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# The Influence of Forest Landscape Spaces on Physical and Mental Restoration and Preferences of Young Adults of Different Genders

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**Abstract:** Forest landscape spaces have positive effects on human physical and mental health. Meanwhile, gender is an important biological factor in differences in human physical and mental responses when facing stress. Therefore, it is necessary to discuss the gender characteristics and differences of people's experiences of restoration in forest landscapes. Meanwhile, it is urgent to attend to the issue of young adults' physical and mental health. This study aimed to clarify the impact of forest landscape exposure on physical and mental restoration and preferences in young adults of different genders and to explore the relationship between them. Six representative forest landscape spaces found in field research in Liaoning were presented to participants through virtual reality (VR) video. Physiological indicators (blood pressure, heart rate, and pulse), mood indicators (simplified profile of mood states), and preference scores of young adults ($n$ = 319) before and after viewing the forest landscape videos were collected. Analysis of differences and Spearman's rho correlation analysis were used to statistically analyse the data. Our results indicated that overlook landscape space, static water landscape space, and coniferous forest landscape space had differential restorative effects on participants' physical and mental health. Male and female participants had different preferences regarding the forest landscape spaces. Meanwhile, there were strong correlations between participants' preferences and restorative effects. Our findings provide preliminary practical basis for forest landscape planning that corresponds to the health needs of tourists of different genders to achieve optimization of health benefits of urban forest resources.

**Keywords:** urban forest landscape; gender; forest therapy; physiological changes; psychological responses



**Citation:** Zhang, Z.; Chen, Y.; Qiao, X.; Zhang, W.; Meng, H.; Gao, Y.; Zhang, T. The Influence of Forest Landscape Spaces on Physical and Mental Restoration and Preferences of Young Adults of Different Genders. *Forests* **2023**, *14*, 37. https://doi.org/10.3390/f14010037

Academic Editors: Anna Maria Palsdottir, Patrik Grahn and Jonathan Stoltz

Received: 6 October 2022
Revised: 1 December 2022
Accepted: 21 December 2022
Published: 25 December 2022



## 1. Introduction

### *1.1. Research Findings on the Influence of Forest Space Exposure on Human Physical and Mental Restoration and Preferences*

With the acceleration of urbanization and environmental pollution, high-density living environments and the pressure of survival have led to unhealthy lifestyles for urban residents [1,2]. As a result, their physical and mental health is threatened, which greatly increases the probability of suffering from mental disorders and cardiovascular diseases [3,4]. Numerous studies have demonstrated that exposure to nature can promote human physical and mental health [5–8]. Forests are representative of a typical natural environment that has been widely indicated to play an active role in relieving physical and mental stress and improving health [8–11]. It is worth noting that the restoration effect of the forest is compared to the artificial environment of the city at the same time period, so it can be determined that the physical and mental restoration after visiting the green environment is brought about by the green environment itself, not by time [5,7]. Exposure to forest environments not only significantly reduced negative emotions such as anxiety and improved vigour and other positive emotions [12–17] but also produced physiological

effects that promoted cerebral activity [12,14] and reduced pulse rate, blood pressure, and cortisol concentration [10]. In addition, a three-day forest exposure experience increased creativity by 27.74% [18].

Different types of forest landscapes have been shown to have differential benefits on physical and mental restoration. For certain types of pure forest, a maple forest environment reduced anxiety about learning, and a birch forest environment reduced anxiety about employment [19]. Moreover, broadleaf forests had stronger relieving effects on the body and mind than coniferous forests [20], and waterscape forests were more effective for psychological stress relief [21]. In addition, environmental characteristics such as location, density, stand level, thermal environment, sound, and light in the forest have been shown to affect its restorative effects, and the research results from different researchers have been somewhat inconsistent. Lin et al. demonstrated that compared to inside the forest, exposure to the forest from the outside had better effects on physical and mental restoration [22]; however, Chiang et al. found that exposure to the forest from the inside had the most effective physiological restorative effects on people and that the forest edge had the most significant effects on attention restoration [23]. This beneficial effect is not only limited to the suburban forest environment; urban roads with roadside trees also increased the positive emotions of pedestrians [24]. For forest environments with different densities, a high density of understory shrubs was shown to negatively affect mental health [11]. The lower-density coniferous forests produced relaxation in the mind, while the broadleaf forest at 50% density caused brain activity and a stable pulse [25]. The greater thermal comfort associated with temperate forests in summer was also shown to promote mental health [26]. In addition, natural forest sounds were shown to activate parasympathetic nervous system activity, decrease oxy-Hb concentrations of prefrontal cortex, and reduce heart rate [27–29]. Medium levels of brightness in forests had the strongest effects on mental health restoration [8].

In addition to these aspects of the physical environment, physical and mental restoration in the forest landscape environment was also related to individuals' subjective perception and evaluation of the landscape. Subjective restorative evaluations were higher in the forest space with higher levels of perception of naturalness and quietness, a rich array of species, appropriate shelter and perspective view, or higher preference for forest space [30] and were accompanied by more positive mood changes in more preferred forest environments [31]. Meanwhile, preference towards a forest environment may lead to a stronger desire to continue the experience and prompt people to enter the restorative forest environment [32]. However, the research results of Han and Hoyle et al. showed that not all highly restorative environments corresponded to higher preferences [33,34].

Generally, stress relief with exposure to the forest landscape space is related not only to the types and characteristics of the forest landscape but to subjective perception and evaluation of the environment. Meanwhile, people's perception preferences and positive changes in physical and mental status following exposure to forest landscapes have not always been consistent. Given the above inconsistencies, the relationship between preferences and the restorative benefits of forest landscape exposure needs further exploration.

### *1.2. Gender Differences in the Benefits of Natural Environments for Human Physical and Mental Restoration*

Gender is considered a biological factor related to human health [35]. There are obvious patterns in the prevalence of several common mental and physical diseases between different genders. Generally, males are more likely to suffer from infectious diseases and cardiovascular diseases, while females are more likely to suffer from autoimmune diseases, depression, and anxiety [36,37]. There are also differences in the physiological or psychological reactions between males and females after exposure to the natural environment. The moods of males with exposure to plant landscapes were more stable than those of females [38]. The physiological effects of exposure to mountain forests and wetland landscapes were better in females than in males [39]. The activity of garden-flower-viewing

showed better psychological improvements in males and better physiological relaxation effects in females [40], and females also prefer gardens with roses more compared to males [41]. In addition, the dose response relationship between exposure to nature and stress reduction was different across different gender [42]. Women exposed to a forest environment showed better results than men on positive emotional expression [43]. Similarly, Lundberg's research showed that psychological factors play a more important role in the expression of gender differences across individuals than biological factors when facing stress—that is, the psychological stress that males and females feel when facing external stimuli [44], which have different influences on their physical and mental health [35].

Therefore, the observed gender differences in the benefits of exposure to the natural environment regarding physical and mental restoration may be closely related to the nature and characteristics of the environment. It is necessary to conduct in-depth studies of the changes in people's psychological status and physical health with changes in environmental characteristics and whether these effects are different between genders.

In addition, there is increasingly fierce social competition today, and young adults must face enormous pressures from study, employment, and social interactions, which have damaged their physical and mental health [19]. Studies have also shown that young adults are more likely to feel pressure, which makes them suffer, and increases the probability of mental illnesses such as anxiety and depression [45]. Therefore, attention should be given to the physical and mental health status of this group, which makes it more urgent to understand the relationships between exposure to forest landscapes and physical and mental benefits in young adults.

In other words, the restorative effects of viewing forest landscapes may not benefit everyone equally. As shown by Weekes et al., gender is a biological factor related to changes in health [35]. Therefore, an in-depth evaluation of gender differences in research into the effects of exposure to forest environments on humans is needed [42]. This study mainly explored stressed young adults, clarified gender differences in the health-promoting benefits of forest landscape exposure, and identified the best forest management and forest experience schemes for young tourists of different genders. These findings will contribute to optimizing the development of forest ecological landscapes for their beneficial effects.

### *1.3. Reliability and Advantages of the Application of Virtual Reality to the Study of Restoration Research*

The physiological and emotional changes in humans evoked by the forest environment can be obtained by perceiving visual stimuli in the environment [46]. Most previous research has used field experiments or two-dimensional image perception methods. However, uncontrollable factors, such as garbage pollution, traffic noise, and weather changes, may have had certain impacts on the accuracy of field experiments, thereby affecting the accuracy of the experimental results [15,47], and two-dimensional images have the characteristic of weak immersion [15,21].

Therefore, considering these levels of accuracy and lack of consistency in the experimental results, related research in recent years has mostly adopted virtual reality technology (VR), which allows participants to perceive the environment in the form of three-dimensional images [17]. Compared to field perception experiments, two-dimensional image projection methods make it difficult to control many interfering factors; the methods are not immersive, the sense of space is relatively lacking, etc. The use of VR technology for environmental perception can effectively control the environmental variables related to space in accordance with the research purpose [42]. The wearing of the VR helmet can isolate the external visual and auditory interference to the greatest extent so that people can be placed into a space with the three-dimensional scene in front of the eyes resulting in a stronger sense of immersion [48,49]. In addition, the main purpose and conclusion of Shi's research showed that the aesthetic preference and cognitive evaluation were consistent between field experiments and VR experiments, which indicated that VR is fungible with field experiments. [50]. Compared to an indoor environment, contact with the real natural

environment and the virtual natural environment both had positive restorative effects on physiology and mood [51].

The above findings show the reliability and advantages of using VR technology to explore the influence of forest landscape exposure on people's physical and mental states and preferences.

This study uses VR technology with forest landscape space as a visual stimulus in the form of panoramic video to explore the effects of the space types and gender factors on the physiological, emotional, and preference changes of young people in the process of viewing forest landscape space. The research mainly evaluates the following issues:

(1) Effects of different types of forest landscape space on physiological and psychological responses in young adults of different genders;
(2) The type of forest landscape space preferred by young adults of different genders;
(3) The relationship between physiological and psychological responses and evaluation of spatial preference.

As previously noted, people's perceived preference for forest landscape space is the medium through which space plays the role of restoration. At the same time, gender is an important biological factor that affects restoration results. It is necessary to understand the physical and mental recovery and preference characteristics of people of different genders in different forest landscape spaces. This is particularly important for forest landscape planners and designers. It will help improve the utilization rate of forest ecological resources and provide theoretical reference and practical strategies for the planning of restoration of forest landscape space (i.e., the basis for forest therapy).

## 2. Materials and Methods

### *2.1. Study Area*

Based on previous investigations, forest landscape spaces in their natural distribution were selected as the study areas. The distribution of natural forest resources in Liaoning Province combined with field investigations resulted in a final selection of forest parks or natural scenic spots in the suburbs of Dandong, Fushun, and Benxi for sample collection (Figure 1).

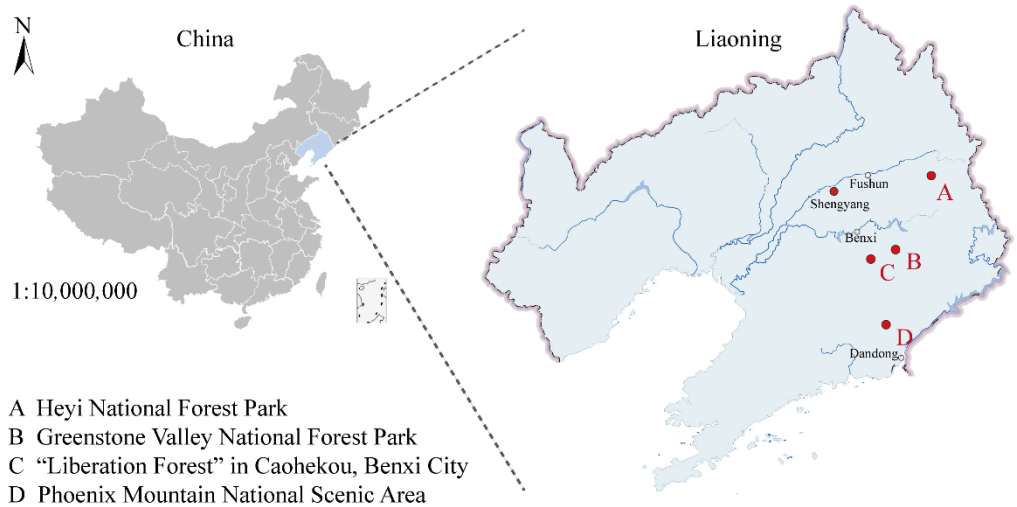


**Figure 1.** Locations of the study sites. A: Heyi National Forest Park is located in southeastern Fushun City, Liaoning Province, with a total area of 1367.85 hectares. B: Greenstone Valley National Forest Park is part of Tanggou National Forest Park of Benxi, Liaoning, with a total area of 2.167 hectares; C: "Liberation Forest" in Caohekou, Benxi City, is the first artificial Korean pine forest in China; D: Phoenix Mountain National Scenic Area is located in Fengcheng City, Liaoning Province, with a total area of 18,200 hectares.

Based on spatial constituent elements, three typical landscape types of space were selected in the forest: forest landscape space, water landscape space, and overlook landscape space. We further divided the forest landscape into coniferous forest landscape space, broadleaf forest landscape space, and mixed forest landscape space according to the type of vegetation. The water landscape space was subdivided into dynamic water landscape space and static water landscape space according to the state of the water. In the end, a total of six types of forest landscape spaces were selected.

We determined the spatial sample through expert and nonexpert evaluations. There were 20 experts, including teachers of a relevant major at this school and employees with associate senior titles (or above) outside the school. Nonexperts included 5 teachers from other majors and 5 members of the public, for a total of 30 people. These individuals scored the forest space based on its representativeness, universality, and aesthetic value. For each of the 6 spaces, 4 samples were selected for shooting, resulting in 24 samples of videos obtained. Through expert and nonexpert evaluations, one video of each type of four samples was selected as the sample of this type of landscape space. The specific characteristics of each area are shown in Table 1.

**Table 1.** The basic characteristics of the sample spaces.

| | **Panoramic Image of Sample Space** | | |
|---|---|---|---|
| |  |  |  |
| The type of space | Overlook landscape space | Dynamic water landscape space | Static water landscape space |
| Location | Phoenix Mountain National Scenic Area | Phoenix Mountain National Scenic Area | Greenstone Valley National Forest Park |
| Constituent elements | Red leaves trees, distant mountains etc. | Red leaves trees, flowing water, stone, bridge, etc. | Calm lake, distant mountains, etc. |
| Spatial features | Open and transparent, highly maintained | Semi-open, plants rich in colour | Open, fewer plants |
| |  |  |  |
| The type of space | Coniferous forest landscape space | Broadleaf forest landscape space | Mixed forest landscape space |
| Location | “Liberation Forest” in Caohekou, Benxi City | Heyi National Forest Park | “Liberation Forest” in Caohekou, Benxi City |
| Constituent elements | Korean pine, Pinus sassafras etc. | Mongolian oak, artificial structure, etc. | Mongolian oak, Korean pine etc. |
| Spatial features | Single species, tall and tidy trees | Highly maintained, rich in plant species | Rich in plant species |

Soundscapes are closely related to visual aspects of the environment; that is, the visual landscape is the basis for the performance of soundscapes in environmental space, and the soundscape will affect the quality of the visual landscape [52]. Therefore, it is necessary to combine visual stimuli with sound stimuli. To produce the most immersive perception of the environment, a panoramic video containing live sound was used as visual stimulus material in this study. The 360 panoramic camera (Insta360 ONE R (Twin)) with recording function was used to shoot the forest landscape space in the early video acquisition stage, and the sound of the forest landscape space was also collected. In the later stage of the

experiment, the video containing the original sound of the forest space was played to the subjects through the headset VR helmet (HTC VIVE FOCUS Plus VR) with audio playback function. From 30 September to 17 October 2020, breezy and sunny weather conditions were chosen, and a 360-degree panoramic camera (Insta360 ONE R (Twin)) with recording function was used at a recording height of 1.4 m to provide a human perspective to the video recording [21], which occurred between 9:00 and 11:00 in the morning. According to the stress reduction theory [53], exposure to the natural environment for 3–5 min can affect the physical and mental status of participants. Finally, forest landscape videos with durations of 3 min that included the least interference from unnatural factors, such as vehicles and people, were used as the experimental environment space materials for immersive experience. The experimental videos were imported into the VR helmet (HTC VIVE FOCUS Plus VR) for the experiment and played during the immersive experience.

### 2.2. Participants

Considering the reliability of the sample size of this space, it was planned to recruit 50 (±5) people in each space. Experimental participants were voluntarily recruited through online and offline advertisements. All participants were healthy adult college students aged 18 and above who could speak Chinese in daily life and had no major cardiovascular diseases or mental disorders. In previous studies, participants were told not to drink coffee or other potentially exciting drinks 12 h before the experiment and were prohibited strenuous exercise 24 h before the experiment [12]. However, since the participants in our study were young people who were active in daily life, in order to ensure the experimental effect, we would appropriately extend this time. Previous studies have also shown that drinking tea can have an effect on positive emotions [54]. Therefore, a week before the start of the experiment, they were told by phone to stop drinking tea, coffee, and eating food that may lead to mental excitement. On the day of the experiment, the participants were informed of the experimental process and precautions.

Finally, 312 undergraduates and postgraduates from Shenyang Agricultural University were recruited, and 298 valid datasets were obtained. The ratio of males to females was approximately 1:1.5, the ages ranged from 18 to 25 years old (M = 20.44, SD = 1.81), and the students included forestry majors, economic management majors, land management majors, and those with many other majors. The main sociodemographic characteristics of the sample of participants are shown in Table 2.

**Table 2.** Main socio-demographic characteristics of the sample of participants.

| Characteristics | Total | OLS | DWS | SWS | CFS | BFS | MFS |
|---|---|---|---|---|---|---|---|
| Participant n (%) | 298 (100.0) | 49 (16.4) | 48 (16.1) | 51 (17.1) | 50 (16.8) | 51 (17.1) | 49 (16.4) |
| Gender n (%) | | | | | | | |
| Male | 123 (41.3) | 20 (40.8) | 21 (43.8) | 20 (39.2) | 20 (40.0) | 22 (43.1) | 20 (40.8) |
| Female | 175 (58.7) | 29 (59.2) | 27 (56.3) | 31 (60.8) | 30 (60.0) | 29 (56.9) | 29 (59.2) |
| Age n (%) | | | | | | | |
| 18–21 (74.8) | 244 (76.5) | 34 (69.4) | 34 (70.8) | 42 (82.4) | 38 (76.0) | 38 (74.5) | 37 (75.5) |
| 22–25 (25.2) | 75 (23.5) | 15 (30.6) | 14 (29.2) | 9 (17.6) | 12 (24.0) | 13 (25.5) | 12 (24.5) |
| Major n (%) | | | | | | | |
| With forest knowledge background | 74 (24.8) | 11 (22.4) | 12 (25.0) | 11 (21.6) | 12 (24.0) | 17 (33.3) | 11 (22.4) |
| Without forest knowledge background | 224 (75.2) | 38 (77.6) | 36 (75.0) | 40 (78.4) | 38 (76.0) | 34 (66.7) | 38 (77.6) |

OLS: overlook landscape space; DWS: dynamic water landscape space; SWS: static water landscape space; CFS: coniferous forest landscape space; BFS: broadleaf forest landscape space; MFS: mixed forest landscape space.

### 2.3. Experimental Design

We used a between-subject experiment for the six types of forest landscape spaces finally selected. To ensure independence in the experiment, the participants could not communicate with each other, and they were randomly assigned to watch a type of forest

landscape video. This study used the Trier social stress test (TSST) to induce acute stress in the participants such that the physical and mental responses of the participants were assessed in a state of tension before watching the forest video. The TSST is a widely accepted laboratory psychological stress research paradigm that has been proven to successfully induce physical and mental stress responses in participants in a short period of time [55,56]. In this study, the TSST included 3 min of public expression and 2 min of oral calculation tasks. The specific experimental process was as follows (Figure 2).

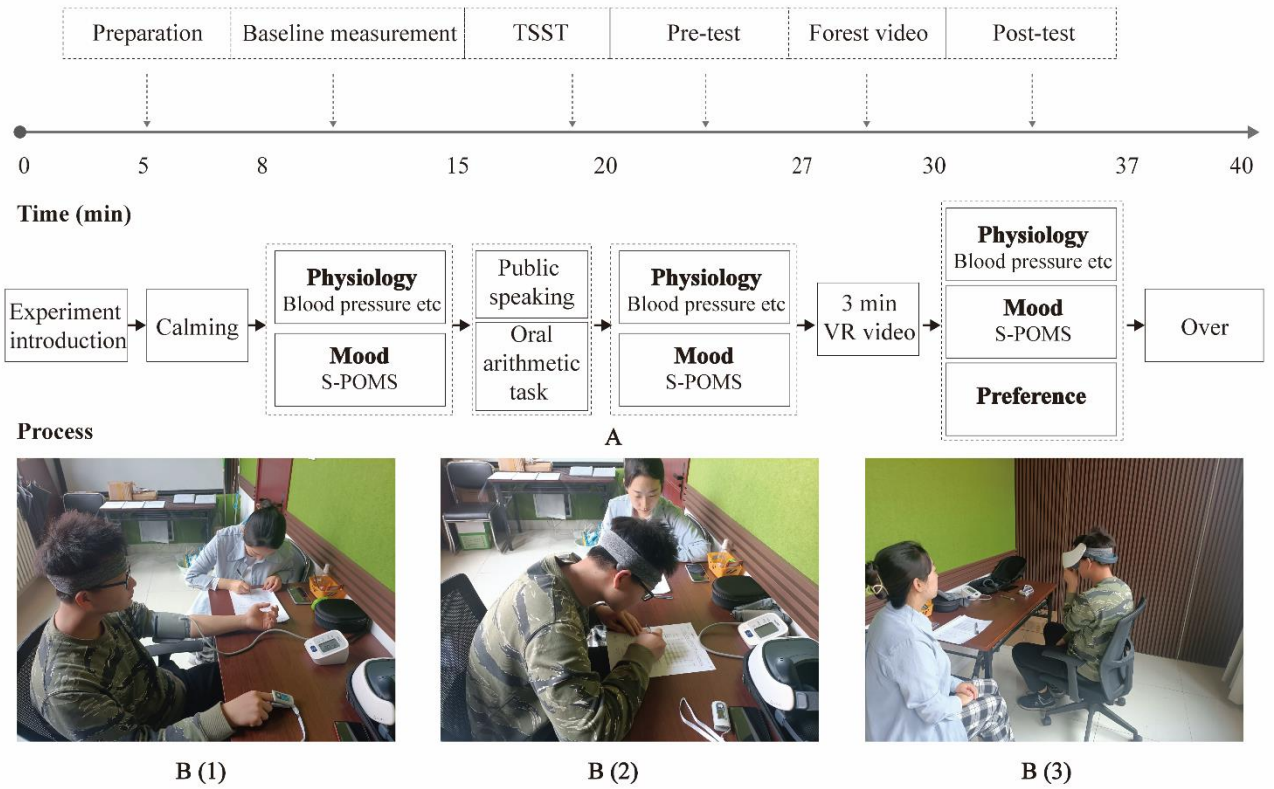


**Figure 2.** Experimental process: (**A**): experimental timeline; (**B**): experimental site. Note: Informed consent was given by the participants for the publication of identity revealing images in an online open-access publication.

### *2.4. Measurements*

#### 2.4.1. Physiological Stress

Blood pressure (BP), heart rate (HR), and pulse (P) are important cardiovascular indicators and are typically used to reflect people's stress levels. Increases in these values correspond to physiological activation—that is, excitement or nervousness [10]. BP includes systolic blood pressure (SBP) and diastolic blood pressure (DBP). In this study, BP and P data were collected using an Omron electronic blood pressure monitor (Japan) [15], and HR was measured using a Lepu ECG recorder ER2.

#### 2.4.2. Psychological Stress

Because the experimental process requires participants to fill in the questionnaire multiple times, to avoid excessive psychological load on the participants during the filling process and negative impact on the experimental results, we did not use the traditional five-dimensional emotional test questionnaire but referred to the Mood Check List-Short Forom.2 adapted by scholar Hirofumi Ueda [57] and referred to the POMS questionnaire adapted by scholar Yu et al. based on applicability and reliability in China [15]. Based on the above questionnaires, we adapted and formed the simple version of the POMS emotion

test questionnaire used in this experiment. It is referred to in this manuscript as S-POMS (simplified POMS).

This questionnaire is composed of 12 emotional test items. Finally, based on the calculation principle of Hirofumi Ueda, three dimensions of "interest", "relaxation", and "worry" were calculated through 12 items, as follows: Excited, eased, uneasy, salubrious, pleasant, anxious, energetic, quiet, depressed, vigorous, calm, concerned.

Interest = excited + salubrious + energetic + vigorous; Relaxation = eased + pleasant + quiet + calm; Worry = uneasy + anxious + depressed + concerned.

At the same time, according to the "Total Mood Disorder" (TMD) calculation logic adopted by the research of scholars Yu et al. in 2020—that is, the total score of negative emotions minus the total score of positive emotions—a higher score indicates a higher degree of emotional disturbance and is further calculated from the above three dimensions [58]. TMD was calculated as follows: total mood disturbance = worry − (interest + relaxation). Higher scores reflect higher emotional levels for each of the dimensions.

Before and after the visual stimulation, the participants were asked to respond on a 7-point Likert-type scale (1 = not at all; 7 = very much). Meanwhile, we also tested the reliability and validity of the questionnaire. The Cronbach $\alpha$ coefficients of the three dimensions of "interest", "relaxation", and "worry" were 0.797, 0.755, and 0.830, respectively, indicating that the reliability of the questionnaire was relatively high.

#### 2.4.3. Preference

In this study, the evaluation of participants' preference for forest landscape spaces was assessed by questionnaire. The question was "how do you like the forest landscape space", and the preference was rated on a 7-point Likert scale, with 1 point indicating "not at all" and 7 points indicating "very much" [59]. After scoring, the participants were asked to write down their favourite elements of the space.

### *2.5. Data Analysis*

Combined with the above-mentioned three aims to be solved in this study, we mainly performed the following analysis:

(1) An examination of the effects of physical and mental recovery

For each index, the change between pre-VR and post-VR is represented by $\Delta$ ($\Delta$ = post-VR value—pre-VR value). First, the Kolmogorov–Smirnov test was used to test the normality of the data. For the same index, the data before TSST, before VR, and after VR are all normally distributed.

First, ANOVA was used to test the differences of the same index after TSST between different types of forest spaces to test whether the same index of participants was based on the same level before viewing different forest landscapes (after the TSST test). The paired sample *t*-test was performed for the same index before and after TSST to test the effectiveness of TSST test in inducing participants' physical and mental stress.

Secondly, the same index before and after VR was tested using the paired sample *t*-test to test whether the viewing of forest landscape was beneficial to the physical and mental recovery of participants.

Finally, ANOVA with post-hoc tests (LSD) was used to compare the differences in physiological and psychological indexes of participants in the different spaces, and independent sample *t*-tests was used to compare the differences in physiological and psychological responses in individuals of different gender in every space.

(2) Assessment of preference

The Kolmogorov–Smirnov test was conducted on participants' preference values of forest landscape space. The results showed that preferences ($p > 0.05$) in this study were normally distributed.

ANOVA and independent sample *t*-tests were used to analyse the space and gender differences in subjective preference ratings.

(3) The correlation between physical and psychological changes and preferences

Spearman's correlation analyses were used to explore the relationships between the participants' physical and psychological changes and preferences in the forest landscape space.

## 3. Results

In order to check that the physical and mental indicators of the participants were at the same benchmark before VR, we used ANOVA, and the results showed that there were no significant differences in the physical and psychological indicators of the participants between the various landscape spaces ($p > 0.05$) (Table 3). This suggests that participants' physical and mental stress states were at the same baseline level before VR. Therefore, it can be determined that the changes in their physiological and emotional indicators after VR can be attributed to watching in different types of space.

The paired sample *t*-test was conducted for the same index of before TSST and after TSST, and the results showed that compared to before TSST, SBP, DBP, HR, P, worry, and TMD significantly increased ($p < 0.05$), but interest and relaxation were significantly decreased ($p < 0.05$). It indicated that stressors were effective—that is, the TSST task before the experiment can effectively induce acute stress in participants (Table 4).

A paired sample *t*-test was conducted for the same index before TSST and after TSST, and the results showed that, SBP, DBP, HR, worry, and TMD post-VR were significantly lower than pre-VR ($p < 0.05$), and interest and relaxation of post-VR were significantly higher than pre-VR ($p < 0.05$). This indicated that the participants' physical and mental states in the immersive forest landscape space were significantly restored (Table 5).

### *3.1. Effects of Forest Landscape Space Exposure on the Physical and Mental Restoration of College Students of Different Genders*

#### 3.1.1. Effects on Physiological Changes

The ANOVA with post hoc tests (LSD) was used to analyse the effect of space type on physiological recovery of participants. The results showed that the forest landscape space had a restorative influence on the physiology of males and females that presented with different characteristics (Figure 3).

First, for males, their ΔSBP, ΔHR, and ΔP showed differences based on exposure to the different forest landscape spaces. The overlook landscape space resulted in significantly lower ΔSBP than broadleaf forest space ($t = -2.31$, $p = 0.023 < 0.05$) and significantly lower ΔHR than dynamic water landscape space ($t = -2.52$, $p = 0.013 < 0.05$), static water landscape space ($t = -3.02$, $p = 0.003 < 0.01$), and mixed forest landscape space ($t = -2.31$, $p = 0.022 < 0.05$). The overlook landscape space had significantly lower ΔP than dynamic water landscape space ($t = -2.91$, $p = 0.004 < 0.01$), static water landscape ($t = -2.79$, $p = 0.006 < 0.01$), broadleaf forest space ($t = -2.04$, $p = 0.044 < 0.05$), and mixed forest landscape space ($t = -2.53$, $p = 0.013 < 0.05$). These results showed that the overlook landscape space had a positive effect on the restoration of various physiological indicators in males.

Second, for females, their ΔSBP showed differences based on exposure to the different forest landscape spaces. The static water landscape space resulted in a significantly lower ΔSBP than the overlook landscape space ($t = 2.31$, $p = 0.022 < 0.05$) and dynamic water landscape space ($t = 2.20$, $p = 0.029 < 0.05$). The results revealed that the static landscape water space had a better restorative effect on females' physiology, while the overlook landscape space had the weakest effect.

**Table 3.** ANOVA of various indicators before VR in different forest spaces.

| | | **OLS** ***n* = 49** | **DWS** ***n* = 48** | **SWS** ***n* = 51** | **CFS** ***n* = 50** | **BFS** ***n* = 51** | **MFS** ***n* = 49** | **F** | $p$ | $\eta p^2$ |
|---|---|---|---|---|---|---|---|---|---|---|
| SBP | M ± SD | 113.49 ± 15.04 | 112.06 ± 13.00 | 110.12 ± 13.91 | 110.60 ± 13.19 | 110.41 ± 13.39 | 110.31 ± 12.03 | 0.486 | 0.787 | 0.008 |
| DBP | M ± SD | 71.90 ± 10.46 | 72.17 ± 10.44 | 69.49 ± 9.24 | 71.94 ± 9.41 | 71.43 ± 9.15 | 72.00 ± 10.00 | 0.537 | 0.748 | 0.009 |
| HR | M ± SD | 77.96 ± 10.93 | 77.71 ± 14.33 | 75.82 ± 12.14 | 74.70 ± 11.53 | 76.65 ± 10.98 | 76.51 ± 10.88 | 0.513 | 0.766 | 0.009 |
| P | M ± SD | 77.35 ± 10.96 | 76.94 ± 14.07 | 75.22 ± 12.30 | 74.32 ± 11.47 | 76.20 ± 11.63 | 75.61 ± 11.09 | 0.435 | 0.824 | 0.007 |
| Interest | M ± SD | 16.41 ± 4.09 | 16.19 ± 4.86 | 15.12 ± 3.68 | 16.42 ± 4.87 | 15.73 ± 3.48 | 15.98 ± 4.65 | 0.671 | 0.646 | 0.011 |
| Relaxation | M ± SD | 15.63 ± 3.63 | 15.38 ± 4.62 | 14.25 ± 3.58 | 15.52 ± 4.36 | 15.47 ± 3.90 | 15.69 ± 4.24 | 0.881 | 0.494 | 0.015 |
| Worry | M ± SD | 9.39 ± 3.42 | 10.77 ± 4.27 | 10.47 ± 4.33 | 9.34 ± 3.86 | 10.20 ± 3.58 | 8.96 ± 3.66 | 1.721 | 0.130 | 0.029 |
| TMD | M ± SD | −22.65 ± 8.95 | −20.79 ± 11.77 | −18.90 ± 9.43 | −22.60 ± 11.71 | −21.00 ± 8.55 | −22.71 ± 10.20 | 1.118 | 0.351 | 0.019 |

SBP: systolic blood pressure; DBP: diastolic blood pressure; HR: heart rate; P: pulse. OLS: overlook landscape space; DWS: dynamic water landscape space; SWS: static water landscape space; CFS: coniferous forest landscape space; BFS: broadleaf forest landscape space; MFS: mixed forest landscape space.

**Table 4.** Pairwise comparison of pre-TSST and post-TSST.

| | | M | SD | t | *p* |
|---|---|---|---|---|---|
| SBP | pre | 106.54 | 12.52 | −9.94 | 0.000 *** |
| | post | 111.15 | 13.40 | | |
| DBP | pre | 68.68 | 8.76 | −6.63 | 0.000 *** |
| | post | 71.47 | 9.75 | | |
| HR | pre | 74.92 | 9.99 | −3.57 | 0.000 *** |
| | post | 76.54 | 11.80 | | |
| P | pre | 75.01 | 9.85 | −2.07 | 0.040 * |
| | post | 75.93 | 11.90 | | |
| Interest | pre | 17.00 | 4.04 | 5.80 | 0.000 *** |
| | post | 15.97 | 4.28 | | |
| Relaxation | pre | 18.55 | 3.61 | 15.53 | 0.000 *** |
| | post | 15.32 | 4.06 | | |
| Worry | pre | 7.44 | 3.03 | −11.03 | 0.000 *** |
| | post | 9.86 | 3.89 | | |
| TMD | pre | −28.11 | 8.31 | −13.96 | 0.000 *** |
| | post | −21.43 | 10.17 | | |

SBP: systolic blood pressure; DBP: diastolic blood pressure; HR: heart rate; P: pulse. * $p < 0.05$. *** $p < 0.001$.

**Table 5.** Pairwise comparison of post-VR and pre-VR.

| | | M | SD | t | *p* |
|---|---|---|---|---|---|
| SBP | pre | 111.148 | 13.403 | 10.848 | 0.000 *** |
| | post | 105.554 | 12.457 | | |
| DBP | pre | 71.473 | 9.749 | 8.502 | 0.000 *** |
| | post | 67.584 | 8.939 | | |
| HR | pre | 76.544 | 11.799 | 3.686 | 0.000 *** |
| | post | 74.812 | 9.879 | | |
| P | pre | 75.926 | 11.900 | 1.845 | 0.000 *** |
| | post | 75.064 | 9.625 | | |
| Interest | pre | 15.966 | 4.284 | −8.047 | 0.000 *** |
| | post | 17.359 | 4.256 | | |
| Relaxation | pre | 15.319 | 4.062 | −16.541 | 0.000 *** |
| | post | 19.010 | 3.843 | | |
| Worry | pre | 9.856 | 3.892 | 15.573 | 0.000 *** |
| | post | 6.862 | 2.819 | | |
| TMD | pre | −21.430 | 10.174 | 17.084 | 0.000 *** |
| | post | −29.507 | 8.911 | | |

SBP: systolic blood pressure; DBP: diastolic blood pressure; HR: heart rate; P: pulse. *** $p < 0.001$.

The independent sample *t*-test was used to compare differences in physiological recovery between male and female students in each forest landscape space (Figure 4). The results showed that there were differences between males and females in the physiological restorative effects following exposure to the forest landscape spaces. The ΔSBP in males with the overlook landscape space was significantly lower than that in females (t = −2.69, $p = 0.010 < 0.05$), and the ΔHR of females in the static water landscape space was significantly lower than that in males (t = 2.47, $p = 0.017 < 0.05$). In general, the males achieved a greater magnitude of physiological restoration in the forest landscape space with a certain height and excitement, while the females had a better physiological restorative experience effect in the quiet and soothing forest landscape space.

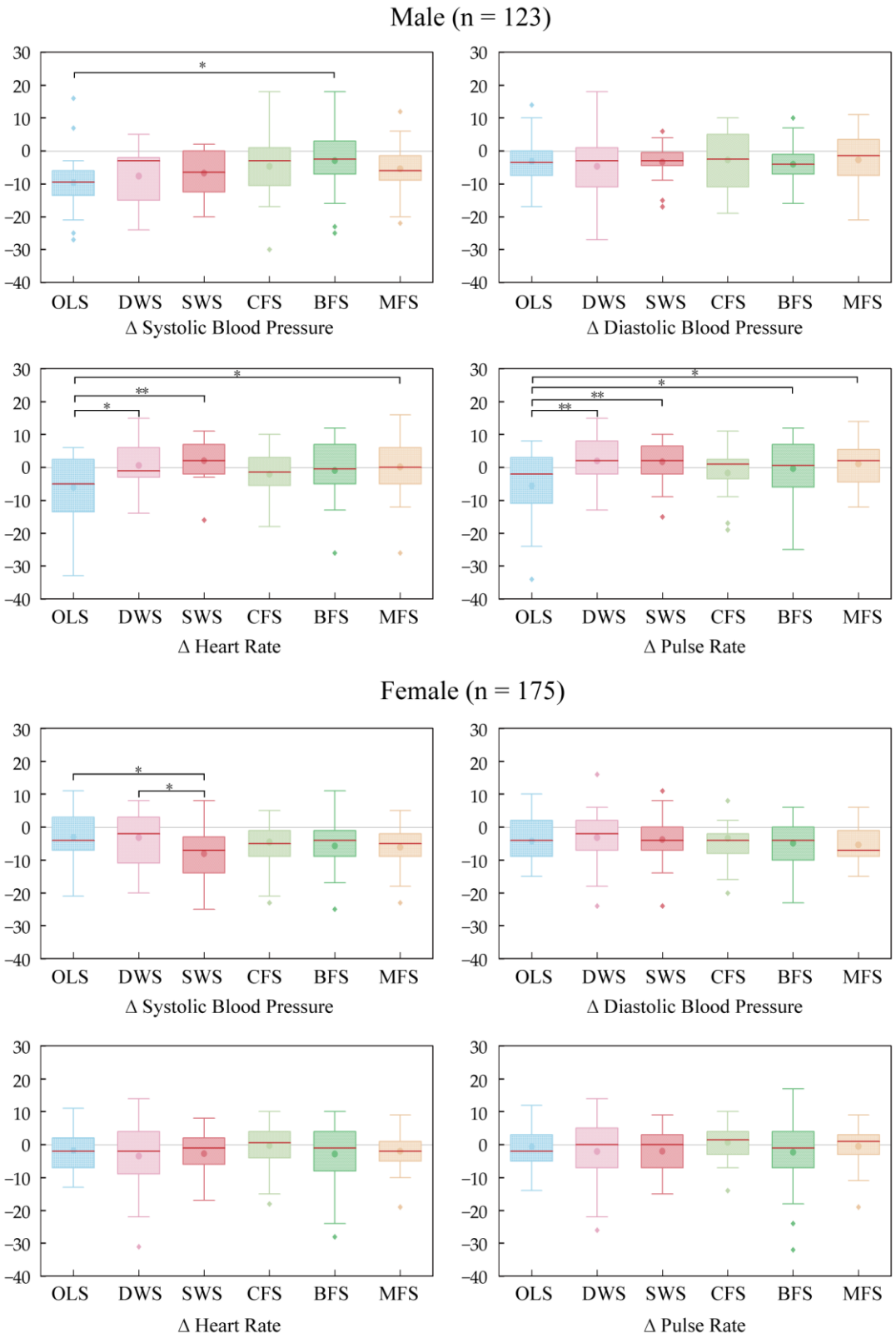


**Figure 3.** Differences in participants' physiological response changes in the different forest landscape spaces. * $p < 0.05$. ** $p < 0.01$. OLS: overlook landscape space ($n = 49$); DWS: dynamic water landscape space ($n = 48$); SWS: static water landscape space ($n = 51$); CFS: coniferous forest landscape space ($n = 50$); BFS: broadleaf forest landscape space ($n = 51$); MFS: mixed forest landscape space ($n = 49$).

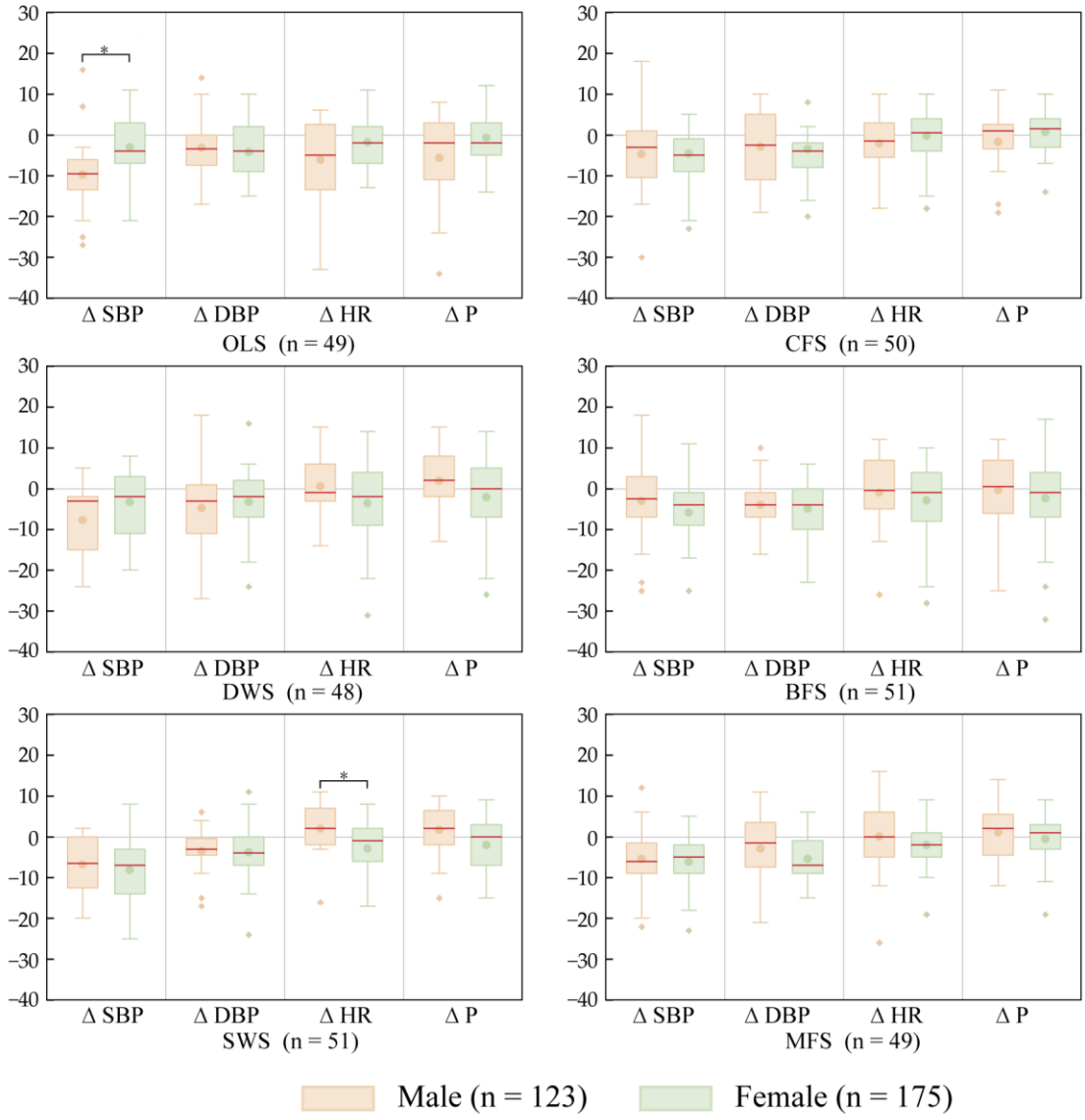


**Figure 4.** Differences in physiological response changes in participants of different gender in each forest landscape space. * $p < 0.05$. OLS: overlook landscape space ($n$ = 49); DWS: dynamic water landscape space ($n$ = 48); SWS: static water landscape space ($n$ = 51); CFS: coniferous forest landscape space ($n$ = 50); BFS: broadleaf forest landscape space ($n$ = 51); MFS: mixed forest landscape space ($n$ = 49).

#### 3.1.2. Effects on Psychological Changes

Similarly, in order to explore the influence of spatial types on the emotional recovery effect of participants, ANOVA with post hoc tests (LSD) was used. The results showed that the forest landscape space had a positive effect on the emotions of males and females by increasing their interest and relaxation and reducing worry and TMD. The tests also showed different characteristics across genders (Figure 5).

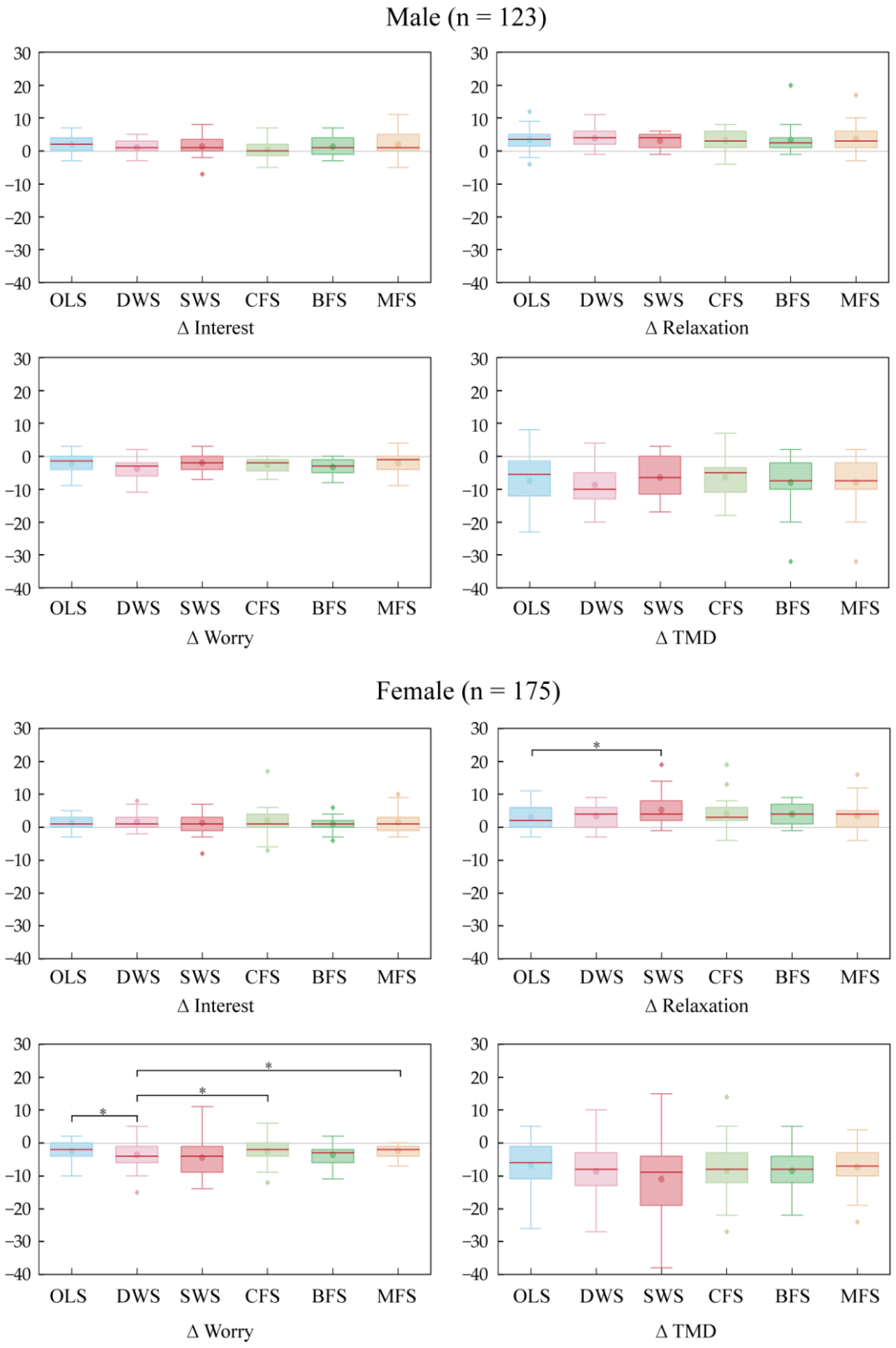


**Figure 5.** Differences in participants' emotional response changes in different forest landscape spaces. * $p < 0.05$. OLS: overlook of the landscape space ($n$ = 49); DWS: dynamic water landscape space ($n$ = 48); SWS: static water landscape space ($n$ = 51); CFS: coniferous forest landscape space ($n$ = 50); BFS: broadleaf forest landscape space ($n$ = 51); MFS: mixed forest landscape space ($n$ = 49).

First, for males, there were no significant differences in the Δ values of their emotions in the different forest landscape spaces ($p > 0.05$). The emotional responses of males when watching different forest landscapes were consistent.

Second, for females, static water landscape space had a significantly higher Δ relaxation than overlook landscape space (t = −2.10, $p = 0.037 < 0.05$). However, the static water landscape space resulted in a significantly lower Δworry score than the mixed forest landscape space (t = −2.25, $p = 0.026 < 0.05$), coniferous forest landscape space (t = −2.17, $p = 0.031 < 0.05$), and overlook landscape space (t = 2.13, $p = 0.034 < 0.05$). The above results showed that the static water landscape space had the strongest restorative effect on alleviating the worry of females, and the overlook landscape space had the weakest restorative effect.

Additionally, independent sample *t*-test results showed that there were gender differences in the emotional restorative effects of participants following exposure to the static water landscape space (Figure 6). The females' Δworry scores with the static water landscape space were significantly lower than those of the males (t = 2.02, $p = 0.048 < 0.05$). This revealed that compared to the males, the females' results showed that quiet and soothing spaces such as the static water landscape had better restorative effects on worry.

### *3.2. Preferences of Young Adults of Different Gender for Forest Landscape Spaces*

#### 3.2.1. Characteristics and Differences in Preferences

Similarly, in order to analyse whether there are differences in the preference scores of college students in different forest spaces for different genders, we conducted ANOVA on the preference scores of male and female college students in different types of forest spaces. Furthermore, the preferences of males and females in each forest space were compared using independent sample *t*-tests.

First, ANOVA results showed that there was no significant difference in preference ratings between males (F = 0.956, df = 5, $p = 0.448 > 0.05$) and females (F = 0.735, df = 5, $p = 0.598 > 0.05$) in different forest spaces. In addition, participants' preference scores for each forest landscape space exceeded 4.5, and the overall preference was relatively high.

Secondly, the average of the respective preference scores of males and females in each forest space was used to present the results of independent sample *t*-tests. The results showed that there were gender differences in participants' preference for the overlook landscape space (t = −2.270, df = 47, $p = 0.028 < 0.05$). Compared to the males, the females preferred this type of forest landscape space (Figure 7).

#### 3.2.2. Preferred Spatial Elements

The frequency of preference elements freely filled in the questionnaire by participants in each forest landscape space was counted by gender, and a frequency map was drawn. The result is shown in Figure 8. Overall, the elements preferred by participants were similar between the spaces with similar elements, such as the water and vegetation in the water space and the plants in the forest space. Participants of different genders preferred different elements in water space and forest space. In the water spaces, the preference of the males for vegetation was obviously higher than that of the females. Compared to the males, the females preferred water and structures in the dynamic water landscape space and water and distant mountains in the static water landscape space. In the forest spaces, the females preferred the vegetation and sky over the males (Figure 8).

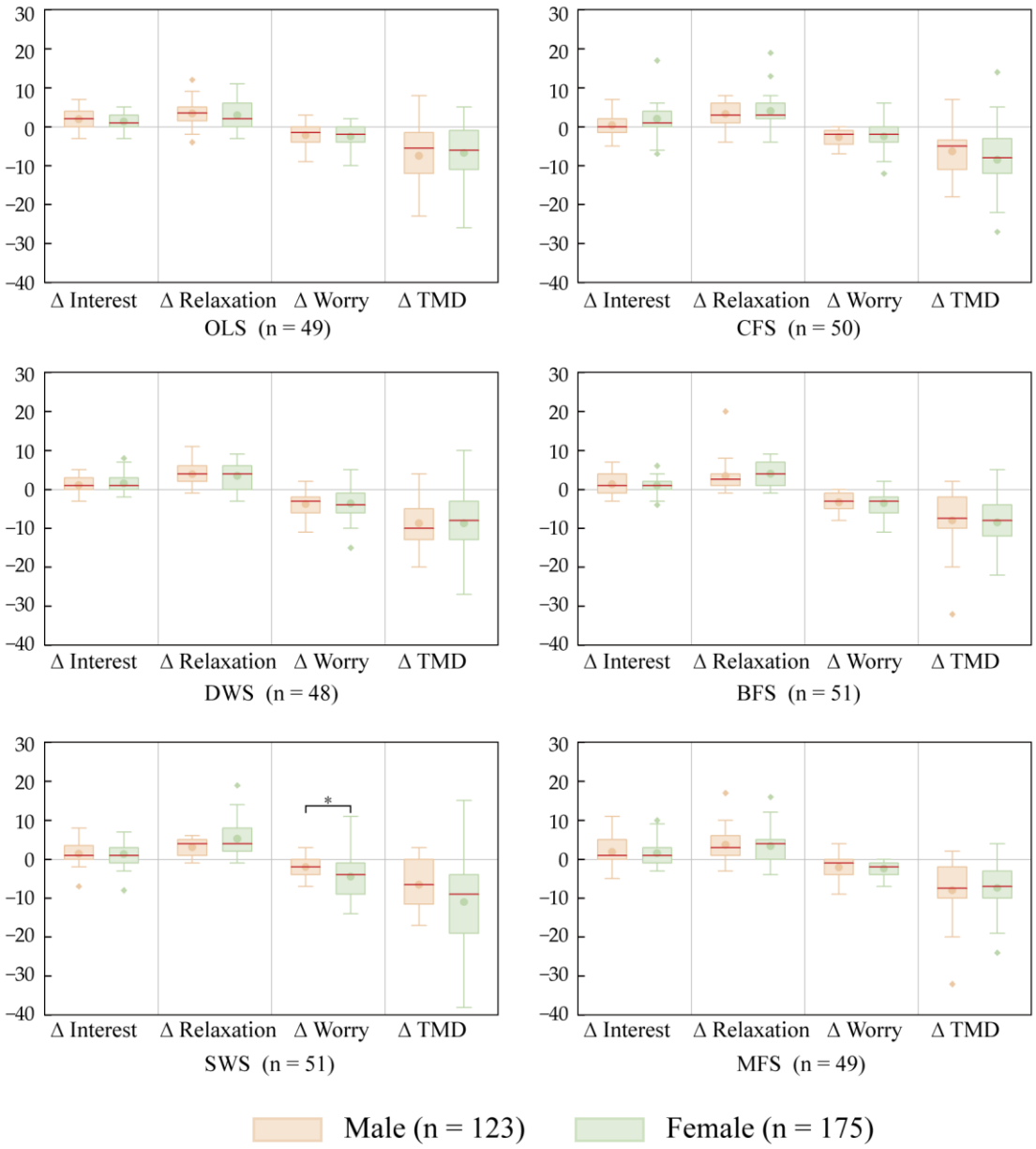


**Figure 6.** Differences in emotional response changes in participants of different gender in each forest landscape space. * $p < 0.05$. OLS: overlook of the landscape space ($n$ = 49); DWS: dynamic water landscape space ($n$ = 48); SWS: static water landscape space ($n$ = 51); CFS: coniferous forest landscape space ($n$ = 50); BFS: broadleaf forest landscape space ($n$ = 51); MFS: mixed forest landscape space ($n$ = 49).

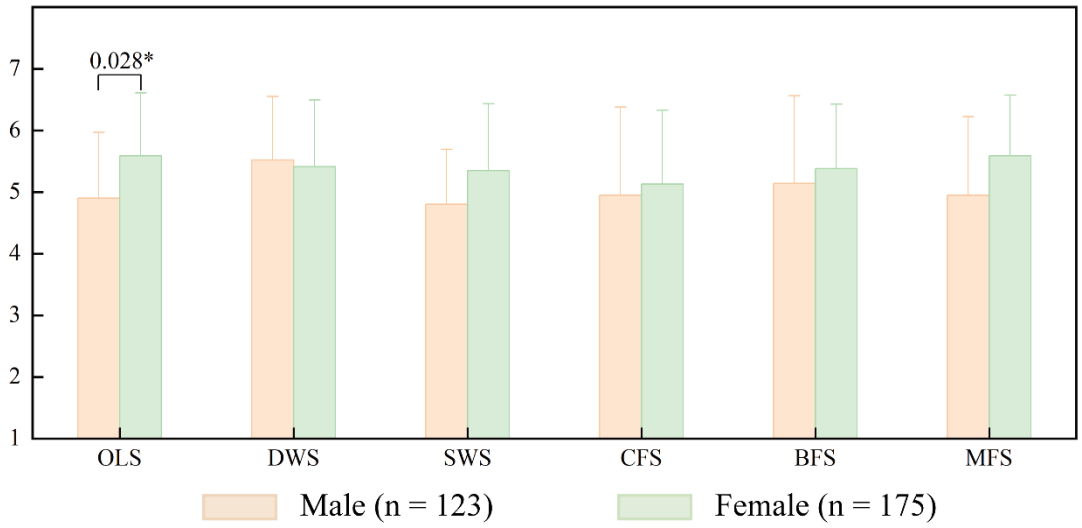


**Figure 7.** The comparison of the mean values of participants' preference scores of the various forest landscape spaces. * $p < 0.05$. OLS: overlook landscape space ($n$ = 49); DWS: dynamic water landscape space ($n$ = 48); SWS: static water landscape space ($n$ = 51); CFS: coniferous forest landscape space ($n$ = 50); BFS: broadleaf forest landscape space ($n$ = 51); MFS: mixed forest landscape space ($n$ = 49).

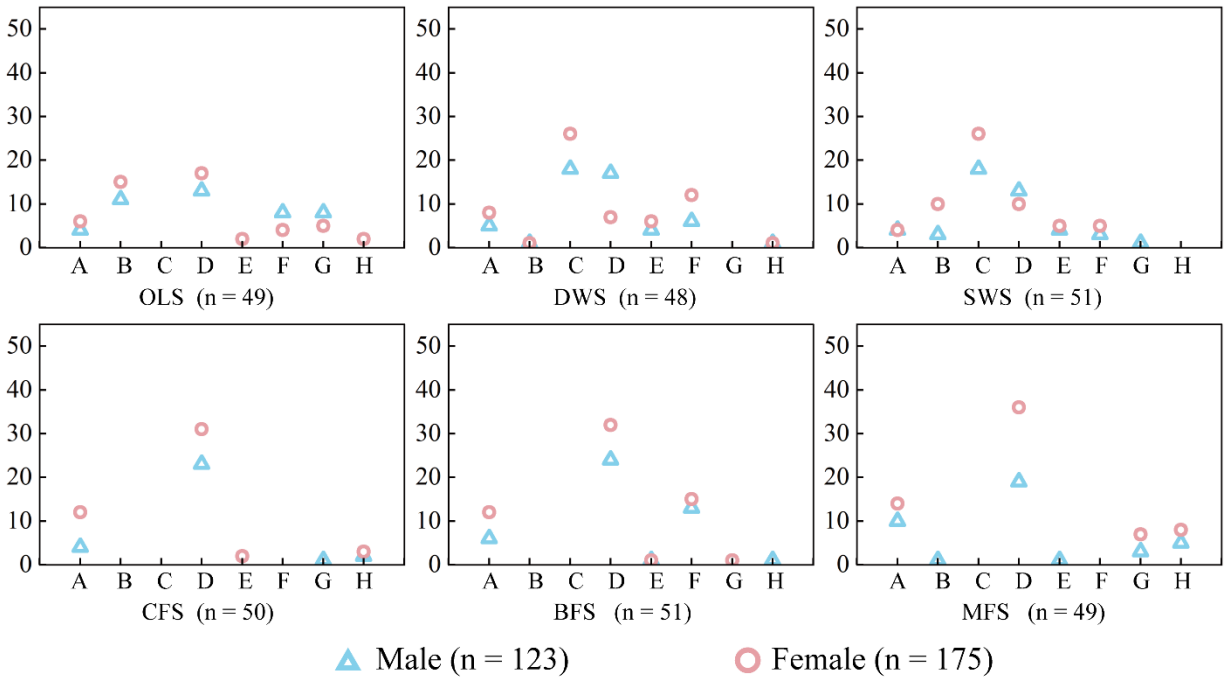


**Figure 8.** The number of participants with preferences for different forest landscape space elements. A: sky; B: distant mountains; C: water; D: vegetation; E: stone; F: structure; G: creatures (birds, butterflies and insects, etc.); H: natural sounds. OLS: overlook landscape space ($n$ = 49); DWS: dynamic water landscape space ($n$ = 48); SWS: static water landscape space ($n$ = 51); CFS: coniferous forest landscape space ($n$ = 50); BFS: broadleaf forest landscape space ($n$ = 51); MFS: mixed forest landscape space ($n$ = 49).

### *3.3. Relationships between Physical and Mental Restoration and Preference*

The results of the correlation analyses showed that regardless of gender, participants' preference for forest landscape space was significantly positively correlated with changes in interest and relaxation ($p < 0.05$) and significantly negatively correlated with changes in

TMD ($p < 0.05$). However, the physiological responses of participants in the forest landscape space were not related to their preferences (Table 6).

**Table 6.** Spearman correlation analysis among physiological response changes, emotional response changes, and preferences.

| | | ΔSBP | ΔDBP | ΔHR | ΔP | ΔInterest | ΔRelaxation | ΔWorry | ΔTMD |
|---|---|---|---|---|---|---|---|---|---|
| | | Spearman's rank correlation coefficient | | | | | | | |
| Male ($n$ = 123) | Preference | 0.033 | −0.039 | −0.015 | 0.015 | 0.265 ** | 0.203 * | −0.114 | −0.256 ** |
| Female ($n$ = 175) | Preference | −0.089 | −0.034 | 0.005 | −0.013 | 0.212 ** | 0.202 ** | −0.024 | −0.197 ** |

Note: * $p < 0.05$. ** $p < 0.01$.

## 4. Discussion

### *4.1. The Effect of Physical and Mental Recovery of College Students of Different Genders in Forest Landscape Space Is Affected by the Landscape Content*

Our purpose was to explore which forest landscape environment had better physical and mental recovery effects for college students from the gender dimension and then to make targeted recommendations for landscape environment planning or forest healing activity space for different groups. Numerous previous studies have shown that demographics do play a role in people's physical and mental recovery [38–43]. Therefore, we further explored the differences in the physical and psychological recovery effects of forest landscape space on people in different gender dimensions and found that different forest spaces indeed showed significant differences in the recovery effects represented by indicators such as SBP, HR, and worry. This positive restorative effect was more significant in terms of emotions [16,60].

Previous studies have shown that there are gender differences in the recovery and health effects of green space for adolescents [61,62]. We found that the forest landscape spaces also had different effects on the physical and mental restoration of participants of different genders. Analysis results showed that the males obtained the greatest physiological stress relief with exposure to the overlook landscape space, while the psychological restoration effects obtained in different forest landscape spaces were more similar (Figures 3 and 5). This is because males, when facing stressors, instinctively show higher levels of physical arousal, such as increased blood pressure [63,64], but can "maintain" their emotions [65]. For females, the static water landscape space not only relieved their blood pressure but also reduced their worry, and the static water landscape space had a significantly more positive effect on worry stress relief than the overlook landscape space. We speculate that this was related to females' susceptibility to negative emotions [66]. With different external stimuli, worry in females may change to a greater extent, and the static water landscape space is the best place for females to restore their negative emotions. In addition, since the participants watched the video containing the live natural sound, the sound of the breeze blowing over the water in the static water landscape space and the rustling of leaves are pleasant and calming natural sounds, while the pleasant, calm and interesting [67].

In general, the interesting forest space including certain adventurous qualities and clear sight had a strong restorative effect on males' physiological stress. A quiet and watery space was most beneficial to females' physical stress and relief of worry.

In other words, not all forest landscape space environments have the same impact on people's recovery and mental health. In this process, the content attributes displayed in the landscape space will have different physical and mental recovery effects on college students in terms of gender [68]. However, in terms of the value provided by forest ecosystems, the needs of teenagers are different from those of adults [69]. Therefore, it has great significance for the management and allocation of forest resources to understand the service needs of young people for such a green environment as forests.

### 4.2. Forest Landscape Types with Open Vision and a Good Sense of Enclosure Are More Popular with Female College Students

Our research found that, first of all, the six types of forest landscapes selected in this experiment were highly favoured by college students, which may be related to the clean and beautiful forest landscapes of all the space samples we selected. A study by scholars Ma et al. once pointed out that the health and tidiness of trees contributes to humans' positive perception of the quality of landscape visual perception [70]. In addition, the females' preference for the overlook landscape space was obviously higher than the males' preference (Figure 7). Meanwhile, compared to female college students, male college students prefer dynamic space.

In addition, Birch, Rishbeth and Payne (2020) found that a broad field of view is a beneficial landscape feature and is conducive to the mental health and happiness of young people [71]. Our analysis showed that although the overlook landscape space had the weakest restorative effect on relieving females' worried emotions (Figure 5), this type of space received the highest favourability rating by the females (Figure 7). In other words, exposure to the overlook landscape space, a more exploratory forest space, had a weaker restorative effect on females' worried emotion than other types of forest spaces, but it still obtained higher subjective preferences of the female participants. The reason for this seemingly contradictory phenomenon may be that there was a certain height in the overlook landscape space, which makes people worry about falling. At the same time, Yuan's research has shown that females are susceptible to negative emotions [66], and being on a high platform, such as an overlook landscape space, will weaken the positive effects forest space exposure in restoring their worried emotion even though their preference for the space is not affected. Psychologically, this phenomenon is regarded as "sensation seeking" of adventurous activities or new behaviours [72].

This phenomenon is also in line with the prospect–refuge theory put forward by Appleton and many other scholars [73–75]. That is, the landscape environment with prospects and a panoramic view is preferred by people, which is conducive to the recovery of adolescents' mental health and the improvement of their happiness [30,71].

In brief, exposure to the higher platforms and hollow railings weakened the restorative effects of the overlook landscape space on females' worried mood. However, they also firmly believed that they would not fall off the cliffs, so there was a sense of excitement about "experiencing danger". These particular psychological feelings resulted in females showing a higher preference rating for this type of space.

### 4.3. Better Physical and Mental Restoration of Young Adults in the Forest Landscape Is Related to Higher Aesthetic Preference

Previous research results on physical and mental restorative effects and their environmental preferences in forest landscape spaces indicated that forest environments had a positive restorative effect on people's mental health and had a positive correlation with environmental preference ratings [76]. Our research also obtained similar results; that is, improvements in people's emotion in the forest landscape spaces were related to their aesthetic preference for particular landscapes. Meanwhile, we also found that the worry response in the forest landscape space was not correlated with preference ratings. This result is similar to the research results of Gao et al.; compared to the improvements in negative emotions, exposure to more preferred environments was related to restorative changes in positive emotional states [31]. In other words, when participants are in a highly preferred forest landscape space, their emotional state will positively change (Figure 9).

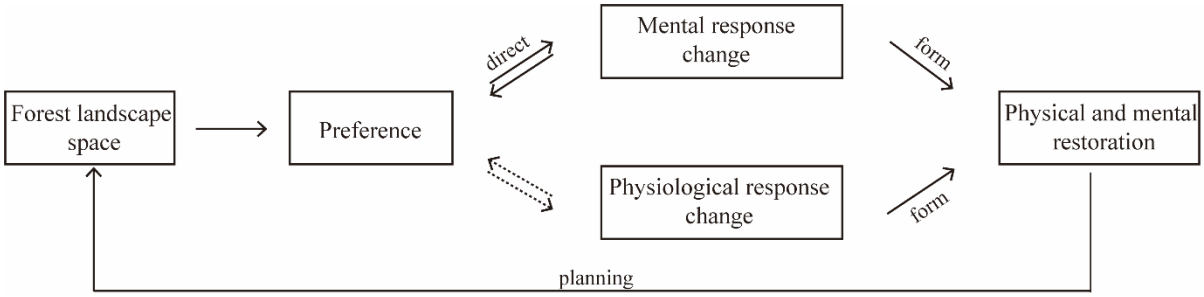


**Figure 9.** Relationships between participants' preference and physical and mental restoration in forest landscape space.

Based on the above findings, it is recommended to combine the types of space and the elements of the forest landscape preferred by participants s in the forest sites planned for young people and to consider adding a lookout platform. In forest water landscape places where young males are active, considerations to strengthen the arrangement of plants should be taken. For the forest water space and forest space where female students are active, it is possible to create a certain sense of openness and permeability by choosing tree species with moderate crown width and rationally defining tree density. At the same time, it is necessary to consider the construction and maintenance of the water landscape and properly matching the structures in the water space to enhance the young female's preference for the space and to enhance their restorative benefits.

## 5. Limitations

(1) Although compared to the artificial environment, the forest has been restored, but in our research, we did not use the control group to verify this view. We only demonstrated whether college students watching different types of forest spaces has different effects on their physical and mental recovery. Compared to watching an artificial environment, what kind of physical and mental recovery mechanism exists in people who watch the forest environment? This is worthy of further discussion.

(2) During the analysis of this study, we found that although college students had a strong recovery in physical and mental state changes after watching forest landscape space, this recovery effect showed some homogeneity among different types of forest spaces. This may be due to the fact that the participants in our experiment are all young college students, which makes their physical and mental states more similar, so their changes in physical and emotional states in the face of pressure are also more similar, which may also be one of the reasons for the limitation of the analysis method of this manuscript. Meanwhile, some studies have indicated that people's perception and preferences for forest landscape environments also show differences among professions [32]. People of different attributes may have different physical and mental states in different environmental conditions due to their different basic physical health levels. Therefore, in future research, it is necessary to further explore the influence of demographic factors such as age, profession, cultural status, and health status on the restorative effects of exposure to forest landscape space on human health. This also makes the research samples more diverse, so more dimensions and analysis methods can be used to discuss the influence mechanism of forest landscape environment on the effects of human physiological and psychological recovery.

(3) Panoramic videos of the forest space were used as the experimental material, which included visual and auditory stimuli. Although vision plays a dominant role in people's experience of the external environment, hearing is also indispensable. High-quality sound in nature can also be used as an important resource for promoting the restoration of people's physical and mental health [77,78]. Therefore, do visual and auditory stimulation have a single impact on people's physical and mental restoration? What is the interaction between these factors? All these questions require further exploration. Meanwhile, with changes in the natural seasons, the spatial characteristics of the forest landscape environment also

change, especially in northern cities. Therefore, we could consider adding the variable of season to the future studies of physical and mental health restoration with exposure to forests.

## 6. Conclusions

The effects of forest landscape spaces on restoring people's physical and mental health have been widely confirmed. However, starting from the demographic attributes of the viewers and their subjective preference needs, along with the different gender of the viewers, the restorative effects of the forest landscape space on people and the changes in people's preferences for particular spaces must be further clarified. At the same time, the relationship between each of these factors is also worthy of in-depth exploration. This study explored the above issues and inferred the following conclusions:

(1) When college students of different genders experience a forest landscape, the restoration effect of the landscape environment on them would be different due to different landscape content. Among them, the overlook landscape space had the strongest physiological stress relief in males and the weakest restorative effect on females' blood pressure and emotional worries. The static water landscape space had the best positive effect on females' physiology and worry.

(2) Regardless of gender, college students have the same preference for different types of forest landscape space, but for overlook landscape space, female students have a higher preference than male students.

(3) When young adults observed their favourite forest landscape space, their sense of interest and relaxation was significantly improved and their disordered mood was significantly reduced.

Based on the above conclusions, we suggest the following:

Generally speaking, when planning and designing a forest landscape space and organizing the forest experience route, we should combine the attributes of the main service target groups, not only paying attention to enhancing the benefits of forest space to human health but also rationally allocating exploration and interesting spaces or elements so as to improve the preference of different attributes space.

Specifically, in the future forest landscape spatial planning and management, we can provide corresponding forest experience road guide for people of different genders. Young men, for example, in their experience route, set up the activities of the forest water landscape space to strengthen the configuration of plant elements. Designers also can arrange some overlooked features; high exposure and adventure or stimulating strong activity space nodes can promote the effect of young males' physical and mental recovery.

In addition, for young females, on the experience route, in addition to some configuration of adventure or stimulating strong activity space node, the configuration of some larger water space and broad-leaved forest rich in colour and vegetation should be considered so that girls can receive better physical and mental recovery effects and so it will be well received by them.

**Author Contributions:** Z.Z. and Y.C. designed and conducted the experiments, analysed data, and wrote the manuscript. T.Z. designed the experiments, collected the experimental materials, and wrote and modified the manuscript. W.Z., H.M. and Y.G. provided suggestions for this manuscript. X.Q. collected literature. All authors have read and agreed to the published version of the manuscript.

**Funding:** The research was supported by the Natural Science Foundation of China (31971714), Educational Commission of Liaoning Province of China (LJK0687) and Shenyang Agricultural University Student Innovation and Venture Fund.

**Institutional Review Board Statement:** We confirmed that informed consent was obtained from all participants, and the study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Ethics Committee of Human Studies, College of Forestry, Shenyang Agricultural University, China.

**Informed Consent Statement:** Informed consent was given from the participants for the publication of identity-revealing images in an online open-access publication.

**Data Availability Statement:** The datasets analysed during the current study are not publicly available due to continuing studies involving them but are available from the corresponding author on reasonable request.

**Acknowledgments:** We would also like to thank the participants in the experiment as well as AJE (https://secure.aje.com/r/HVPMKW56 (accessed on 10 January 2022)) for its linguistic assistance during the preparation of this manuscript.

**Conflicts of Interest:** The authors declare no conflict of interest.

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