Introduction

Stress refers to the physical and psychological tension or disorder experienced by living things when faced with an environment or a condition to which it is difficult to adjust (Folkman, 2020). When stressed, humans show physiological responses like the activation of the sympathetic nervous system (Bae and Hur, 2016), as well as increased heart rate and blood pressure, increased respiration, muscle stress, and poor digestion (Jang et al., 2018). Moreover, continued stress makes humans more and more unhappy due to increased mental fatigue and negative emotions as well as decreased energy (Dolling et al., 2017; Gunnarsson et al., 2022; Ulrich et al., 1991).

University students are in a period of transition from late adolescence to adulthood, and they experience new environments and roles in college and start getting credits, managing time, forming various interpersonal relationships, and thinking about career and employment (Lee and Yu, 2008). This causes them to frequently experience mental fatigue, which may deteriorate academic efficiency and achievement and cause negative affect (Koo and Shim, 2016). Accordingly, university students may experience a great deal of stress and emotional anxiety. This stress can...
enable the students to maintain a positive mindset or lead to diseases along with distortion and physiological responses depending on how they manage and cope with it (Balint et al., 2022; Folkman and Lazarus, 1988). Therefore, there must be a way to reduce stress, maintain a positive mind, and help maintain a healthy life.

Stress is measured using self-report questionnaires, heart rate variability (HRV) measurement, cortisol, and adrenaline tests. HRV measurement in particular is known to be a quantitative and objective method for measuring the autonomic nervous system in coping with stress (Bielinis et al., 2019; Castaldo et al., 2019; Jang et al., 2018; Kim et al., 2018; Lee and Hyun, 2018). HRV measurement is non-invasive, simple, and can check the results immediately after the test, which is why it is widely used in obtaining information on diseases related to stress (Castaldo et al., 2015; Tan et al., 2011). Moreover, there is a known association of a specific cyclical component between HRV and autonomic nervous system activity. Among components related to HRV, high frequency component (HF) is related to respiration and is used as an index for parasympathetic nervous system activity, while low frequency component (LF) is related to heart rate variability by blood pressure control and thus tends to mostly reflect sympathetic nervous system activity (Woo, 2004). Recently, it is possible to monitor stress based on HRV using a wearable biosensor (Akbulut et al., 2020; Yoo and Chung, 2018), which is used as a method for self-management. Moreover, emotional support is a factor that affects happiness, and emotional support from others helps relieve stress and promote emotional stability (Park and Kim, 2009).

Among thoughts that induce affect, positive thinking especially plays a major role in coping with stress and induces positive response, and it is closely related to positive affect (Thak, 2010). Affective response is measured using the positive and negative affect schedule (PANAS) developed by Watson et al. (1988).

The natural environment is a complex factor of plants, trees, insects, animals, and weather, creating a different forest environment in each season. This also creates a difference depending on the season, composition of tree species, or the horizontal or vertical structure of the colonies, which is information that has a direct effect on the senses (Lu et al., 2020; Mu et al., 2022; Muukkonen et al., 2009; Wang, 2021). Moreover, contact with nature leads to psychological and physiological recovery and relaxation (Adevi and Lieberg, 2012; Berto, 2005; Beute and De Kort, 2018; Dolling et al., 2017; Hartig et al., 2014; Kaplan, 1995; Moran, 2019; Shin, 2015; Ulrich et al., 1991), and the benefits as nature as a restorative environment were proved in many studies. In particular, it was discovered that universities students in their 20s who enjoyed forest landscape views in May had higher HF component and lower average heart rate compared to the city (Joung et al., 2013). It was also found that taking a walk in the downtown arboretum in June brought psychological stability to male university students (Lee et al., 2011). A self-directed forest therapy program including stretching, breathing, walking, meditating, and exercising in the forest for male and female university students from September to October reduced negative emotions of the participants (Shin and Kim, 2023). Therefore, forests seem to be having a huge impact on the psychological stability of university students.

This study verifies whether there are differences in stress, LF, HF, and affective responses of male and female university students by season after actual short-term experience of the forest that changes according to the seasons at an urban forest close to their everyday life.

Research method

Research site

This study was conducted in an urban forest (Fig. 1) (N 36°37'42.42", E 127°27'13.08") in Chungbuk National University, Chungcheongbuk-do, Korea. This is an urban forest located on the campus of Chungbuk National University with the area of 25,711 m², dominated by pine, Japanese larch, oak, Japanese cherry, magnolia, yellowwood, and zelkova, and then snowbell, cherry, fragrant snowbell, and tree of the gods in the middle and lower layers, forming a mixed forest. The dominant trees in this forest were approximately 27 cm in diameter and 19 m in height. There are also trails in the forest to see the changes of trees according to the seasons, leading uni-
versity students naturally to nature and being used as a place for rest and walks.

Participants

This study selected 30 participants (13 male students, 17 female students, age 20.5 ± 1.3) and conducted longitudinal research, but there was a difference in the number of participants due to no-shows on the day of the experiment. By season, 28 students participated in spring (12 male students, 16 female students), 30 in summer (13 male students, 17 female students), 22 in fall (8 male students, 14 female students), and 22 in winter (7 male students, 15 female students).

Procedures

This study verifies whether there are differences in stress, LF, HF, and affective response of male and female university students by season as time passes in the urban forest close to the everyday life of university students. Total 4 surveys were conducted on November 11, 2021 (fall), December 12, 2021 (winter), April 27, 2022 (spring) and June 15, 2022 (summer) with approximately 30 male and female university students. Experiments were conducted from 11 a.m. to 4 p.m. each day, and the temperature and relative humidity during research were 17.2°C and 47.3% on November 11, 2021, 6.7°C and 73.0% on December 12, 2021, 20.7°C and 33.1% on April 27, 2022, and 25.0°C and 83.5% on June 15, 2022.

The participants first measured stress using HRV and filled out the self-report questionnaire on affect indoors, after which they went to the urban forest on campus and took a simple walk for 10-20 minutes and concentrated their vision on the measurement spot located within the urban forest, and then measured their stress again and filled out the self-report questionnaire for the second time. This study is conducted on humans and thus was deliberated and approved by Chungbuk National University’s Institutional Review Board (IRB approval: CBNU-202110-HR-0152) prior to research.

Measurement tools

Changes in stress levels, LF, and HF were measured using an HRV monitor (uBioMacpa, Biosense Creative, Korea) by attaching a finger pulse oximeter on the left index finger of the participant in relaxed sitting position and measuring for 2.5 minutes. The measures were stress level, LF, and HF.

The PANAS questionnaire was used to measure affect. The PANAS questionnaire we used was the Korean version adapted by Lee et al. (2003) from the questionnaire designed by Watson et al. (1988). The questionnaire consisted of 10 items on positive affect and 10 items on negative affect, rated on a self-report 5-point Likert scale from 1 point (‘Strongly disagree’) to 5 points (‘Strongly agree’). Cronbach’s α of the PANAS questionnaire when developed was 0.84. Cronbach’s α in this study was 0.72, proving that there was no problem with the reliability of the measurement factors.
Data analysis

The collected data were analyzed using non-parametric statistics Kruskal-Wallis H test, Wilcoxon signed rank test through SPSS Statistics ver. 18. The homogeneity of male and female university students by season was tested through Kruskal-Wallis H test, and the Wilcoxon signed rank test was conducted to test the differences in stress, LF, HF, and affect between male and female students before and after experiencing the urban forest by season.

Results and Discussion

Homogeneity test of participant groups by season

The Kruskal-Wallis H test was conducted to test the similarities of participant groups in short-term urban forest experience by season. As a result of testing the groups of male and female participants by season, there were no significant differences in stress (male students: $x^2 = 4.145, p > .05$, female students: $x^2 = 4.427, p > .05$), LF (male students: $x^2 = 0.671, p > .05$, female students: $x^2 = 3.446, p > .05$), HF (male students: $x^2 = 1.694, p > .05$, female students: $x^2 = 2.117, p > .05$), positive affect (male students: $x^2 = 1.069, p > .05$, female students: $x^2 = 3.246, p > .05$), and negative affect (male students: $x^2 = 2.422, p > .05$, female students: $x^2 = 2.198, p > .05$). Therefore, the participant groups by season are similar (Table 1).

Comparison of physiological responses after short-term urban forest experiences by season

Changes in stress levels

For changes in stress levels after urban forest experience in spring, the stress levels of female students decreased with statistical significance ($z = -2.151, p < .05$), while male students did not show statistically significant results. The stress levels of male students decreased with statistical significance ($z = -2.362, p < .05$) after urban forest experience in summer, while female students did not show statistically significant results. Both male and female university students did not show statistically significant results after urban forest experience in fall. The stress levels of male students decreased with statistical significance ($z = -2.207, p < .05$) in winter, while female students did not show statistically significant results (Fig. 2).

Fig. 2. Changes in the stress index of male and female university students by seasons before and after urban forest experience. The stress index was significant for female in spring, male in summer, and male in winter. (*: $p < .05$).
Table 1. Homogeneity test of groups by gender and seasons

<table>
<thead>
<tr>
<th>Factor</th>
<th>Season</th>
<th>Gender</th>
<th>n</th>
<th>Mean</th>
<th>S.D.</th>
<th>$x^2$</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stress</td>
<td>Spring</td>
<td>Male</td>
<td>12</td>
<td>37.17</td>
<td>7.28</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>Male</td>
<td>13</td>
<td>39.31</td>
<td>5.36</td>
<td>4.145</td>
<td>.246</td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>Male</td>
<td>8</td>
<td>36.63</td>
<td>6.89</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Winter</td>
<td>Male</td>
<td>7</td>
<td>40.86</td>
<td>3.89</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spring</td>
<td>Female</td>
<td>16</td>
<td>31.25</td>
<td>7.56</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>Female</td>
<td>17</td>
<td>31.76</td>
<td>9.18</td>
<td>4.427</td>
<td>.219</td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>Female</td>
<td>14</td>
<td>31.71</td>
<td>12.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Winter</td>
<td>Female</td>
<td>15</td>
<td>37.47</td>
<td>10.44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physiological</td>
<td>Spring</td>
<td>Male</td>
<td>12</td>
<td>7.92</td>
<td>.73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>indicators</td>
<td>Summer</td>
<td>Male</td>
<td>13</td>
<td>7.87</td>
<td>.85</td>
<td>.671</td>
<td>.880</td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>Male</td>
<td>8</td>
<td>7.90</td>
<td>.90</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Winter</td>
<td>Male</td>
<td>7</td>
<td>8.11</td>
<td>.73</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spring</td>
<td>Female</td>
<td>16</td>
<td>7.88</td>
<td>.71</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>Female</td>
<td>17</td>
<td>7.94</td>
<td>.71</td>
<td>3.446</td>
<td>.328</td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>Female</td>
<td>14</td>
<td>7.59</td>
<td>.81</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Winter</td>
<td>Female</td>
<td>15</td>
<td>7.47</td>
<td>.79</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LF</td>
<td>Spring</td>
<td>Male</td>
<td>12</td>
<td>7.20</td>
<td>.94</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>Male</td>
<td>13</td>
<td>6.83</td>
<td>.74</td>
<td>1.694</td>
<td>.638</td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>Male</td>
<td>8</td>
<td>6.91</td>
<td>.53</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Winter</td>
<td>Male</td>
<td>7</td>
<td>7.13</td>
<td>.68</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spring</td>
<td>Female</td>
<td>16</td>
<td>7.38</td>
<td>.71</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>Female</td>
<td>17</td>
<td>7.21</td>
<td>.88</td>
<td>2.117</td>
<td>.548</td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>Female</td>
<td>14</td>
<td>7.40</td>
<td>1.18</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Winter</td>
<td>Female</td>
<td>15</td>
<td>7.11</td>
<td>.63</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HF</td>
<td>Spring</td>
<td>Male</td>
<td>12</td>
<td>28.87</td>
<td>6.37</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>Male</td>
<td>13</td>
<td>28.69</td>
<td>6.10</td>
<td>1.069</td>
<td>.785</td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>Male</td>
<td>8</td>
<td>30.63</td>
<td>6.63</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Winter</td>
<td>Male</td>
<td>7</td>
<td>26.86</td>
<td>7.27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive Affect</td>
<td>Spring</td>
<td>Female</td>
<td>16</td>
<td>29.93</td>
<td>11.35</td>
<td>3.246</td>
<td>.355</td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>Female</td>
<td>17</td>
<td>24.00</td>
<td>7.96</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>Female</td>
<td>14</td>
<td>29.93</td>
<td>11.35</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Winter</td>
<td>Female</td>
<td>15</td>
<td>28.00</td>
<td>6.86</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Psychological</td>
<td>Spring</td>
<td>Male</td>
<td>12</td>
<td>17.33</td>
<td>7.71</td>
<td></td>
<td></td>
</tr>
<tr>
<td>indicators</td>
<td>Summer</td>
<td>Male</td>
<td>13</td>
<td>21.62</td>
<td>12.24</td>
<td>2.422</td>
<td>.490</td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>Male</td>
<td>8</td>
<td>16.63</td>
<td>5.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Winter</td>
<td>Male</td>
<td>7</td>
<td>25.29</td>
<td>12.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative Affect</td>
<td>Spring</td>
<td>Female</td>
<td>16</td>
<td>21.38</td>
<td>10.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>Female</td>
<td>17</td>
<td>21.00</td>
<td>7.17</td>
<td>2.198</td>
<td>.532</td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>Female</td>
<td>14</td>
<td>20.21</td>
<td>8.68</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Winter</td>
<td>Female</td>
<td>15</td>
<td>17.40</td>
<td>5.53</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Changes in LF and HF

For LF and HF responses after urban forest experience in spring, HF decreased with statistical significance among male students (z = -2.096, p < .05), while female students did not show significant differences. Both groups did not show statistically significant differences in LF. In summer, fall, and winter, both male and female university students did not show statistically significant differences in LF and HF (Fig. 3 and 4).

Affective response after short-term urban forest experiences by season

For affective response, positive affect in spring increased with statistical significance among both male and female students (male, z = 2.983, p < .01; female, z = 2.19, p < .05) and negative affect decreased with statistical significance among male students (z = -2.366, p < .01), while female students did not show statistically significant results (Figs. 5 and 6). In summer, both groups did not show sig-
significant differences in positive affect and negative affect. In summer, both groups did not show statistically significant differences in positive affect, but negative affect decreased with statistical significance among female students \((z = -2.356, p < .05)\), whereas there were no statistically significant results among male students. After urban forest experience in winter, positive affect increased with statistical significance among male students \((z = 1.992, p < .05)\), whereas there were no statistically significant results among female students (Figs. 5 and 6).

**Discussion**

The research site in this study is located near the everyday life of university students and is used as a space connecting the students to nature. Since forests have different environmental characteristics for the organisms living there depending on the season, the landscapes that appear also
turn out to be different. This study shows the differences in stress, LF, HF, and affective response between male and female students.

First, HRV was used to identify the changes in stress, LF, and HF after short-term urban forest experiences by season. HRV helps neurocardiologically and neurophysiologically evaluate the autonomic nervous system related to stress, measuring the imbalance of the autonomic nervous system as a tool measuring the overall health state of the heart and autonomic nervous system (Woo, 2004). When stressed, the changes in the autonomic nervous system are commonly known to be characterized by increased LF and decreased HF (Kim et al., 2018; Lee and Hyun, 2018; Porges, 2007). Green spaces are known to lower human stress, and it has been discovered that human stress is also reduced by using green spaces due to the recent COVID-19 pandemic (Berdejo-Espinola et al., 2021; Hedblom et al., 2019; Maury-Mora et al., 2022). As such, in this study, stress decreased in female university students in spring when the forest was mostly green, while it decreased in male university student in summer. However, only male university students showed a significant decrease in stress in the winter forest that was not mostly green, while female university students did not show statistically significant differences. The key factors of stress relief for female university students were warm temperature (Park, 2022) and bright green (Oh and Park, 2022) in the urban forest, whereas the factors of stress relief for male university students were the natural environment with a high density of a dark green forest (Jeong and Ahn, 2015; Jeong and Ahn, 2016; Park, 2022), pine forest, or summer and winter (Lee, 2020).

LF is mostly used as an index for sympathetic nervous system activity, and HF for parasympathetic nervous system activity (Woo, 2004). Previous studies on forest therapy showed that, out of 50 adolescents, those participating in forest therapy activities in summer showed emotional stability through the balance of the autonomic nervous system and the activation of the parasympathetic nervous system (Jeon et al., 2021). A study on 23 male students in Japan showed that walking around urban parks during fall increased parasympathetic nerves and decreased sympathetic nerves (Song et al., 2015). As such, forest experience is known to affect the autonomic nervous system. Another study showed that female university students feel more psychologically “comfortable”, “natural”, and “relaxed” in the forest compared to the city, but there were no significant differences in the index of parasympathetic nervous system activity such as HF or the indices of sympathetic nervous system activity such as LF/HF and heart rate (Song et al., 2018). Just short forest bathing experience is known to have limited effect on the sympathetic and parasympathetic nervous systems (Yu et al., 2017). In this study, LF did not show a significant change in both male and female university students, and HF decreased only in male university students in spring. The results of this study on autonomic nervous system response showed that short-term contact with the urban forest did not have sufficient effect in the urban forest environment. Moreover, the autonomic nervous system shows different responses depending on not only stress but also various factors or recent experiences (Lee and Hyun, 2018), fatigue (Ko et al., 2000), and gender (Chang et al., 2010), which is why continuous and repeated research is necessary considering these factors.

Second, changes in affect after urban forest experience by season are also found in other studies as follows. The forest environment in spring increased positive affect and decreased negative affect among university students (Park, 2022), and forest bathing in 4 regions of Japan in summer by the participants in their 20s decreased negative affect and increased positive affect (Takayama et al., 2014). Forest bathing in winter increased PANAS-based positive affect of 62 university students (32 male and 26 female) in Poland (Bielinis et al., 2018b), 34 female university students in Poland exposed to the forest environment in winter showed an increase in PANAS-based positive affect but no significant change in negative affect (Bielinis et al., 2019). As for comparison between seasons, graduate students with the average age of 35.9 (male: 11, female: 4) exposed to the forest in spring and fall did not show a significant change in PANAS-based affect between the two seasons (Takayama et al., 2017). Some studies also report that there is a greater change in affect in winter forests than spring (Bielinis et al., 2018a). Moreover, the impact of forest experience on affect also varies depending on the season, gender, and form of stands (Janeczko et al., 2020;
Simkin et al., 2020), and situations in the forest environment (Bielinis et al., 2021), thereby suggesting that various characteristics of forests have an impact on affect.

In this study, positive affect of male and female university students increased after forest experience in spring, and negative affect of female students decreased after forest experience in fall, while positive affect of male students increased after forest experience in winter. As such, forest experiences by season led to different experimental reasons between seasons in the changes of affect among male and female university students. However, this study had a small sample and did not conduct repeated experiments in each season for multiple years, which is why further research must be conducted to make up for these deficiencies.

Conclusion

In this study, short-term forest experiences by season led to differences in gender, stress, and physiological and affective changes. In particular, spring forest experience was effective in stress and physiological and affective responses in both male and female students; summer forest experience lowered stress in male students; fall forest experience brought changes to affective responses in female students; and winter forest experience brought changes to stress and affective responses in male students. The results of this study can be used to create urban forests and select the best period for effectively using urban forests to relieve stress and refresh the emotions of university students. Furthermore, additional research is needed to consider how to use urban forests according to various factors comprising the urban forest environment (leaf unfolding period of tree species, leaf duration period, flowering period, foliage season, forest tree density, etc.).

Reference


Effects of Short-term Urban Forest Experiences by Season on Stress and Affective Response of University Students


Koo, H. and J. Shim. 2016. A study on influential factors to the late adolescents' anger control ability: with Choonchun city as the center. Forum For Youth Culture 45:7-34. https://doi.org/10.17854/ffyc.2016.01.45.7


Song, C., H. Ikei, M. Igarashi, M. Takagaki, and Y. Miyazaki. 2015. Physiological and psychological effects
Effects of Short-term Urban Forest Experiences by Season on Stress and Affective Response of University Students


Thak, E.J. 2010. Differences in high-school students' school adaptation and peer relations according to level of positive thinking. Master's thesis. Chonnam National University, Gwangju, Republic of Korea.


