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Analyzing the Effects of Seed Pot Care on Emotions and Stress: An Exploratory Randomized Controlled Trial

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Abstract. **The coronavirus disease 2019 (COVID-19) pandemic heightened mental health challenges in urban life. Engaging in gardening can improve emotions and reduce stress. However, the emotional and stressful effects of indoor seed pot care (SPC) during germination are poorly understood. This study investigated the emotional and stress-relieving effects of SPC on germination during the COVID-19 pandemic. In an exploratory randomized controlled trial, 60 university students were randomly assigned to experimental and control groups. The experimental group cared for basil seed pots for 14 days and their daily emotions and perceived life stress (PLS) levels were recorded. The control group continued their usual activities. The experimental group consistently demonstrated a significant increase in pleasure over the 14-day study period. On day 4, the experimental group reported significantly higher viewing frequency, stress reduction, and emotional improvement than those on most other days, likely because of seed germination. Although the seed pots did not germinate on day 1, the experimental group experienced significantly more pleasure than the control group, possibly because of the expectancy effect. However, beyond day 1, no significant differences in pleasure, arousal, or PLS were observed between the experimental and control groups. On day 4, although the control group experienced emotions that were more aligned with excitement, the experimental group demonstrated a smaller increase in arousal, indicating that SPC may have cultivated an emotional state characterized by pleasure or relaxation. Overall, SPC did not negatively affect pleasure, arousal, or PLS, and the indoor use of seed pots was encouraged.**

Urban development has been linked to several mental health issues (McDonald et al. 2018). Isolation and lockdowns during the coronavirus disease 2019 (COVID-19) pandemic have exacerbated these mental health challenges for those living in cities (Berdejo-Espinola et al. 2021; Sia et al. 2022; Theodorou et al. 2021). Engaging with nature is a beneficial strategy that can mitigate negative effects on mental health caused by significant stressful life events (Berdejo-Espinola et al. 2021). Contact with nature (e.g., home gardening activities) can help reduce stress and promote mental well-being when confined to the home (Egerer et al. 2022; Sia et al. 2022; Theodorou et al. 2021). Numerous studies have highlighted the benefits of gardening activities for physical and mental health (Hassan et al. 2018; Kelley et al. 2017; Kim et al. 2021; Lee et al. 2017; Makizako et al. 2019; Park et al. 2016a; Soga et al. 2017). Therefore, gardening offers significant mental health benefits.

Gardening activities include plant cultivation, garden observation, creative flower arrangements, sensory exploration, and social and communal gardening experiences (Scott 2017). Gardening courses often span several weeks, covering the entire cycle from planting and harvesting to cooking, and are supplemented by plant-related classes and travel (Han et al. 2018; Kenmochi et al. 2019; Park et al. 2016a; Siu et al. 2020; Yang et al. 2022; Zhu et al. 2016). Garden maintenance is also a course that provides practical skills training regarding fertilization, weeding, watering, and harvesting, as well as creative and social activities such as flower arrangement, flower pressing, tea time, garden parties, and garden walks, as seen in countries such as South Korea (Kim and Park 2018; Lee et al. 2018; Park et al. 2016b), Japan (Kojima and Kunimi 2013), Sweden (Palsdottir et al. 2020), Singapore (Sia et al. 2018), and Serbia (Vujcic et al. 2017). A comprehensive gardening course series often encompasses the aforementioned activities and covers the entire spectrum of gardening experiences and skills (Lee and Kim 2008).

Studies that explore the benefits of individual gardening activities such as plant cultivation, growing specific plants, and flower arrangement are relatively scarce. This research gap highlights the need for a more focused investigation of the distinct advantages of gardening practices. For example, Lee et al. (2017) observed that although flower tea consumption positively affected self-esteem, it had no significant effect on life satisfaction or ego integrity. Mochizuki-Kawai et al. (2018) reported that a structured floral arrangement improves visuospatial memory and recognition, but it does not significantly affect digit span, block tapping, and apathy levels. Gong et al. (2020) demonstrated that lavender essential oil significantly reduced temporary anxiety more than other essential oils such as rose and citrus. Examining the specifics of gardening activities can contribute to the development of future practices.

Indoor plants compensate for the lack of natural views of indoor environments (Bringslimark et al. 2011). Doxey et al. (2009) found that indoor plants had the greatest impact on students in classrooms lacking natural elements and sometimes even serve as substitute for windows. Cultivation of indoor plants is a daily gardening activity that improves mental health. Lohr et al. (1996) found that indoor plants in a windowless workplace significantly enhanced productivity and attention and reduced stress among undergraduate students. Lee et al. (2015) noted that engaging in transplanting activities with the common indoor plant *Peperomia dahlstedtii* could reduce psychological stress more effectively than mental work among male university students. Dravigne et al. (2008) found that individuals who work in offices with plants and windows reported higher levels of job satisfaction. Toyoda et al. (2020) demonstrated that regular interaction with preferred indoor plants for 4 weeks in a work environment could effectively reduce physiological stress among office workers. Spano et al. (2021) reported that having plant pots at home is associated with fewer negative emotions. Yan et al. (2022) determined that most surveyed individuals experienced anxiety during the COVID-19 pandemic, and that many supported the idea that indoor plants could help alleviate anxiety, indicating an indirect psychological benefit.

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Seed sowing and seedling growth are common horticultural activities (Chu et al. 2019; Lai et al. 2018; Sia et al. 2018; Zhu et al. 2016). These activities offer participants novel and enjoyable experiences without the pressure of performance or outcomes (Pálsdóttir et al. 2014). Observing seeds develop into mature plants can instill a sense of hope (Kim et al. 2020b; Pálsdóttir et al. 2014; Siu et al. 2020). However, current research of the psychological benefits of seed germination remains limited.

Although observing and caring for indoor plants can improve mental health, several aspects remain unknown. Indoor seed pots, which are involved in stages such as sowing, germination, growth, and maintenance, are popular for indoor horticultural activities. These pots housing densely arranged seeds allowed for varied growth stages and rapid germination, thus making them ideal for small indoor spaces (e.g., offices and apartments). Despite their commonality in gardening activities, few studies have focused on the emotional and stress-relieving benefits of indoor seed pot care (SPC), particularly during germination. Considering the rapid growth and unique characteristics of different seeds, this study aimed to investigate the emotional and stress effects of caring for indoor seed pots, specifically during high-stress periods such as the COVID-19 pandemic. This study explored which stages of SPC most improve mental health and focused on the understudied germination phase, which is a symbol of the beginning of life.

University students' mental health has rarely been explored within the context of horticultural therapy. A 2019 survey conducted in the United States identified anxiety, depression, and stress as significant factors that impact academic performance (American College Health Association 2019). Key stressors that contribute to these issues include academic pressure, drivers of success, and concerns about postgraduation plans (Beiter et al. 2015). During the COVID-19 pandemic, economic stressors, disruptions in daily life, and academic delays were positively linked to increased anxiety among university students (Cao et al. 2020). Although prior randomized controlled trials of horticultural therapy have primarily targeted older adults (Tu 2022), this study addressed the mental health needs of university students.

Materials and Methods

Study design and participants. This study was approved by the Human Research Ethics Committee at National Cheng Kung University (Approval No. NCKU HREC-E-111-081). This was an exploratory randomized controlled trial (RCT). The required sample size was determined using G*Power (Faul et al. 2007, 2009). This study planned to use an analysis of covariance (ANCOVA) with α set at 0.05, β set at 0.2, and power set at 0.8. Because previous research of the effects of horticultural therapy on mental health has demonstrated a large effect size (Tu 2022), the effect size was set at 0.40. The sample size was 52. We recruited 60 participants who were randomly assigned to the experimental and control groups to account for potential dropouts during recruitment.

The research process included enrollment, intervention allocation, follow-up, and analysis. During the enrollment process, this study was conducted with university-level and master-level students at National Chung Hsing University. The socioeconomic backgrounds of the student groups were similar, which may have reduced their influence on the study findings. Previous studies have also conducted horticultural therapy studies of students (An et al. 2021; Chang and Chen 2005). Because of the COVID-19 pandemic, study participants were recruited online using a recruitment announcement posted on social networks and communication boards about campus life and students from 13 to 29 Apr 2022. Applicants read the research consent form, completed the online application form, and entered their names into a signature box to complete the research consent form. Ultimately, 60 participants were included in this study.

This study involved university students who shared similar educational backgrounds, marital statuses, and income levels. Additionally, because of the absence of complex racial dynamics in Taiwan, the study primarily focused on age and sex as key variables. During the intervention allocation process, all 60 study participants were randomly assigned to the control and experimental groups according to sex using an Excel random number table. The control and experimental groups included 30 participants (21 women and 9 men). The age ranges of the control and experimental groups were 19 to 28 years and 18 to 24 years, respectively. The age difference between the two groups was not significant [$\chi^2 = 0.11$; degrees of freedom (df) = 2; $P < 0.946$], indicating equivalent age distributions. The study was conducted on 2 May 2022 using a pretest electronic questionnaire. The pretest was conducted on day 0. After the initial assessment, the experimental group began the intervention using indoor seed pots. The follow-up period spanned from 3 to 16 May 2022, comprising 14 d that were labeled days 1 to 14. Twenty-one and 19 participants in the control and experimental groups, respectively, completed the study, including the pretest and posttest assessments (Fig. 1).

This study used an intention-to-treat (ITT) analysis. The ITT method of the RCT ensured that participants were analyzed in their original groups regardless of withdrawal, maintenance of randomization integrity, and trial validity (McCoy 2017; Polit and Gillespie 2010). The ITT analysis included 30 participants in each group; missing values were addressed using multiple imputation methods.

Intervention activities. The intervention used seed pots containing basil (*Ocimum basilicum*), which is a plant species safe for consumption and suitable for germination and growth indoors under low-light conditions. A potting mix composed of equal parts peatmoss and vermiculite was selected for its optimal drainage, aeration, and suitability for low-light indoor environments. The mixture was placed into 2-inch plastic pots. On 2 May 2022 (day 0), following completion of a pretest questionnaire, participants in the experimental group gathered in a classroom at the Department of Horticulture at National Chung Hsing University. The first author demonstrated the sowing procedure and explained the experimental protocol. Participants independently sowed basil seeds in a group setting and then took their seeded pots home and placed them on their desks. Participants were responsible for maintaining plant care over 14 d, conducting daily observations for 15 s, photographing the plant, and uploading images to document growth. Posttest questionnaires were completed via e-mail at 7:00 PM each evening during days 1 to 14 (Fig. 2).

As instructed, the participants placed the seed pot on their desk, observed it for 15 s, photographed and uploaded its growth process, and completed a posttest questionnaire sent via e-mail at 7:00 PM every evening during days 1 to 14 (Fig. 2). Most recorded germination by day 3. The control group was asked to engage in their usual daily activities and complete pretest and posttest questionnaires. The timing of the pretest and posttests was consistent in both groups.

Instrument: Emotion and perceived life stress. During the follow-up period, the participants completed the questionnaire daily. To evaluate emotions and stress throughout the 14-d SPC period, participants completed identical questionnaire items daily. Because of the prolonged survey duration, the large number of questionnaire items could cause fatigue and increase dropout rates. Therefore, brief versions of these scales were used to enhance participant engagement and ensure data collection.

The pretest and posttest questionnaires included items about pleasure, arousal, and perceived life stress (PLS). The emotion scale uses pleasure and arousal to measure emotional states with adequate reliability, convergent validity, and discriminant validity (Russell et al. 1989). Previous studies have used pleasure and arousal to assess emotions (Chang et al. 2013; Lin and Wu 2021; Medeiros et al. 2022). A 9-point scale (range, −4 to 4) was used to assess emotions. Higher scores indicated greater pleasure or arousal. We measured PLS using the perceived stress scale (Cohen et al. 1983). This study used a brief version of four items (inability to control life, confidence in handling problems, things going well, and difficulties accumulating) that have adequate reliability and predictive validity, thus making it a reliable tool for measuring PLS (Cohen and Williamson 1988; Karam et al. 2012; Vallejo et al. 2018; Warttig et al. 2013). Higher scores indicated greater PLS. From day 0 to day 14, the α reliability ranged between 0.72 to 0.92, indicating strong internal consistency for PLS. Test–retest reliability values across the same period were 0.85 for pleasure, 0.87 for arousal, and 0.93 for

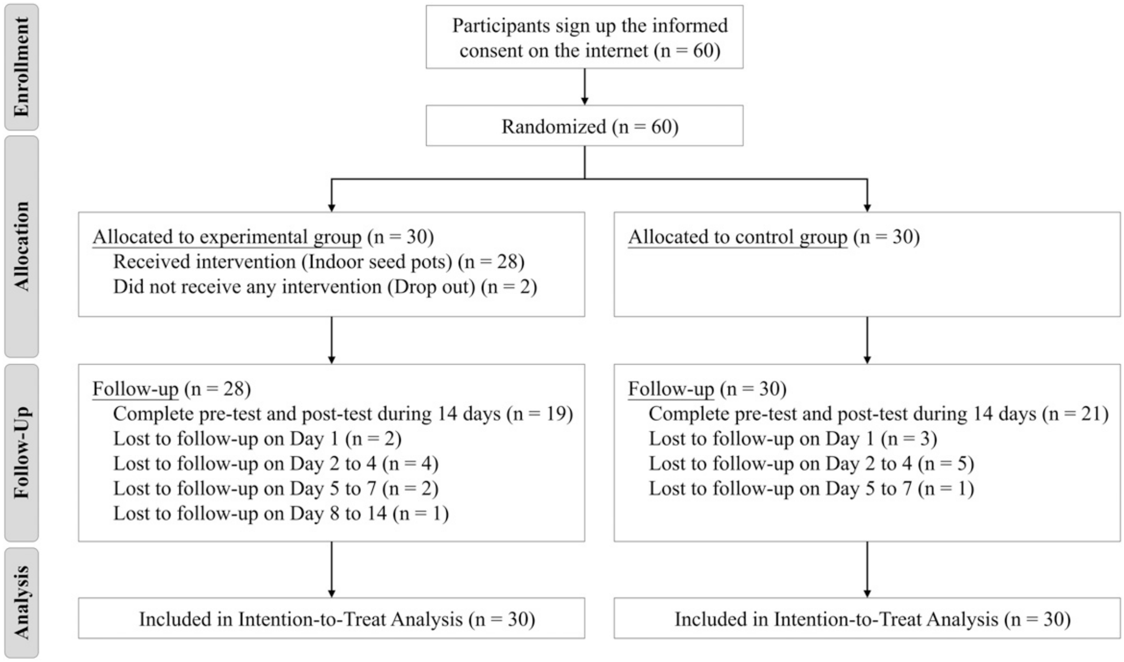

Fig. 1. Flowchart.

PLS, demonstrating high reliability over the same period.

Instrument: Variables of SPC. Between days 1 and 14, the experimental group was asked three additional questions regarding SPC, including the effects of SPC on viewing frequency, stress improvement, and emotional improvement. The frequency question, "In the past 24 h, how frequently did you observe the seed pot?", was answered using a 7-point scale, with 1 indicating "very infrequently" and 7 indicating "very frequently." The stress improvement question was "In the past 24 h, how effective was the seed pot in relieving your stress?" The emotion improvement question was "In the past 24 h, how effective was the seed pot in improving your emotions?" Both questions were answered using a 7-point scale, with 0 indicating "not at all" and 6 indicating "very helpful." Between days 1 and 14, test–retest reliability values were 0.89 for viewing frequency, 0.89 for stress improvement, and 0.78 for other measures, respectively, indicating good reliability. This study used a single-item measure for certain variables; this method is considered appropriate for exploratory research and contexts involving weaker effect sizes or smaller samples (Diamantopoulos et al. 2012).

On day 14, the final survey for the experimental group included three additional questions regarding their intentions to grow gardening-related plants, grow seed pots, and eat seed pots. The questions were as follows: "In the future, would you like to continue growing gardening-related plants?"; "In the future, would you like to continue growing seed pots?"; and "In the future, would you like to eat the plants grown from the seed pots?" These three questions were answered using a 7-point scale, with 1 indicating "very unwilling" and 7 indicating "very willing."

Instrument: Control variables. Because the survey was conducted during the COVID-19 pandemic, it measured perceived COVID-19 stress daily using a single item. A 7-point scale was used, with 1 indicating "strongly disagree" and 7 indicating "strongly agree." Higher scores indicated greater COVID-19 stress. The test–retest reliability value for COVID-19 stress from day 0 to day 14 was 0.97, indicating excellent reliability. Because positive or negative events could be potential influencing factors, the final survey on day 14 given to the experimental and control groups asked whether they had experienced any positive or negative events during the past 2 weeks. The question for positive events was as follows: "Apart from this study, have you experienced anything that made you happy in the past 2 weeks?" The question for negative events was as follows: "Apart from this study, have you experienced anything that caused stress in the past 2 weeks?" Both questions used a 7-point scale, with 0 indicating "not at all" and 6 indicating "very much."

Data analysis. An independent samples *t* test was used to examine the effects of the control variables across the experimental and control groups. When significant differences in the control variables were identified between groups, these variables were included in subsequent analyses. A paired sample *t* test was used to assess differences in emotion and PLS of the experimental and control groups between the pretest (baseline) and posttest (follow-up, 1–14 d) to identify significant

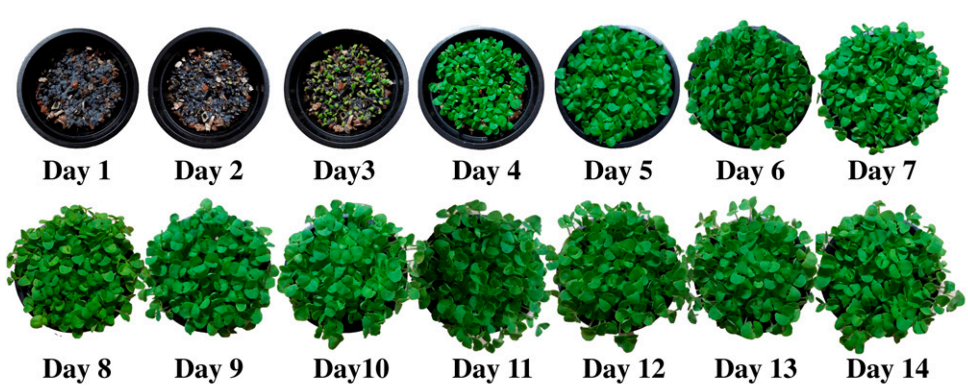

Fig. 2. The growth of basil microgreens from days 1 to 14.

changes over time. An ANCOVA was conducted using pretest scores (baseline) as a covariate to evaluate the effect of intervention activities to explore whether significant differences in emotions and PLS existed between groups. Additionally, a one-way analysis of variance was used to investigate the effects of SPC on stress relief, emotion improvement, and observation frequency in the experimental group; post hoc tests were applied to assess differences across follow-up days and examine the effect of seed pot growth conditions. Finally, means and standard deviations (*SD*s) were calculated to assess gardening intentions after seed potting.

Results and Discussion

Effect of SPC on pleasure, arousal, and PLS. Because no significant differences were observed in the control variables between the experimental and control groups, the analysis indicated that COVID-19 stress and the frequencies of positive and negative events were consistent across both groups. Therefore, control variables were not included in subsequent analyses. The control group showed a significant increase in pleasure on follow-up days 2 to 6, 8, and 10 to 14; however, no significant changes were observed on days 1, 7, or 9 (Table 1). In contrast, the experimental group consistently increased pleasure across days 1 to 14. The ANCOVA results indicated a significant increase in pleasure for the experimental group compared with that of the control group on follow-up day 1 [mean difference = 1.04; standard error (*SE*) = 0.52; F = 4.06; $P < 0.05$; $\eta^2 = 0.07$) after adjusting for baseline pretest covariance (Table 2). On day 1, although the seed pots had not yet germinated, the experimental group demonstrated a significant increase in pleasure compared with that of the control group, possibly because of the expectancy effect associated with the seed pots. Throughout days 1 to 14, the experimental group showed increased pleasure, indicating no negative effects of placing the seed pots indoors. Although the ANCOVA did not show a significant difference between the experimental and control groups from days 2 to 14, this observation may have been affected by the small sample size.

The control group showed a significant increase in arousal on days 4 to 6, with no significant changes on days 1 to 3 or days 7 to 14 (Table 1). The experimental group showed significantly increased arousal on days 4 to 6 and days 12 to 13. The ANCOVA results determined that the control group had a significant increase in arousal compared to that of the experimental group on follow-up day 4 (mean difference = −0.94; *SE* = 0.33; F = 8.17; $P < 0.01$; $\eta^2 = 0.13$) (Table 2). On follow-up day 4, a significant increase in pleasure was observed in both the control and experimental groups (Table 1). In general, high pleasure combined with elevated arousal corresponds to a state of excitement, whereas moderate arousal levels align more closely with a state of pleasure, and low arousal levels are associated with relaxation (Russell et al. 1989). The findings of this study indicated that the control group on follow-up day 4 experienced emotions that were more closely associated with excitement on follow-up day 4. In contrast, the experimental group experienced a smaller increase in arousal, suggesting that the SPC may have fostered an emotional state that was more reflective of pleasure or relaxation.

The control group showed a significant reduction on days 4 to 5, with no significant changes noted on days 1 to 3 or days 6 to 14 (Table 1). The experimental group showed a significant reduction in stress levels on days 3, 6, and 12. Throughout days 1 to 14, the experimental group experienced no stress from placing seed pots indoors. However, the ANCOVA results revealed no significant difference in stress levels between the control and experimental groups on any follow-up day (Table 2).

Several studies have shown that indoor plants can reduce perceived stress among workers (Toyoda et al. 2020), university students (Lohr et al. 1996), junior high school students (Han 2018), dental patients (Elsadek et al. 2023), and patients in hospital rooms (Dijkstra et al. 2008). Transplanting plants indoors can also reduce university students' perceived stress (Lee et al. 2015). Several studies have reported that indoor plants can reduce and promote negative emotions (Archary and Thatcher 2022; Chang and Chen 2005; Elsadek et al. 2023; Hassan et al. 2018, 2020; Kim et al. 2020a). However, other studies have not supported the idea that indoor plants improve emotions or perceived stress (Evensen et al. 2015). Evensen et al. (2015) observed that workplace plants did

Table 1. Mean differences of pleasure, arousal, and stress in each group according to a paired sample *t* test.

	Control group			Experimental group		
Variables	Mean difference	*SE*	t-value	Mean difference	*SE*	t-value
Pleasure emotion						
Baseline vs. follow-up day 1	−0.46	0.51	−0.90	1.35	0.41	3.31**
Baseline vs. follow-up day 2	1.00	0.44	2.30*	1.19	0.40	2.95**
Baseline vs. follow-up day 3	1.27	0.46	2.73*	1.73	0.45	3.87***
Baseline vs. follow-up day 4	1.48	0.38	3.95***	2.43	0.41	5.93***
Baseline vs. follow-up day 5	1.51	0.49	3.12**	1.82	0.44	4.16***
Baseline vs. follow-up day 6	1.25	0.38	3.28**	2.35	0.42	5.61***
Baseline vs. follow-up day 7	0.86	0.45	1.93	1.48	0.50	2.98**
Baseline vs. follow-up day 8	1.11	0.43	2.57*	1.69	0.40	4.23***
Baseline vs. follow-up day 9	0.48	0.39	1.22	1.50	0.42	3.56**
Baseline vs. follow-up day 10	1.09	0.45	2.43*	1.00	0.45	2.22*
Baseline vs. follow-up day 11	1.02	0.37	2.76*	1.92	0.47	4.13***
Baseline vs. follow-up day 12	1.51	0.45	3.35**	2.36	0.48	4.92***
Baseline vs. follow-up day 13	1.28	0.37	3.43**	1.97	0.41	4.81***
Baseline vs. follow-up day 14	1.28	0.38	3.37**	1.61	0.52	3.08**
Arousal emotion						
Baseline vs. follow-up day 1	−0.43	0.48	−0.90	0.38	0.40	0.95
Baseline vs. follow-up day 2	0.61	0.33	1.88	0.35	0.43	0.83
Baseline vs. follow-up day 3	0.43	0.44	0.97	0.50	0.45	1.12
Baseline vs. follow-up day 4	1.31	0.44	2.99**	0.86	0.39	2.19*
Baseline vs. follow-up day 5	0.96	0.31	3.05**	0.99	0.38	2.60*
Baseline vs. follow-up day 6	0.97	0.42	2.31*	0.90	0.44	2.05*
Baseline vs. follow-up day 7	0.14	0.40	0.35	0.58	0.46	1.26
Baseline vs. follow-up day 8	0.10	0.43	0.25	0.39	0.52	0.75
Baseline vs. follow-up day 9	−0.04	0.38	−0.11	0.54	0.39	1.39
Baseline vs. follow-up day 10	−0.01	0.41	−0.02	0.44	0.43	1.04
Baseline vs. follow-up day 11	−0.14	0.46	−0.30	0.76	0.41	1.88
Baseline vs. follow-up day 12	0.47	0.48	0.98	1.10	0.40	2.76*
Baseline vs. follow-up day 13	0.22	0.43	0.50	1.15	0.35	3.29**
Baseline vs. follow-up day 14	−0.15	0.50	−0.31	0.61	0.40	1.51
Perceived life stress						
Baseline vs. follow-up day 1	0.41	0.89	0.46	−1.08	0.64	−1.68
Baseline vs. follow-up day 2	−0.77	0.85	−0.91	−1.22	0.74	−1.64
Baseline vs. follow-up day 3	−1.03	0.94	−1.10	−2.08	0.71	−2.91**
Baseline vs. follow-up day 4	−2.37	0.86	−2.77*	−1.74	0.61	−2.88**
Baseline vs. follow-up day 5	−2.39	0.77	−3.12**	−1.73	0.70	−2.45*
Baseline vs. follow-up day 6	−1.08	0.87	−1.25	−2.69	0.72	−3.73***
Baseline vs. follow-up day 7	−0.42	0.78	−0.53	−1.30	0.66	−1.97
Baseline vs. follow-up day 8	0.06	0.80	0.07	−1.28	0.82	−1.56
Baseline vs. follow-up day 9	−0.13	1.05	−0.12	−0.54	0.74	−0.73
Baseline vs. follow-up day 10	0.01	0.72	0.01	−0.18	0.76	−0.24
Baseline vs. follow-up day 11	−1.10	0.82	−1.35	−1.35	0.86	−1.57
Baseline vs. follow-up day 12	−1.58	0.84	−1.88	−2.67	0.78	−3.41**
Baseline vs. follow-up day 13	−1.34	0.75	−1.80	−0.28	0.68	−0.42
Baseline vs. follow-up day 14	−0.87	0.76	−1.14	−1.41	0.83	−1.71

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.
SE = standard error.

Table 2. The mean difference in pleasure between the control and experimental groups.

	Follow-up day (adjust by baseline covariance)			
Variables	F	η^2	Mean difference	*SE*
Pleasure emotion				
Follow-up day 1	4.06*	0.07	1.04	0.52
Follow-up day 2	1.29	0.02	−0.53	0.47
Follow-up day 3	0.72	0.01	−0.39	0.46
Follow-up day 4	0.15	0.00	0.13	0.35
Follow-up day 5	2.60	0.04	−0.65	0.41
Follow-up day 6	0.62	0.01	0.29	0.37
Follow-up day 7	0.61	0.01	−0.34	0.43
Follow-up day 8	0.22	0.00	−0.20	0.42
Follow-up day 9	0.65	0.01	0.39	0.48
Follow-up day 10	3.61	0.06	−0.90	0.48
Follow-up day 11	0.05	0.00	0.09	0.41
Follow-up day 12	0.06	0.00	−0.10	0.41
Follow-up day 13	0.04	0.00	−0.07	0.38
Follow-up day 14	1.76	0.03	−0.57	0.43
Arousal emotion				
Follow-up day 1	0.72	0.01	0.42	0.49
Follow-up day 2	2.92	0.05	−0.65	0.38
Follow-up day 3	1.11	0.02	−0.42	0.40
Follow-up day 4	8.17**	0.13	−0.94	0.33
Follow-up day 5	1.11	0.02	−0.34	0.33
Follow-up day 6	1.79	0.03	−0.53	0.40
Follow-up day 7	0.00	0.00	0.01	0.44
Follow-up day 8	0.16	0.00	−0.19	0.48
Follow-up day 9	0.39	0.01	0.30	0.47
Follow-up day 10	0.02	0.00	0.06	0.45
Follow-up day 11	1.17	0.02	0.43	0.40
Follow-up day 12	0.13	0.00	0.14	0.38
Follow-up day 13	1.76	0.03	0.58	0.44
Follow-up day 14	0.46	0.01	0.32	0.48
Perceived life stress				
Follow-up day 1	0.63	0.01	−0.73	0.90
Follow-up day 2	0.11	0.00	0.31	0.95
Follow-up day 3	0.01	0.00	−0.08	0.88
Follow-up day 4	2.64	0.04	1.38	0.85
Follow-up day 5	3.27	0.05	1.46	0.81
Follow-up day 6	0.79	0.01	−0.83	0.93
Follow-up day 7	0.16	0.00	−0.38	0.95
Follow-up day 8	0.40	0.01	−0.62	0.99
Follow-up day 9	0.13	0.00	0.40	1.11
Follow-up day 10	0.19	0.00	0.40	0.93
Follow-up day 11	0.27	0.01	0.52	1.01
Follow-up day 12	0.11	0.00	−0.32	0.96
Follow-up day 13	3.03	0.02	1.60	0.92
Follow-up day 14	0.04	0.00	0.19	0.95

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.
SE = standard error.

not provide restorative effects when compared with inanimate objects. Michels et al. (2022) reported that green plant pictures benefit from positive emotions compared with green objects, grayscale plants, and grayscale objects, but not from negative emotions or stress. This study included an RCT, which was a major difference from previous studies. In a randomized crossover study, Lee et al. (2015) used the activity of transplanting indoor plants to reduce perceived stress. In comparison, transplanting indoor plants allowed participants to view the plants directly, potentially resulting in a stronger stress-reducing effect, whereas the seed pots required more time to grow into mature plants.

This study's primary contribution was the use of an exploratory RCT to assess the benefits of SPC. We did not find any evidence that SPC enhances pleasure or reduces PLS. The control group exhibited excitement-related emotions, whereas the experimental group experienced emotions aligned more with pleasure or relaxation. Additionally, placing the seed pot did not decrease pleasure or increase the PLS in the experimental group. Therefore, placing seed pots indoors does not produce any negative effects, and maintaining indoor seed pots can be considered safe.

Viewing frequency, stress improvement, and emotion improvement of seed pots. A repeated measures analysis revealed significant differences in the frequency of viewing seed pots between days 1 and 14 ($F = 2.42$; df = 13; $P < 0.05$) (Table 3). Pairwise comparisons indicated that day 4 had a significantly higher viewing frequency when compared to most other days. Moreover, the viewing frequency on day 7 was significantly higher than that on days 2 and 10. Significant differences in stress improvement ($F = 2.90$; df = 13; $P < 0.05$) and emotion improvement ($F = 3.37$; df = 13; $P < 0.05$) attributed to seed pots were noticed across days 1 to 14. Pairwise comparisons revealed significantly greater stress improvement on day 4 compared to days 1, 2, 5, and 7 to 14. Similarly, significantly greater stress improvement was observed on day 3 compared to days 1, 2, 8, 10, and 12. Moreover, significantly greater emotional improvement was observed on day 4 compared to days 1, 2, 7, and 10. Significantly less stress and emotional improvement were observed on days 1, 2, and 10 compared to most of the other days.

Overall, higher levels of viewing frequency, stress improvement, and emotional improvement when viewing the seed pots were observed on follow-up day 4. This pattern likely occurred because day 4 coincided with the critical germination phase. In contrast, lower viewing frequency, reduced stress relief, and fewer emotional benefits occurred on days 1, 2, and 10. The lower viewing frequency on days 1 and 2 may be related to the seeds not yet germinating (Fig. 2). On day 10, which was a Saturday, the viewing frequency may have decreased because the participants were likely to return home.

In practical and research applications, the germination stage of seed pots, even before the plants were fully grown, effectively improved stress and emotions in the experimental group. This finding supports the integration of indoor plants into workplaces, schools, and homes where individuals seek relaxation. Organizations and institutions can promote the use of small seed pots in shared spaces, especially for those seeking to enhance pleasure or reduce life stress. This form of biophilic design is low-cost and space-saving, providing a practical solution for environments with limited space.

Gardening intention after SPC. In the experiment group, the mean values (*SD*s) of the intention to use potted plants and the intention to use seedling pots were 5.92 (0.95) and 5.63 (1.10), indicating high willingness to use potted plants and seedling pots. The mean (*SD*) value of the willingness to eat basil was 4.27 (1.78), indicating ordinary willingness to eat basil. This is because basil is small or used mainly for ornamental purposes.

Limitations of the study and recommendations for future research. This study had three limitations. First, the sample size was small, making it difficult to achieve statistically significant differences. For example, Tu (2022) reported that many RCTs of horticultural therapy did not show significant results, likely because of small sample sizes. However, a meta-analysis that included samples from various studies revealed that horticultural therapy improved mental health (Tu 2022). Therefore, future research should consider increasing the sample size or conducting similar studies to accumulate more results and samples for meta-analyses.

Second, the inability to control daily activities of participants in the experimental and control groups during the 2-week observation period was problematic. The participants may have engaged in their preferred activities, leading to differences in daily

Table 3. The effect of seed pots on improving stress and emotion in the treatment group.

Variables	Mean	*SD*	df	F	Pairwise comparisons (follow-up day)
Viewing frequency			13	2.42*	4 > 1–3, 6–10, 13, 14;
Follow-up day 1	3.39	1.15			11 > 2, 10
Follow-up day 2	3.15	1.16			
Follow-up day 3	3.34	1.39			
Follow-up day 4	4.04	1.22			
Follow-up day 5	3.46	1.24			
Follow-up day 6	3.48	1.34			
Follow-up day 7	3.37	1.35			
Follow-up day 8	3.50	1.50			
Follow-up day 9	3.49	1.44			
Follow-up day 10	3.13	1.24			
Follow-up day 11	3.75	1.29			
Follow-up day 12	3.52	1.15			
Follow-up day 13	3.24	1.38			
Follow-up day 14	3.55	1.43			
Stress improvement			13	2.90*	3 > 1, 2, 8, 10, 12;
Follow-up day 1	3.91	0.91			4 > 1, 2, 5, 7–14;
Follow-up day 2	4.14	0.82			5 > 1, 12;
Follow-up day 3	4.64	0.88			3–9, 11, 14 > 1;
Follow-up day 4	4.89	0.72			3, 4, 6, 7, 14 > 2;
Follow-up day 5	4.52	0.83			2–9, 11–14 > 10
Follow-up day 6	4.62	0.90			
Follow-up day 7	4.53	0.89			
Follow-up day 8	4.26	0.98			
Follow-up day 9	4.33	0.75			
Follow-up day 10	3.80	0.80			
Follow-up day 11	4.40	0.88			
Follow-up day 12	4.26	0.84			
Follow-up day 13	4.28	0.86			
Follow-up day 14	4.50	0.80			
Emotion improvement			13	3.37*	3–6, 9, 11, 12, 14 > 1;
Follow-up day 1	4.04	0.96			3–5, 9 > 2;
Follow-up day 2	4.18	0.97			3–7, 9, 12, 14 > 10;
Follow-up day 3	4.68	0.79			4 > 1, 2, 7, 10
Follow-up day 4	4.86	0.83			
Follow-up day 5	4.83	0.89			
Follow-up day 6	4.57	0.88			
Follow-up day 7	4.51	0.77			
Follow-up day 8	4.50	1.03			
Follow-up day 9	4.62	0.96			
Follow-up day 10	4.15	0.77			
Follow-up day 11	4.48	1.01			
Follow-up day 12	4.51	0.69			
Follow-up day 13	4.50	0.85			
Follow-up day 14	4.62	0.92			

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.
SD = standard deviation.

activities between groups. This study had a 2-week follow-up period and was not conducted in a well-controlled laboratory environment, which may explain its findings. Thatcher et al. (2020) noticed that although indoor plants improved work performance in a laboratory setting, these positive effects were not replicated in two field studies that used various performance and well-being measures over 6 to 14 weeks of exposure. Because of the nonlaboratory environment, the usual daily activities of the control group did not consistently involve similar tasks. Therefore, this was a field study in which the results reflected the real-world conditions. However, from the perspective of random assignments, daily activities could be randomly distributed across both groups. Therefore, future studies should track daily activities as potential control variables.

Third, the green area provided by the seed pot was too small to significantly affect the emotions or PLS. Because seed pots are space-saving and easy to maintain, the greenery area was small, which may explain why this study did not affect emotions and stress. Increasing the green area of the seeds or plant pots may enhance this effect. Lei et al. (2021) suggested a 12% greenery ratio for biophilic designs because 0.2% and 5% were insufficient to create restorative effects. Rhee et al. (2023) found that indoor vegetation density optimally enhanced well-being by 13% to 24%. Future research should consider horticultural care activities in larger green areas. According to Lei et al. (2021) and Rhee et al. (2023), greenery areas must be more than 12%; however, exceeding 24% greenery coverage reduced psychological effects. If plants require care for more than 2 weeks, as in this study, then choosing options that are easy to maintain to avoid the negative effects of plant death is crucial.

Future research should use different outcome variables and tools in addition to emotions and perceived stress. Genjo et al. (2019) indicated that observing vegetables and foliage plants, particularly mint and basil, could reduce eye fatigue among office workers. Bringslimark et al. (2007) determined that the number of indoor plants at a work desk has a small effect on reducing the number of sick days and promoting productivity. Ng et al. (2021) explored the effects of horticultural activities on social connectedness and biological inflammation. Relative physical, mental, social, and biological effects are potential variables for future studies.

Conclusions

This study explored the long-term effects of SPC on pleasure, arousal, and PLS through an exploratory RCT. Although the seedling pots did not germinate on day 1, the experimental group experienced increased pleasure, possibly because of the expectancy effect. However, beyond day 1, no significant impact on pleasure, arousal, or PLS was observed. However, the experimental group consistently demonstrated an increase in pleasure over the 14-d period. On day 4, the experimental group reported higher viewing frequency, stress reduction, and emotional improvement, likely because of seed germination. On day 4, although the control group experienced emotions that were more aligned with excitement, the experimental group experienced a smaller increase in arousal, indicating that the SPC may have cultivated an emotional state characterized by pleasure or relaxation. Overall, SPC did not negatively affect pleasure, arousal, or PLS, and the indoor use of seedling pots was encouraged. Therefore, future research should focus on increasing the sample size and expanding the greenery of seed pots.

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