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Horticultural activity improves postpartum women's cognitive function: Preliminary evidence from an exploratory pilot study

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Abstract: Postpartum can lead to cognitive impairment as well as mental health problems. To prevent these symptoms from getting worse, there needs to be a care method that the mother can easily implement while the infant is nearby. This exploratory pilot study examined that cognitive function improves with horticultural activity. Fifteen healthy women less than one year postpartum participated in this study. They participated in eight sessions of horticultural activity. Psychological tests were administered to assess participants' mental health and cognitive functioning before and after gardening activities. Compared with before gardening activity, the trail making test (TMT)-A and TMT-B were significantly decreased, and the Digit Symbol Substitution Test was significantly increased. Also, the scores for the Edinburgh Postpartum Depression Scale, State-Trait Anxiety Inventory, and anger-hostility, confusion-bewilderment, fatigue-inertia, tension-anxiety, Total Mood Disturbance of the Profile of Mood States 2 was significantly decreased, respectively. Vigor-activity and friendliness of the Profile of Mood States 2 were significantly increased. Given these positive benefits, horticultural activity may improve mental health and cognitive functions in postpartum women and may provide a great contribution to postpartum women's healthy life.

Subjects: Environmental Psychology; Health Psychology; Cognitive Psychology; Psychiatry & Clinical Psychology - Adult; Positive Psychology

Keyword: postpartum women; childbirth; delivery; horticultural activity; cognitive function; processing speed

ABOUT THE AUTHOR

She researches using questionnaires and biomarkers to investigate the causes of mental health problems and improve mental health from psychology and neuroscience.
Currently, She's main research topics are as follows;

(1) The psychological changes in postpartum women and the psychological impact of lifestyle interventions on their children.

(2) Examination of social isolation and related factors.

PUBLIC INTEREST STATEMENT

Postpartum women are at risk of worsening their mental health by experiencing many changes, both physically and environmentally, and it has been reported that likely to exhibit poor memory, forgetfulness, poor concentration, and distractibility. However, going to the hospital while noticing something different about herself can be a hurdle for postpartum women. The aim of the current paper is to identify postpartum women's cognitive function to improve using the horticultural activity that is easy to apply in everyday life. Although various types of psychological support exist for postpartum women, we hope to help prevent postpartum mental health problems by suggesting that postpartum women take care of themselves easily at home.

1. Introduction

For many women, childbirth is one of the most important events in their lives. Postpartum women are at risk of worsening their mental health by experiencing many changes, both physically and environmentally (Agrati & Lonstein, 2016; Biaggi et al., 2016; Munk-Olsen et al., 2012). At the same time, it has been reported that postpartum women are more likely to exhibit poor memory, forgetfulness, poor concentration, and distractibility (Anderson & Rutherford, 2012; Brett & Baxendale, 2001; Eidelman et al., 1993; Henry & Sherwin, 2012a; Meena et al., 2016; Shin et al., 2018). Mild cognitive changes are reported to be occurring in many postpartum women (Anderson & Rutherford, 2012), they often go without being specifically followed up. Postpartum cognitive impairment may be caused by changes in hormone levels (Henry & Sherwin, 2012a). It has recently been suggested that these symptoms of postpartum women are an objective cognitive impairment (Anderson & Rutherford, 2012; Henry & Sherwin, 2012a; Shin et al., 2018). Additionally, it has also been suggested that cognitive impairment may occur before postpartum mental disorders occur (Henry & Sherwin, 2012a; Hoekzema et al., 2017; Meena et al., 2016; Zheng et al., 2018). In the postpartum life with an infant, forgetfulness, and distractibility, which can be worrisome for a mother, can lead to accidents and problems in the home and is not a good thing in daily life. However, as a mother who spends much of her day with her infant, it is important to do something easy and less burdensome for both mother and infant to do to take care of their cognitive function. This study focused on a horticultural activity as a way to take care of the mother's cognitive functioning at home while caring for her infant.

Horticultural activity is based not only on the effects of a series of growing, harvesting, and incorporating them into life, but also on the effect of the attachment to the plant and the physical function being restored (Gonzalez et al., 2010; Hansen-Ketchum et al., 2009; Hayashi et al., 2008; Maller et al., 2006; Rappe, 2005). The horticultural activity has been noted to have a positive impact on people (Shao et al., 2020) and has been reported to be effective in improving mental health and cognitive functioning (Cimprich, 1993; Kaplan & Kaplan, 1989; Park et al., 2019). Many studies have been conducted using horticultural activities with the children, adult, elderly, people with disabilities, and ailing patient (Cimprich & Ronis, 2003; Gigliotti et al., 2004; Gonzalez et al., 2010; Kam & Siu, 2010; Kim et al., 2012; Park et al., 2019; Rappe, 2005; Relf & Dorn, 1995; Simon & Straus, 1998). In particular, many of these studies have been conducted with the elderly (Makizako et al., 2015; Ng et al., 2018; Park et al., 2019). Therefore, few studies have been conducted with mothers, especially postpartum women. Also, postpartum women's cognitive function improves by horticultural activity is unclear. This study hypothesized that horticultural activity improves cognitive function in postpartum women. The horticultural activity can be done in a room at home, in the garden or on a balcony, and can be done beside the infant, even if it is difficult to go out with the infant. It thought that this activity could be effective as a way to care for mothers themselves, both cognitively and mentally, since it could be easily carried out at home when they felt a little unwell.

This study was conducted to identify postpartum women's cognitive function improve by horticultural activity from an exploratory pilot study.

2. Methods

2.1. Participants

This study was an exploratory pilot study. Fifteen postpartum women (mean age: 30.4 ± 3.2 years old) of about less than one year after childbirth recruited by newspaper advertisement participated in this study. The Research Ethics Committee of Iwate Medical University approved all procedures. Written informed consent was obtained from all participants. All procedures were performed by

the Helsinki Declaration. Because these analyses were exploratory rather than hypothesis-driven, a priori power analyses were not performed to determine the sample size.

2.2. Study protocol

The study protocol is shown in Figure 1. After informed consent, participants completed a psychological test to assess their mental health and cognitive functioning. Participants will participate in a total of eight gardening activities. In the end, they will answer the same test as the first one to assess their mental health and cognitive functioning.

2.3. Horticultural activity

Participants were asked to attend a total of eight gardening activities once a week at the lecture room of Iwate Medical University. The activity was guided by a facilitator with experience in leading community gardening activities. The facilitator was a gardener and gardening instructor for over 10 years. In this gardening activity, participants planted and nurtured plants, weeded, gathered the flowers they grew, and made a herbarium from the plants they grew into dried flowers. This activity was not part of the ordinary farm work. The participants, who attended to

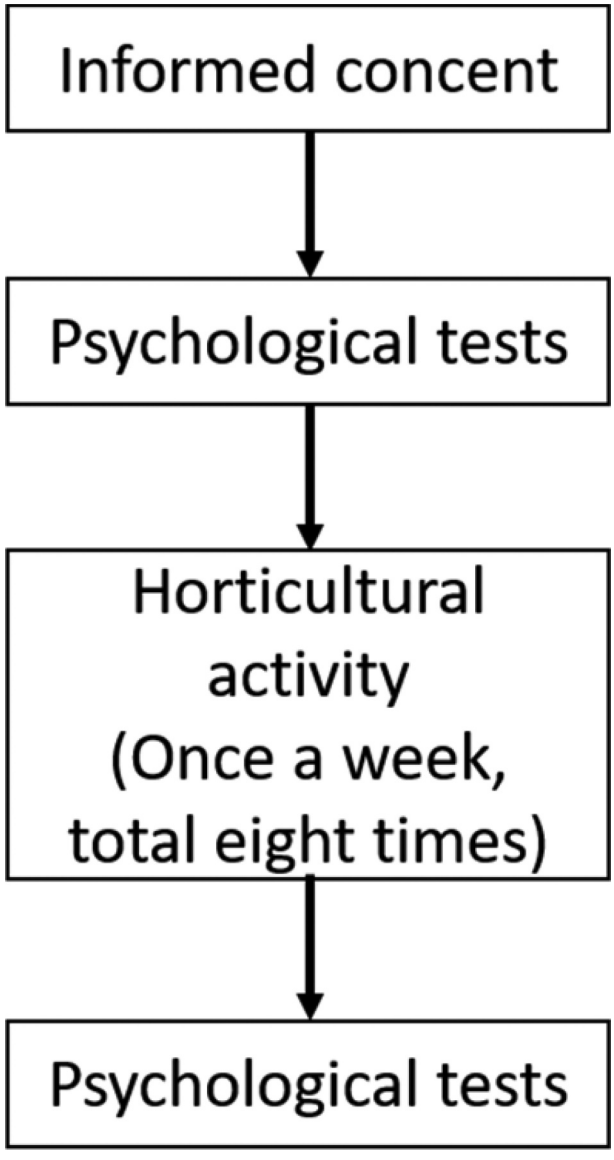

Figure 1. Study protocol.

enjoy the experience and not to learn how to play the gardening, touch the plant. Each time the facilitator presented an actual plant, explaining it to the participants and teaching them how to plant and care for it and participants experienced touching, potting, and caring for the plants while listening to the facilitator's explanations. The facilitator checked the participants' work and modified it. Rather than giving the participants spoon-feed instructions, the facilitator gave them instructions and the participants themselves corrected it did. Participants also did daily gardening activities at home using the same plants.

2.4. Trail Making Test (TMT)

The TMT consists of two tests; TMT-A and TMT-B (Abe et al., 2004; Lezak et al., 2004; Reitan, 1958). The TMT-A score reflects visual searchability and motor skills, whereas the TMT-B score additionally reflects the ability for cognitive alternation (Crowe, 1998). This study used the Japanese version of TMT (Abe et al., 2004). Before test trials, a practice run was administered to make sure the subjects understood the task. The participants were ordered to keep their head immobile as much as possible and not speak during measurements. In TMT-A, the participants were required to draw a line as rapidly as possible joining consecutive numbers (from 1 to 25), and in TMT-B they were required to draw a line alternately between consecutive numbers and letters (ex. 1-A-2-B − 12-L). Both in TMT-A and TMT-B, numbers or letters were pseudorandomly arranged on each page. The time limits for performing TMT-A and TMT-B were set at 180 s and 480 s, respectively.

2.5. Digit Symbol Substitution Test (DSST)

The DSST is part of the Wechsler Adult Intelligence Scale-III (WAIS-III), which is designed to measure processing speed, visual perception and attention (Wechsler, 1997) (Wechsler, 2006). This study used the Japanese version of DSST (Wechsler, 2006). In this test, subjects are required to substitute each of the 133 digits with a simple symbol within 120 s. The number of correctly filled symbols is counted, giving a total score of 0 to 133. A higher score is indicative of better cognitive performance.

2.6. Edinburgh Postpartum Depression Scale (EPDS)

The Japanese version of EPDS measured to assess for symptoms of depression, including anxiety, feelings of guilt, and dysphoria, during and after pregnancy (Okano et al., 1996). A ten-item self-reported questionnaire assesses the frequency of depressive symptoms over the previous seven days and scored using a four-point scale (0–3). A higher score indicates a higher degree of depressive symptoms.

2.7. State-Trait Anxiety Inventory (STAI)

The STAI measured to assess state anxiety and trait anxiety separately (Nakazato & Mizuguchi, 1982; Spielberger & Reheiser, 2009). This study used the Japanese version of STAI (Nakazato & Mizuguchi, 1982). Both the state and trait sections of this questionnaire comprise 20 questions, with total scores on each section ranging from 20 to 80. STAI-state scores of ≥ 51 and STAI-trait scores of ≥ 55 suggest diagnoses of anxiety disorder and pathological vulnerability to threat as a personality trait.

2.8. Profile of Mood States 2 (POMS 2)

The POMS 2 measured to evaluate mood (Heuchert & McNair, 2012; Lin et al., 2014; Yokoyama & Watanabe, 2015). This study used the Japanese version of POMS 2 (Yokoyama & Watanabe, 2015). This test consists of 35 items questions and evaluates seven mood scales of anger-hostility (AH), confusion-bewilderment (CB), depression-dejection (DD), fatigue-inertia (FI), tension-anxiety (TA), vigor-activity (VA), friendliness (F) at the same time. Also, the Total Mood Disturbance (TMD) score is calculated by the sum of the elementary scores of AH, CB, DD, FI, TA, and VA. Because VA is weighted of negative, it is subtracted from the sum of the other five and is a comprehensive evaluation of expression of negative mood. The TMD score and negative mood state (AH, CB, DD, FI, and TA) is the higher the T score, the stronger the emotion concerning negative emotion or mood disorder. The positive emotional state (VA, F) is the higher the T score, the more positive emotion means.

2.9. Statistical analyses

Data analyses were carried out with SPSS version 25 (IBM Corp., Armonk, NY, USA). We used within-group t-tests to compare pre- and post-test. Statistical significance was designated as $P < 0.05$.

3. Results

3.1. Participant characteristics

The characteristics of the participants are shown in Table 1. About half of the participants (46.7%) had a higher level of education. 60.0% of participants were unemployed. 86.7% of participants were married at the time of the study. More than half of the participants (53.3%) had their first birth. There were no smokers among the participants, and 20% of the participants had been drinking.

Table 1. Participant Characteristics (n = 15)

Variables	
Age (mean ± SD)	30.4 ± 3.2
Highest educational attainment (%)	
High school	26.7
College	26.7
University or more	46.7
Employment status (%)	
Full time	33.3
Part time	6.7
Unemployed	60.0
Marital status (%)	
Single	6.7
Married	86.7
Divorce	6.7
Number of children (%)	
One	53.3
Two	33.3
Three or more	13.3
Smoking (%)	0
Drinking (%)	20.0

SD, standard deviation

Table 2. TMT, DSST, EPDS, and STAI scores between pre- and post-test

	pre-test, mean (SD)	**post-test, mean (SD)**	**t**	**p value**
TMT-A (sec)	53.3 (8.1)	46.9 (9.3)	2.428	**0.029**
TMT-B (sec)	73.5 (17.2)	57.4 (16.9)	2.896	**0.012**
DSST	75.4 (20.3)	99.2 (9.5)	−3.819	**0.002**
EPDS	2.8 (2.7)	1.3 (2.5)	3.659	**0.003**
STAI				
STAI-state	38.9 (7.9)	30.9 (8.4)	5.055	**<0.001**
STAI-trait	40.7 (10.4)	32.9 (8.2)	4.516	**<0.001**

SD, standard deviation

Statistical significant ($p < 0.05$).

TMT, Trail Making test; DSST, Digit Symbol Substitution Test; EPDS, Edinburgh Postnatal Depression Scale; STAI, State-Trait Anxiety Inventory.

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3.2. Cognitive function (TMT and DSST)

Table 2 shows the changes in cognitive function scores between pre-and post-test. The implementation time of TMT-A was significantly decreased (TMT-A: t = 2.428, p = 0.029) and the implementation time for TMT-B was also significantly decreased (TMT-B: t = 2.896, p = 0.012). The DSST score was significantly increased in the post-test as compared to the pre-test (t = −3.819, p = 0.002).

3.3. Mental health (EPDS, STAI, and POMS 2)

Table 2 shows the changes in mental health scores between pre-and post-test. The EPDS was significantly decreased (t = 3.659, p = 0.003). Additionally, both STAI-state score and STAI-trait score were significantly decreased (STAI-state: t = 5.055, p < 0.001, STAI-trait: t = 4.516, p < 0.001). Figure 2 shows the changes in POMS 2 between pre-and post-test. With the exception of DD, each of negative mood state scores and TMD score was significantly decreased (AH: t = 2.523, p = 0.024, CB: t = 2.475, p = 0.027, FI: t = 4.916, p < 0.001, TA: t = 3.065, p = 0.008, TMD: t = 6.911, p < 0.001) and the positive mood state scores was significantly increased (VA: t = −2.757, p = 0.015, F: t = −4.536, p < 0.001).

4. Discussion

The current study was to investigate postpartum women's cognitive function improve by horticultural activity from an exploratory pilot study. As a result, attentional function and positive mood state were significantly increased, and processing speed, postpartum depression, negative mood state, state anxiety, and trait anxiety were significantly decreased. These results supported the initial hypothesis and may help to comprehend the impact of the horticultural activity on postpartum women's cognitive function.

Horticultural activity significantly increased attentional function of postpartum women who participated in the current study. Although there have been no previous reports of improved attentional function and processing speed in postpartum women through horticultural activity, horticultural activities have been reported to improve cognitive function from studies with people with disabilities, children, adult, older adult, and cancer patient (Cimprich, 1993; Cimprich & Ronis, 2003; Gonzalez et al., 2010; Kaplan & Kaplan, 1989; Kaplan, 1995; Kim et al., 2012; Lee & Kim, 2008; Park et al., 2019; Söderback et al., 2004). The horticultural activity has cognitive benefits in that participants can sharpen observation, problem-solving, and decision-making skills, while adding to participants' level of curiosity and experimentation (Adil, 1994). Also, even exposure to plants for a few minutes can lead to positive effects on cognitive function (Elings, 2006). From the above, it can be inferred that for mothers who put their infants first and spend a lot of time with them after birth, their own physical and psychological care is often a secondary or tertiary priority. In this situation, it is assumed that mothers exposed to plants through horticultural activity may feel a change of pace and curiosity in growing and planting

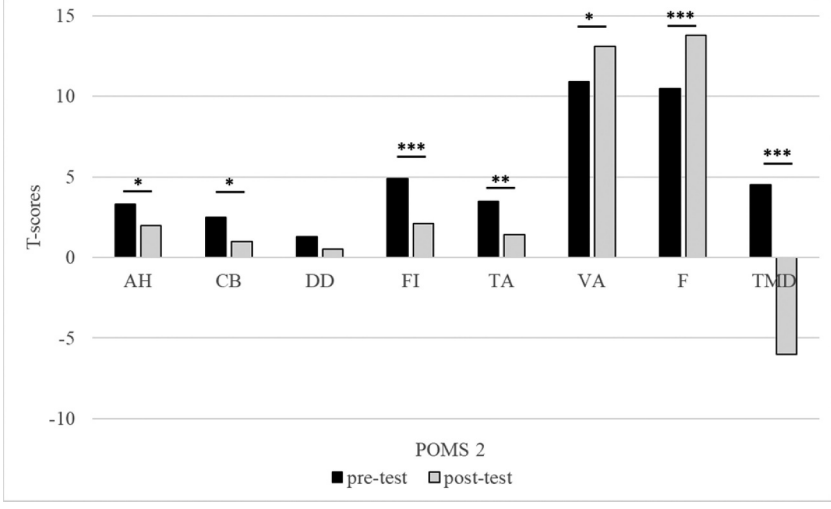

Figure 2. POMS 2 scores between pre- and post-test.

POMS 2, Profile of Mood States 2; AH, anger-hostility; CB, confusion-bewilderment; DD, depression-dejection; FI, fatigue-inertia; TA, tension-anxiety; VA, vigor-activity; F, friendliness; TMD, Total Mood Disturbance.* p < 0.05 ** p < 0.01 *** p < 0.001

a variety of plants and that the repetition of a series of tasks such as regular watering, pruning, and fertilization may stimulate the body and mind, leading to increased cognitive abilities.

The present study found that horticultural activity reduced depression, negative mood and anxiety, and increased positive mood. Improvements in mental health due to horticultural activities have been reported in adults, especially in the elderly (Eriksson et al., 2010, 2011; Grabbe et al., 2013; Infantino, 2004; Polansky, 1979; Shao et al., 2020; Soga et al., 2017). Erikson et al. reported that mental health improved as a result of gardening activities from a survey of 5 women (Eriksson et al., 2011). Also, Grabbe et al. reported from a study of 8 women that gardening can interrupt negative ruminations and alleviate stress and that it may be an inexpensive and potentially positive intervention for populations with high rates of mental illness and distress (Grabbe et al., 2013). Ghanbari et al. reported that their depressive symptoms improved after having 50 women engage in horticultural activity for two months (Ghanbari et al., 2015). Gonzalez et al. reported that horticultural activity improved anxiety state and mood (Gonzalez et al., 2010, 2011). Shao et al. reported that horticultural activity is associated with a significant increase in positive emotions (Shao et al., 2020). In the present study, the results were similar to those of previous studies, suggesting that the effects of horticultural activities are also effective in improving the mental health of postpartum women. Presumably, being in contact with plants through horticultural activity and engaging in the daily cultivation of plants will improve their mental health, as they are more likely to have positive emotions, such as familiarity with plants and the satisfaction, anticipation, and enjoyment of being close to the process of growing them.

On the other hand, it has been suggested that postpartum mental health failure and cognitive decline may occur in parallel (Henry & Sherwin, 2012a; Hoekzema et al., 2017; Meena et al., 2016; Zheng et al., 2018). It has been reported that changes in hormone levels such as estrogen, progesterone, and glucocorticoid (cortisol) levels due to pregnancy and childbirth can cause cognitive decline in the postpartum period (Henry & Sherwin, 2012a). Henry et al. reported that estradiol and cortisol levels in postpartum women were negatively and linearly associated with attentional scores and that fluctuating hormone levels during late pregnancy and early postpartum may modulate selected cognitive abilities (Henry & Sherwin, 2012a). Estradiol has been shown to affect verbal memory and working memory (Maki et al., 2002). Cortisol levels have also been found to affect working memory (Lupien et al., 1999). Working memory is considered to be one of the executive functions related to the control of thoughts and actions (Miyake et al., 2000). The central executive system, one of the systems of working memory, is responsible for higher-order cognitive activities such as attentional control and allocation of processing resources (Miyake et al., 2000). Although there are no studies that mention a relationship between horticultural activity and estrogen, multiple studies have shown that horticultural activity lowers cortisol levels (Lee et al., 2018; Van Den Berg & Custers, 2010; Ward Thompson et al., 2012). Van den Berg et al. reported that horticultural activities can reduce cortisol levels and improve stress conditions (Van Den Berg & Custers, 2010). The results of this study showed that mental health and cognitive functioning scores improved as a result of the horticultural activity. To guess from the above, postpartum mothers who have undergone pregnancy and childbirth and significant hormone level changes, coupled with normal daily activities, their postpartum body recovery, and caring for their infants, such as breastfeeding and diaper changes, leave them more than a little susceptible to stress. In this situation, having time to switch moods, for example, by having the opportunity to interact with plants through gardening activities, the mother's feelings are stimulated by the healing power and vitality of the plants themselves. It is also assumed that growing plants will enrich their lives and have a positive impact on them, both cognitively and mentally.

Therefore, horticultural activity may have potential as a method of self-care for cognitive and emotional functioning for postpartum women, who spend most of their time at home with their infants and can easily do so in the comfort of their own homes and without worrying about time. Besides, with the recent outbreak of the new coronavirus infection, it is easy for stress to build up in a situation where life tends to be more restrictive, and gardening activities that can be easily carried out at home may be an effective tool for postpartum mothers to stabilize their minds and bodies.

The limitations of this study are as follows. This study was an exploratory pilot study and it is susceptible to the influence of confounding factors for not providing the control condition. Also, alongside with revision of the program, future study needs a randomized controlled trial to establish a control group and to test the effectiveness of the program.

In conclusion, the present study aimed to investigate postpartum women's cognitive function improve by horticultural activity from an exploratory pilot study. The result shows that horticultural activity may improve mental health and cognitive function in postpartum women. This study contributes to the fact that horticultural activity may be used as a form of cognitive and psychological care for postpartum women. There were some limitations to our study, such as the one-armed approach. Due to the small sample size, a larger number of participants should be recruited in future studies. Also, more realistic and practical activities on the application of the findings are needed in future research.

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Competing interests
The authors declare that they have no competing interests.

Author's Contributions
YK designed the study, conducted the interviews, analyzed the data, and wrote the manuscript. The author read and approved the final manuscript.

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