
<td>Making organic fertilizers</td>
<td>-</td>
<td>2.8</td>
</tr>
<tr>
<td>10</td>
<td>Maintaining garden</td>
<td>-</td>
<td>2.7</td>
</tr>
<tr>
<td>11</td>
<td>Planting plants</td>
<td>peperomia, rose</td>
<td>2.4</td>
</tr>
<tr>
<td>12</td>
<td>Maintaining garden</td>
<td>-</td>
<td>3.3</td>
</tr>
<tr>
<td>13</td>
<td>Flower arrangement</td>
<td>chrysanthemum</td>
<td>2.3</td>
</tr>
<tr>
<td>14</td>
<td>Harvesting and sowing seeds</td>
<td>spinach</td>
<td>3.3</td>
</tr>
<tr>
<td>15</td>
<td>Garden party</td>
<td>-</td>
<td>2.5</td>
</tr>
</tbody>
</table>

² Estimated metabolic equivalents (METs) based on the previous studies for measuring exercise intensities of gardening tasks (Park et al., 2011, 2012, 2014) and a study for compendium of physical activities (Ainsworth et al. 2000).
Physical health

- **Body composition:** Height (anthropometer), body weight, body mass index (body fat analyzer), waist and hip circumference (measuring tape)
- **Physical functional ability:** Senior fitness test (Rikli and Jones, 2013)
- **Hand function ability:** Grip strength, pinch force (Jamar), hand dexterity (Grooved pegboard)
- **Blood pressure:** Systolic and diastolic (T4 with Intellisense)
- **Cholesterol:** Total cholesterol, HDL-cholesterol, LDL-cholesterol
- **Immunity:** Inflammation, oxidative stress
Psychological health

- **Depression** (Korean Version of the Short Form of Geriatric Depression Scale)
- **Sociality** (Social behaviors of elderly)
- **Cognitive function ability** (Korean Mini Mental State Examination)
Exercise intensity of gardening intervention

- **Heart rate**: HR monitor and wireless receiver
- **% HR max**: \[
\frac{(\text{measured HR} - \text{resting HR})}{(\text{HR max} - \text{resting HR})} \times 100
\]
  (ACSM, 2014)
- Randomly selected four sessions

Subjective exercise intensity of gardening intervention

- **The Rating of Perceived Exertion Scale** (Borg, 1970)
- Self-reported at the end of each session of the gardening intervention
- A score of 8 to 10: low intensity, 11-13 score: moderate intensity,
  14-16 score: vigorous intensity, above 17 score: high intensity (ACSM, 2014)
Results of Study 7: Gardening Intervention for Improving Physical and Psychological Health of Elderly Women

Positive effects

Physical health
- Aerobic endurance, hand dexterity, HDL cholesterol, muscle mass, agility, dynamic balance, blood pressure, waist circumstance, markers of immune activation (TNF-α, RAGE expression)

Psychological health
- Depression, cognitive ability

Gardening intervention as a physical activity

Healthy Ageing

Park et al., HortTechnology, 2016
Park et al., HortScience, 2017
Study 8: Horticultural Therapy Program for Stroke Patients

- Date: 2016, Aug. – Sep.
- Subject: 50 elderly women aged over 70 years
- Design: a quasi-experimental design with a nonequivalent control group
- Place: a garden plot, senior center, Seoul, Korea
- Intervention: a 15-session gardening program (twice a week)

Lee et al., 2017
Results of Study 8: Horticultural Therapy Program for Stroke Patients

- Improvements of upper body function, grip strength, pinch force, balance, daily living ability, and falls efficacy
- Decreased depression

Horticultural therapy is a treatment for rehabilitation patients

Lee et al., 2017
Conclusions

- Evidence-based practice
- Professional horticultural therapy
- Industry expansion
References cited

Thank you!

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