

The Impact of Indoor Plants on Patient Recovery: Physiological and Psychological Effects in Dental Clinics

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Abstract. Patient recovery and well-being in healthcare settings can be influenced by various factors, including the stress induced by hospitalization and medical care. This study investigated the impact of indoor plants on patient recovery in dental clinics using state-of-the-art techniques to address the limited evidence supporting the claim that nature can alleviate stress and pain in hospitals. Thirty patients were randomly assigned to either a room with indoor plants or a control room without plants for a duration of 5 minutes after their treatment. Physiological responses were assessed using electroencephalography (EEG), heart rate variability, and skin conductance, whereas psychological responses were evaluated using the State-Trait Anxiety Inventory (STAI) and a visual analogue scale (VAS). The results revealed a significant increase in alpha wave power in the frontal region, indicating enhanced relaxation, as well as a significant increase in parasympathetic activity, suggesting improved autonomic balance. Furthermore, a significant decrease in skin conductance was observed when indoor plants were present compared with their absence, indicating reduced physiological arousal. Psychological assessments using the STAI demonstrated lower levels of stress and anxiety, whereas the VAS indicated reduced pain intensity among participants. Overall, these findings suggest that the presence of indoor plants contributes to patients' relaxation and improved coping mechanisms during the recovery process. This study highlights the significance of incorporating indoor plants into healthcare settings to enhance patients' overall well-being and promote positive recovery outcomes.

In recent years, the global population has witnessed a significant increase in health problems, including stress, anxiety, depression, and chronic diseases (WHO 2017). Moreover, hospitalization significantly intensifies feelings of depression and anxiety, thus impacting patients' emotional well-being (Alzahrani 2021). Additionally, fear, uncertainty, and anxiety can hinder the healing process, potentially leading to delayed wound healing among patients (Broadbent et al. 2003; Dijkstra et al. 2008). Dental clinics present a

unique setting where patients often experience anxiety and stress because of pain, discomfort, and uncertainty surrounding their treatment procedures (Appukuttan 2016). Dental anxiety is a prevalent condition that often results in the avoidance of dental care (Armfield 2013). Recognizing the profound impact of these conditions, researchers and healthcare professionals have been exploring innovative approaches to foster healing and enhance overall well-being.

Throughout history, various cultures have recognized the inherent healing properties of plants and the natural environment. Considering the potential therapeutic benefits of nature, incorporating natural elements within healthcare settings offers a promising approach to reduce stress associated with hospitalization. However, many healthcare facilities are often located in urban areas and lack an abundance of nature. Therefore, integrating indoor plants into hospitals has become a viable alternative to alleviate patient stress and potentially enhance recovery outcomes. By bringing nature indoors, we possess a unique opportunity to

create environments that support healthier lifestyles and promote the well-being of individuals.

Remarkably, studies that examined the impact of nature exposure on stress recovery have yielded compelling results. For instance, one study demonstrated that individuals exposed to a video featuring a natural environment recovered from stress at a faster rate than those exposed to an urban environment video (Ulrich et al. 1991). Similarly, it was found (Lohr and Pearson-Mims 2000) that participants exposed to indoor plants exhibited higher pain tolerance and reported a more positive perception of their environment, thus highlighting the potential of plants to enhance pain management. Furthermore, research has revealed that patients undergoing flexible bronchoscopy experienced better pain control when exposed to natural murals and sounds (Diette et al. 2003). Collectively, these studies have provided robust evidence supporting the positive effects of nature exposure.

A comprehensive review article extensively explored the role and significance of indoor plants in promoting human health and comfort and emphasized their positive psychological effects (Deng and Deng 2018; Han et al. 2022). The interest in incorporating indoor plants within healthcare settings to improve psychological well-being and reduce stress continues to grow. In this regard, the inclusion of indoor plants within the clinical environment may be a promising way to help patients cope and experience more positive outcomes (Deng and Deng 2018; Elsadek and Liu 2020; Elsadek et al. 2017). Indoor plants serve as an effective solution by bridging the gap between nature and healthcare settings, replicating the benefits associated with outdoor green spaces. Plants have the potential to improve air quality, lower stress levels, boost cognitive function, and enhance well-being (Aydogan and Cerone 2020; Elsadek et al. 2012). Moreover, the presence of plants creates a pleasant and relaxing environment, thereby leading to heightened satisfaction and productivity (Raanaas et al. 2011).

Furthermore, indoor plants have demonstrated significant positive impacts on mental and physical health in various environments, including homes, schools, and hospitals (Aydogan and Cerone 2020; Elsadek and Liu 2020; Han et al. 2022; Li and Sullivan 2016; Park and Mattson 2008). Their advantages extend beyond the workplace environment. Research has indicated that incorporating indoor plants into office spaces can reduce stress and improve the overall health of workers (Largo-Wight et al. 2011; Raanaas et al. 2011). Similarly, a systematic review emphasized the positive influence of indoor plants within residential environments, thus highlighting improvements in attention, task performance, and recognition of the importance of green spaces both indoors and outdoors for fostering health and productivity in urban areas (Han et al. 2022).

Several factors, including the stress induced by hospitalization, can affect patient recovery in healthcare settings. To explore

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methods that can lower anxiety and improve patient outcomes, some researchers have proposed integrating plants into the clinic environment as a promising strategy to reduce anxiety and enhance patient satisfaction (Hartig et al. 1996; Stanhope et al. 2020). However, there is limited evidence supporting this claim, and the potential associations between plant exposure and patient stress, anxiety, and recovery in dental clinics have received little attention.

This study aimed to investigate the impact of indoor plants on patient recovery within dental clinics and provide insights into their potential when used as a simple and cost-effective intervention to alleviate stress, improve human health, and promote overall well-being. Despite the growing interest in the potential benefits of indoor plants, limited research has comprehensively examined their influence on patient recovery using measures such as electroencephalography (EEG), heart rate variability (HRV), skin conductivity (SC), the State-Trait Anxiety Inventory (STAI), and the visual analogue scale (VAS). To address this research gap, our study adopted a multidimensional approach encompassing objective assessments of patients' physio-psychological responses through EEG, HRV, and SC measurements, and it evaluated their psychological reactions using the well-established STAI and VAS. By using this comprehensive methodology, we aimed to provide robust evidence supporting the claim that nature can aid in patient recovery in healthcare settings.

Materials and Methods

Participants

The present study enrolled a total of 30 volunteers with an average age of 38.06 ± 7.56 years (mean \pm SD) who had normal or corrected-to-normal vision. Participants with ongoing neurological illnesses undergoing treatment were excluded from the study. Additionally, participants were instructed to abstain from consuming alcohol on the day before the experiment, as well as from consuming caffeine and tobacco throughout the study duration. Table 1 presents the characteristics of the participants. Regarding the participant numbers in our study, it is noteworthy that certain prior studies have conducted comparable research with a similar or smaller number of participants (Jo et al. 2019; Ulrich 1984; Yamashita et al. 2021).

The recruitment of volunteers was conducted through two methods. First, advertisements containing study details were distributed to a physician at the clinic via WeChat groups (a popular Chinese social media application). Second, the authors personally approached and

invited patients to participate in the experiment. A crucial criterion for participant inclusion was the commitment to visiting the dental clinic on two separate occasions to undergo identical treatments, thereby allowing exposure to one experimental condition on each day. All participants provided written informed consent before their involvement in the study. The study adhered to the principles outlined in the Helsinki Declaration and approval was obtained from the Ethics Committees of Tongji University (approval number: 2019tjdx283).

Visual stimuli

The selection of green money plants, *Epipremnum aureum*, for this study was motivated by their aesthetic appeal, global popularity, and low-maintenance characteristics. These plants were chosen as visual stimuli for the experiment. Three plant pots were arranged in a specific configuration (Fig. 1) to ensure standardized presentation and placement during the study.

Procedure

The experiment was performed in a dental clinic located in Shanghai. A within-subject design was used to evaluate physio-psychological differences between two environmental conditions, as depicted in (Fig. 2). Before the study, a comprehensive explanation of the research objectives was provided to the hospital physicians and nurses, emphasizing the need for consistent patient treatment protocols. After obtaining informed consent from the participants after their dental procedures, they were randomly assigned to either a room with indoor plants or a room without plants (Fig. 1). Before the experiment, all participants completed the STAI and VAS questionnaires in the hospital room. The recovery room was maintained at a temperature of 22.5°C , relative humidity of 50%, and illumination level of 300 lx. EEG electrodes and ErgoLAB sensors were attached to the scalp and body to measure the participants' physiological responses. Subsequently, the participants were randomly assigned to one of two room conditions for their initial session: "without plants" or "with plants." Subsequently, the participants were randomly assigned to one of two room conditions for their initial session: "without plants" or "with plants." Each session lasted for 5 min; during that time,

participants were instructed to relax and remain motionless while their physiological data were recorded. After each session, participants were asked to complete the STAI and VAS questionnaires to evaluate their mood and pain levels.

Measurements

Physiological measurements. The physiological measurements included EEG, HRV, and SC. We used the ErgoLAB platforms (Kingfar Inc., Beijing, China) to measure HRV and SC. These platforms consist of wireless wearable sensors and a computer-based platform connected through a wireless receiver. The accuracy of ErgoLAB has been confirmed by researchers in related fields (Zhang et al. 2019).

Electroencephalography data collection, processing, and analysis. The Emotiv EPOC EEG headset was used to measure the electrical activity of the brain (Pham and Tran 2012). EEG, widely recognized as a reliable indicator of cortical arousal, provided valuable insights into brainwave patterns (Hagerhall et al. 2008). With 14 channels positioned according to the internationally recognized 10–20 electrode system, the portable Emotiv EPOC headset provided noninvasive, high-resolution measurements of the brainwave amplitude and frequency (Chiang et al. 2017). The EEG signals were captured, amplified, digitized, and transmitted to a computer via Bluetooth. The signals underwent filtering to eliminate electrical noise and undesirable characteristics. MATLAB was used for data processing; an automatic independent component analysis-based algorithm (ADJUST) was used to remove any remaining artifacts on a per-channel basis. Among the EEG channels, we used two channels from prefrontal brain lobes (AF3, AF4), to capture alpha relative wave power. The choice of electrode locations focused on the role of the prefrontal cortex in regulating cognition and thinking processes, as well as the prominence of alpha wave power in these regions (Fink et al. 2005).

Heart rate variability. The HRV describes the changes in the time interval between consecutive heartbeats over a specific duration (McCraty and Shaffer 2015). To analyze HRV in the frequency domain, we measured low-frequency (LF) power (0.04–0.1 Hz), indicating sympathetic activity, high-frequency (HF) power (0.15–0.4 Hz), indicating parasympathetic

Table 1. Descriptive details of the study participants (n = 30).

Variables	Mean	SD
Age	38.06	7.56
Height (cm)	169.74	5.82
Body weight (kg)	68.68	9.85

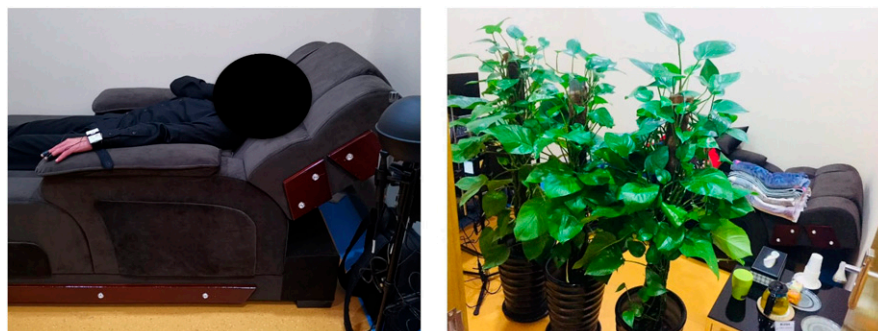


Fig. 1. The recovery room: (left) without plants (control) and (right) with plants.

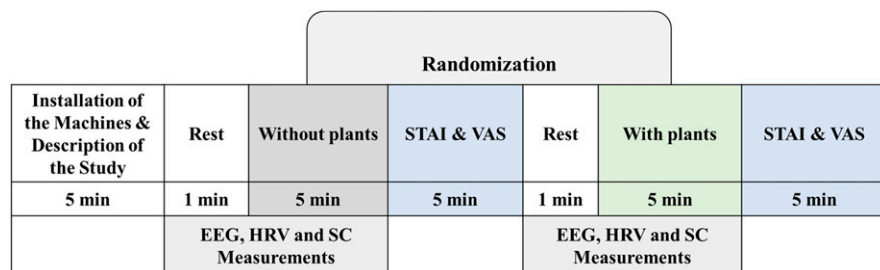


Fig. 2. Study procedures.

activity, and the LF/HF power ratio. These measures provide an indication of the level of sympathetic activity, with a higher LF/HF power value suggesting increased sympathetic nervous system activity, which has been associated with heightened levels of stress and anxiety (Malik et al. 1996). Filtering techniques, such as white de-noise, low-pass de-noise, baseline de-noise, and band stop, were applied to remove noise and heart rate interference. The ErgoLAB platform facilitated the processing and analysis of HRV and other physiological data.

Skin conductance. Skin conductance (SC), which reflects the electrodermal activity of the skin, was measured using a wireless sensor with electrodes placed on two different fingers of the left hand. This activity is an important indicator of thermoregulation in the human body because it reflects the dilation and constriction contraction of blood vessels and the activity of sweat glands in the skin (Lang and Bradley 2010). By measuring changes in skin resistance and sweating, SC can provide information about the physiological state of an individual. The measurement range of the sensor was 0 to 30 μ S, with an accuracy of 0.1 μ S and a sampling frequency of 32 Hz. To complete the circuit, we placed two electrodes of the sensor on two different fingers of the left hand. We processed the electrodermal activity signal to eliminate noise using filtering techniques and image deconvolution methods; then, we analyzed it in the time domain.

Psychological measurements

State-Trait Anxiety Inventory. We assessed anxiety levels using the STAI. This inventory measures changes in anxiety across different contexts by asking participants to report their current feelings of tension, nervousness, anxiety, and autonomic nervous system arousal (Hidano et al. 2000). The inventory's questions

gauge the severity of anxiety, with low scores indicating mild anxiety, median scores indicating moderate anxiety, and high scores indicating severe anxiety (Julian 2011; Martinelli et al. 2020).

Visual analog scale. To assess the intensity of acute pain experienced by the participants, we used the VAS, which is a reliable tool (Fig. 3). The VAS involved a 10-cm line to represent the spectrum of pain from no pain (0 cm) to the most severe pain imaginable (10 cm) (Martinelli et al. 2020). Participants were requested to indicate their most intense pain level during the stimulation by marking the line. This measurement was obtained immediately after the cessation of the stimulation (Kaertner et al. 2021).

Statistical analysis. Statistical analyses were conducted using SPSS version 25.0 (IBM Corp, Armonk, NY, USA). To assess the physiological differences between the two conditions, repeated-measures analyses of variance and paired *t* tests were used. The significance level for the physiological data analyses was set at $P < 0.05$. Psychological data were analyzed using Wilcoxon signed-rank tests, with a significance level of $P < 0.01$. All data were presented as mean \pm SD.

Results

The objective of this study was to investigate the potential benefits of incorporating plants in dental clinics to reduce stress, anxiety, and pain experienced by patients. Based on this objective, the following hypothesis was formulated: the presence of plants would have a positive impact on reducing stress, anxiety, and pain levels. By examining the results obtained, we can gain insights into the effectiveness of plants to enhance the well-being of dental clinic patients.

Physiological measurements

Electroencephalography. The statistical analysis revealed significant alterations in alpha wave activity within the prefrontal region when participants were exposed to two visual stimuli (Fig. 4). When comparing the presence and absence of indoor plants, a notable increase in alpha relative power was observed in AF3 (1.60 ± 0.12 and 0.90 ± 0.10 , respectively; $P < 0.05$). Similarly, AF4 exhibited a significant increase in alpha relative power (2.00 ± 0.10 and 1.21 ± 0.14 , respectively; $P < 0.05$). These findings provide compelling evidence that the visual exposure to indoor plants resulted in a significant augmentation in alpha relative power within the prefrontal region. This outcome signifies a state of relaxation and a positive emotional attitude toward the observed surroundings.

Heart rate variability. The results presented in Figs. 5 and 6 demonstrate significant differences in HRV in the room with plants and the room without plants. The mean LF/HF power in the presence of plants was significantly lower compared with the control condition (0.77 ± 0.12 vs. 2.52 ± 0.28 ; $P < 0.01$), indicating a shift toward parasympathetic activity (Fig. 5). Additionally, HF power in the room with plants was significantly higher compared with the control room (392.57 ± 33.51 vs. 213.68 ± 23.57 ; $P < 0.01$), reflecting increased parasympathetic activity (Fig. 6). Conversely, LF power was significantly higher in the control room than in the room with plants (533.74 ± 45.39 vs. 302.33 ± 45.67 ; $P < 0.01$), indicating greater sympathetic activity. These findings suggest that patients experienced a higher level of relaxation when they were in the presence of indoor plants.

Skin conductance. The average SC of the participants during the 5-min exposure period is depicted in Fig. 7. Notably, the presence of plants had a positive effect on the patients, as indicated by significant reductions in their SC levels. A comparison of the SC changes between the room with plants and the room without plants revealed a significantly lower SC in the presence of plants (1.43 ± 0.29) compared with that in the absence of plants (2.44 ± 0.15) ($P < 0.01$). These findings highlight the calming influence of indoor plants on patients, reflected by the notable reductions in SC.

Psychological measurements

State-Trait Anxiety Inventory. Cronbach's alpha is used for measuring the internal consistency. The results indicated that Cronbach's alpha was 0.86, confirming that the STAI had high internal consistency. The initial anxiety levels of the patients, as measured by the STAI, did not differ significantly between the conditions without plants (46.67 ± 4.31) and with plants (47.27 ± 3.72). However, after spending 5 min in the recovery room without plants, the patients' anxiety levels increased significantly (52.87 ± 4.27). In contrast, patients exposed to plants in the recovery room reported significantly lower

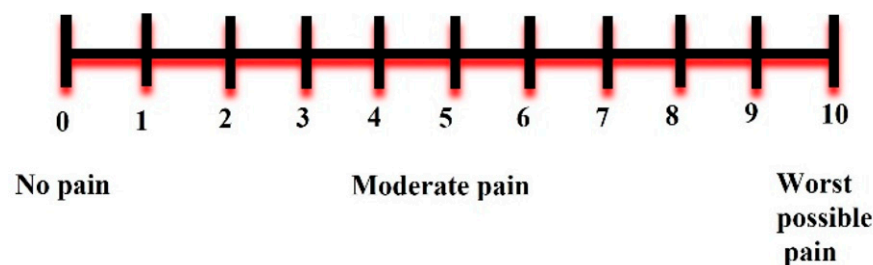


Fig. 3. The visual analog scale (VAS).

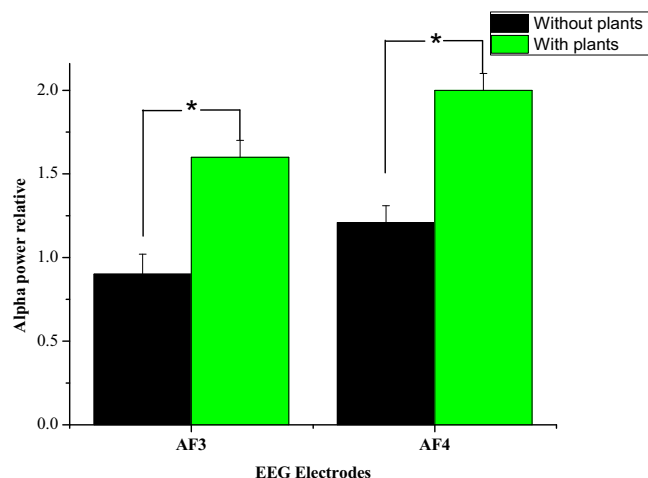


Fig. 4. Comparison of alpha relative power variability in AF3 and AF4 electrodes during the 5-min period in the absence or presence of plants (n = 30). * $P < 0.05$ (Wilcoxon-signed rank test).

anxiety levels (28.30 ± 4.45) after the 5-min period (Fig. 8). These results indicate that the absence of plants in the recovery room led to heightened anxiety and stress levels among the patients, whereas the presence of plants had a calming effect.

Visual analog scale. The VAS was used to measure the patients' pain intensity. Before the experiment, the pain intensity did not differ significantly between the conditions without plants (6.90 ± 0.48) and with plants (7.03 ± 0.81). Furthermore, spending 5 min in the recovery room without plants did not result in a notable change in pain intensity. However, after spending 5 min in the recovery room, patients exposed to plants reported a significant reduction in pain intensity (4.70 ± 0.67) compared with those not exposed to plants (7.50 ± 0.73) ($P < 0.05$) (Fig. 9). These findings provide strong evidence that the presence of plants in the recovery room had a significant impact on reducing the perception of postsurgical pain.

Discussion

Despite the existence of several studies that have investigated human health–nature interactions (Hartig et al. 2014), our understanding of the specific positive effects of indoor plants on patients' stress and anxiety reduction remains limited. In this study, we sought to investigate the impact of indoor plants on patients' stress and anxiety levels within a dental clinic setting. To comprehensively assess patients' responses, we used physiological measures, including EEG, HRV, and SC, along with psychological surveys such as the STAI and VAS. Our findings revealed that patients exposed to indoor plants in their recovery rooms exhibited lower stress and anxiety levels, as evidenced by increased alpha relative wave and parasympathetic nerve and reduced SC. Furthermore, subjective reports from patients indicated reduced levels of anxiety and pain when surrounded by indoor plants during their recovery. These results suggest that the presence of indoor plants in healthcare settings

can potentially yield beneficial effects on patients' overall well-being.

The observed systematic variations in alpha relative power between the two environmental conditions are highly intriguing. Specifically, the presence of indoor plants resulted in significantly higher alpha relative oscillations compared with that resulting from the absence of plants. Previous investigations that explored brain wave patterns in response to natural environments have consistently reported that increases in alpha power are associated with internal changes, such as heightened relaxation, reduced anxiety levels, and augmentation of positive emotions (Neale et al. 2017). Importantly, alpha-band activity has been demonstrated to play a role in cognitive processes and is indicative of states characterized by calmness, attentiveness, and positive mood (Kim et al. 2013). The enhanced alpha relative power observed in the presence of plants within the recovery room suggests a shift toward focused internal attention (Benedek et al. 2014). This contributed to a state of increased calmness, heightened alertness, and improved concentration on the indoor surroundings for the participants. Notably, the findings of increased alpha relative waves while viewing indoor plants during the current study align with those reported by prior relevant investigations. The findings of the present study contribute additional evidence supporting the calming effects associated with the visual exposure to indoor plants.

HRV serves as a valuable metric for assessing the response of the autonomic nervous system to stress and relaxation in the human body. Activation of the parasympathetic nerve elicits relaxation and calmness, whereas activation of the sympathetic nerve promotes stress and anxiety (Malik et al. 1996). Studies have indicated that HRV acts as an indicator of the impact of mental stress on the body and the level of physiological stability (Kim et al. 2008). In the presence of indoor plants, patients exhibited a significant increase in parasympathetic nerve activity, indicating a heightened sense of relaxation, along with a slight decrease in sympathetic nerve activity, indicating a reduced level of stress compared with that associated with the room without plants. These findings suggest that incorporating indoor plants into hospital environments may contribute to improved human health by alleviating stress (Elsadek and Liu 2020; Kexiu et al. 2021). Previous studies have also highlighted the relaxing effects of indoor plants, demonstrating their ability to enhance the activity of the nerve associated with calmness, diminish the activity of the nerve associated with stress, and promote physiological relaxation in individuals (Xie et al. 2021).

SC serves as a vital indicator of stress levels. The average SC was notably lower in the presence of indoor plants than in their absence. This indicates that the presence of plants facilitated a faster relaxation response within the nervous system. SC tends to increase with heightened psychological and physiological arousal (Andreassi 2007) or in

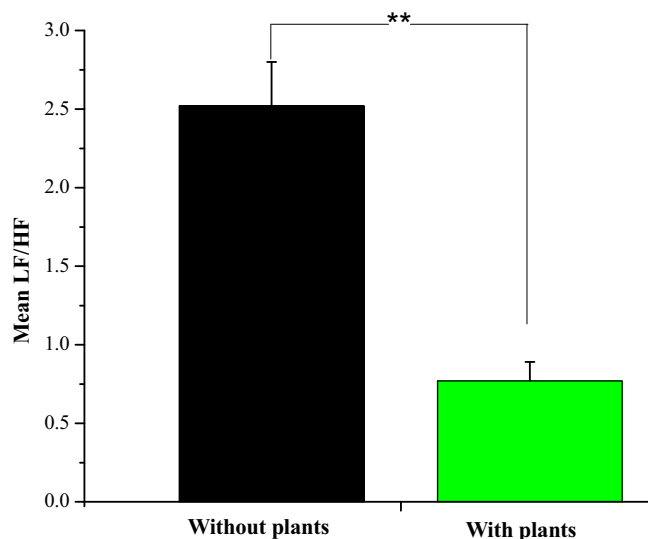


Fig. 5. Comparison of low-frequency (LF)/high-frequency (HF) power during the 5-min period in the absence or presence of plants (n = 30). ** $P < 0.01$ (Wilcoxon-signed rank test).

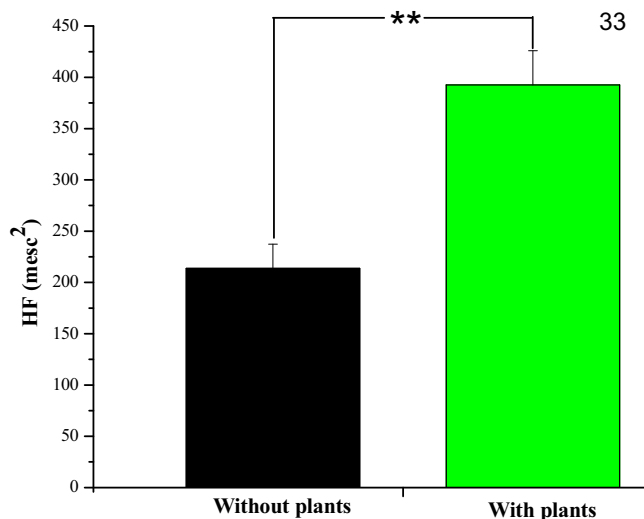


Fig. 6. Average of the high-frequency (HF) power component of participants' heart rate in the absence or presence of plants (n = 30). ** $P < 0.01$ (Wilcoxon-signed rank test).

response to stress (Setz et al. 2010). Prior research has consistently demonstrated that exposure to nature can lead to a reduction in heart rate and SC (Elsadek et al. 2019a, 2021). This study found increased parasympathetic nerve activity and decreased sympathetic nerve activity, which were in alignment with the observations by Ulrich et al. (1991), who reported a more rapid decline in SC and a similar impact on HRV after viewing natural scenes as opposed to urban scenes.

Results of the STAI questionnaire indicated that patients felt more negative emotions, such as discomfort, nervousness, and distress, in the control room without plants. This confirmed the positive effects of indoor plants on human well-being. These findings are consistent with those of other studies that reported negative emotions in the absence of plants (Elsadek et al. 2017; Han et al. 2022). Additionally, these findings support the findings of Song et al. (2015), who reported that participants experienced fewer negative emotions and

less anxiety when visiting an urban park. This study provides strong evidence that having plants in a dental clinic positively affects patients' well-being.

During the present study, we observed a significant decrease in pain sensation, as indicated by the VAS scores, after contact with plants. This finding suggests that exposure to indoor plants may have a positive impact on pain reduction. Similar observations were reported by Stanhope et al. (2020), who proposed that exposure to nature can be beneficial for individuals experiencing pain. Therefore, our study provides additional support for the notion that the presence of plants in a hospital setting can improve the pain experience. Unlike previous studies that primarily focused on nature exposure in natural environments, such as forests (Elsadek et al. 2019b; Janeczko et al. 2020), the present study examined the effects of indoor plants. This supports previous research that suggested that even limited urban greenspace can offer psychological benefits. It

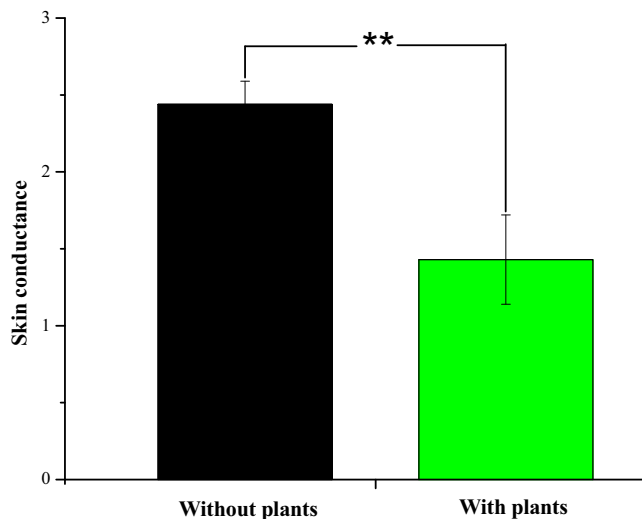


Fig. 7. Comparison of participants' skin conductance during the 5-min experience period in the absence or presence of plants (n = 30). ** $P < 0.01$.

was proposed that the relief of pain through exposure to greenspace may be attributed to the distraction of attention from pain perception by the natural stimulus (Kline 2009). Hence, pain reduction can be interpreted in this context. Additionally, Stanhope et al. (2020) proposed alternative explanations for the pain-reducing effects of brief greenspace exposure. For example, phytoncides may affect the human immune system, boost the activity of natural killer cells activity, and contribute to pain relief. However, these mechanisms lack direct evidence; therefore, further research is necessary to explore them in greater detail.

The results of our study further reinforce the positive effects of incorporating indoor plants in hospital settings on patient well-being. Consistent with previous studies, our findings demonstrate that the presence of indoor plants contributes to a more positive perception of the waiting experience and significantly reduces anxiety levels among patients (Dijkstra et al. 2008). This aligns with the comments provided by patients during our study, who noted that the plants effectively reduced stress and conveyed a positive impression of hospital employees' care (Park and Mattson 2008). Moreover, our research supports the notion that patients with plants in their rooms experience reduced stress and anxiety, improved pain tolerance, and overall satisfaction with their hospital stay. These results are consistent with those of previous studies conducted in a hospital setting that indicated that the presence of indoor plants can have a holistic positive impact on patient well-being (Hall and Knuth 2019).

Although the stress-reducing properties of natural elements in built environments have been observed, the underlying mechanisms responsible for this effect remain unclear. Kaplan (1995) and Ulrich (1984) have proposed theories that humans possess an inherent preference for natural settings that is potentially rooted in evolutionary factors. Although these theories differ in their specifics, they share the common assumption that humans inherently respond positively to natural elements (Ulrich 1993). This innate preference for nature over human-made objects may explain the stress-reducing effects observed. Consequently, it can be hypothesized that natural elements influence stress levels through the perceived attractiveness of the environment.

The recognition of the positive effects of indoor plants on patients recovering in hospital settings after surgery is important. Based on the EEG, HRV, SC, and the questionnaire results, our findings demonstrate that the presence of plants in the recovery room had a significant positive impact on patient well-being, resulting in increased relaxation and decreased anxiety and pain. The inclusion of indoor plants during the recovery period after dental surgery directly influenced patients' physiological and psychological experiences. Incorporating indoor plants in healthcare facilities can be a simple and cost-effective approach to improving patient well-being and enhancing the healing environment. Future research should explore the long-term effects

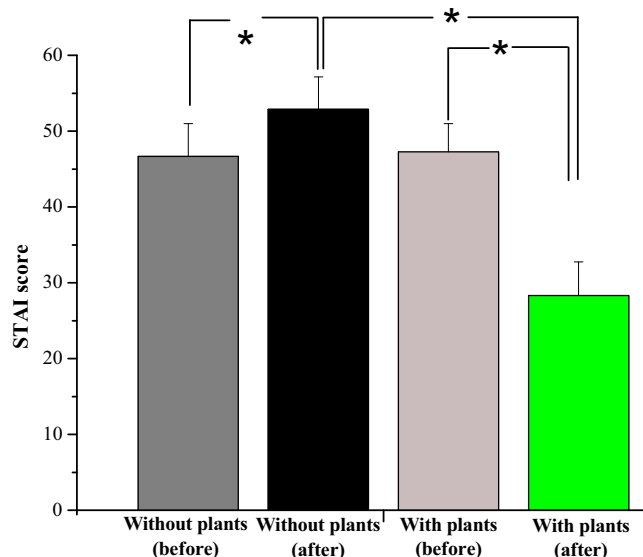


Fig. 8. Comparison of the participants' state of anxiety in the absence or presence of plants (before and after) (n = 30). * $P < 0.05$.

of indoor plant exposure and investigate the specific plant characteristics that contribute to the observed positive outcomes. Despite its limitations, this study contributes to the growing body of scientific evidence supporting the integration of indoor plants in healthcare settings and hospitals, thus promoting positive physiological and psychological well-being of patients. Furthermore, it underscores the potential of using indoor plants as a design element to create more sustainable and healthier spaces, thereby offering valuable insights to interior landscape designers.

Conclusion

Our investigation of the impact of indoor plants on stress, anxiety, and pain levels of dental patients within a recovery room has

produced statistically significant results. It provides robust evidence supporting the significant positive effects of indoor plants on stress, anxiety, and pain levels of dental patients during the recovery period. By using a comprehensive approach that incorporates physiological measures and psychological surveys, we have demonstrated that the presence of indoor plants in the recovery room leads to a notable reduction in stress, as evidenced by decreased sympathetic nerve activity and increased alpha relative wave. Additionally, patients exposed to indoor plants reported lower anxiety levels and a substantial alleviation of pain. These findings highlight the therapeutic potential of indoor plants in healthcare settings, thus offering a natural and effective approach to enhancing patient well-being. Integrating

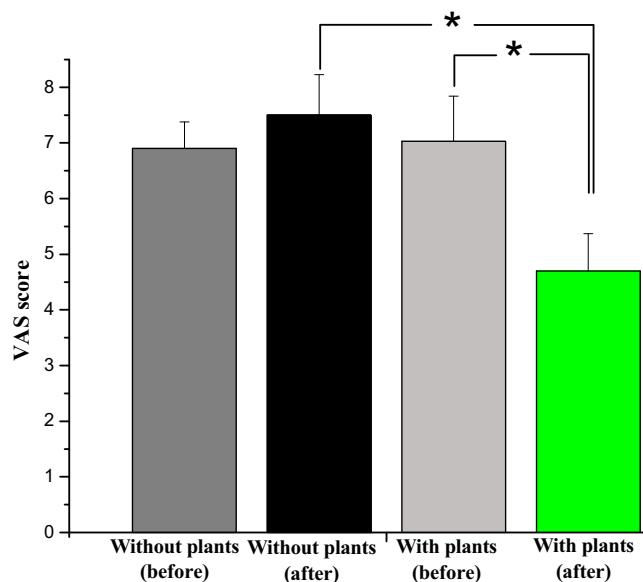


Fig. 9. Comparison of visual analog scale (VAS) scores in the absence or presence of plants (before and after) (n = 30). * $P < 0.05$.

indoor plants as an integral part of healing environments has the potential to revolutionize healthcare practices by promoting improved patient satisfaction and overall outcomes. We recommend that healthcare professionals consider the strategic incorporation of indoor plants as a simple yet impactful intervention to foster a healing environment that prioritizes patient comfort and holistic care.

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