東南アジアのウェルビーイングオフィスに関する研究

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Studies on Well-Being Office in the Southeast Asian Context

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Abstract

To explore well-being office environments suited to the Southeast Asian context, we investigated the impact of working in different seating areas and mental health program participation in a Singapore office. The results of the experiment suggested the following: 1) Longer use of a dedicated mental health application improved well-being and work engagement scores after the experiment, particularly with the Utrecht Work Engagement Scale score showing a significant enhancement. 2) The option to freely select the seating position contributed positively to these improvements. 3) Participation in the experiment increased awareness of furniture and health aspects in the office. 4) Similar to Japan, low thermal comfort satisfaction was recognized as a barrier to intellectual productivity; however, in Singapore, dissatisfaction stemmed from overcooling, whereas in Japan, it was due to heat during summer.

1. Introduction

As a global trend, prioritizing the health and well-being of employees and providing a comfortable working environment have become cornerstones of initiatives aimed at long-term employee retention, reduced turnover, and improved performance of organization[1]. In this regard, well-being and work engagement are recognized as factors that impact both employee happiness and performance[1]. Well-being refers to a state of being physically, mentally, and socially well, whereas work engagement represents an employee's sense of energetic and effective connection with their work activities. These two factors are interrelated, as enhancing employee well-being often leads to improved work engagement, and highly engaged employees tend to actively engage in endeavors that support their well-being[2].

In Japanese companies, one measure for enhancing work engagement is the implementation of activity-based working (ABW) in the office environment[3]. ABW refers to a flexible working style in which employees can choose the most suitable location based on their tasks, with the aim of improving intellectual productivity without being restricted by time or place[4]. As a practical implementation, lounge cafés and collaborative spaces that encourage communication and collaboration are gaining attention in office design[5]. In addition, efforts have been made to create environments that enhance employee well-being, including incorporating natural light and installing greenery[5]; presently, efforts are also being made to develop indicators and tools to evaluate the effectiveness of office environments. Through surveys and the analysis of performance metrics, attempts have been made to quantitatively assess the effects of improvements of office environments[6].

In the rapidly developing Southeast Asian region job-based employment, where individuals are assigned specific roles, is predominant, unlike in Japan[7], which leads to high labor mobility[8]. Singapore has implemented legal reforms to improve the working environment for laborers, enabling them to evaluate job offers and benefits from companies[9]. In Thailand, some residential environments are not suitable for remote work, leading to a strong desire to work in comfortable and health-conscious offices equipped with quiet workspaces, ergonomic furniture, temperature, humidity management, and ventilation systems. While Japan and Southeast Asia differ in terms of diversity, labor market conditions, and regional characteristics, there is a shared recognition that the improvement of office environments is an important factor in attracting and retaining top talent[10]. Although studies have reported the impact of the indoor environment quality of offices on work engagement and intellectual productivity in Southeast Asia[11], these studies are still relatively limited. There is a need for more focused research that considers the cultural and environmental differences across regions.

This study focused on strategies for achieving a well-being-oriented office environment, suitable for the work environment and culture of Southeast Asia, with specific emphasis on

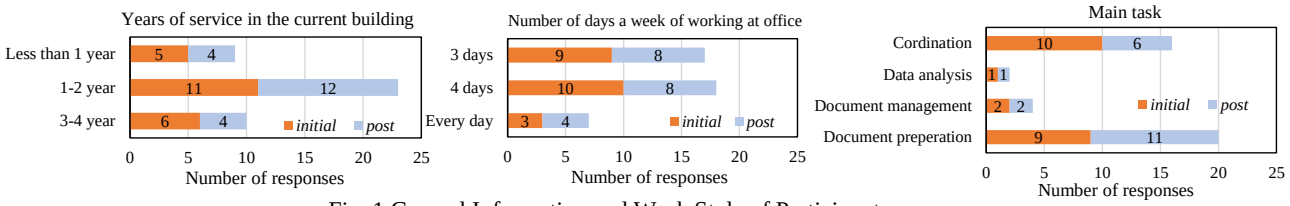

Fig. 1 General Information and Work Style of Participants

diversity in workspaces and mental health programs, such as health programs and stress management support. To investigate the effectiveness of these strategies quantitatively, a field experiment was conducted at the Obayashi Asia-Pacific Regional Headquarters. This report presents the results of evaluating the impact of different seating areas and participation in mental health programs on employees' physical and psychological well-being, as well as their awareness of the office environment.

2. Method

2.1 Overview of experiment

The experiment was conducted over 12 weeks, from September 24 to December 17, 2023, at the P office of the Obayashi Asia-Pacific Regional Headquarters in Singapore. The participants were 30 staff members working at the P office. Fig. 1 shows the general information and work styles of the participants.

Most participants were engaged in regional management and worked mainly in offices. The majority had worked in their current office for 1–2 years and the most common frequency of coming into the office was 4 days each week. The primary task of most participants was document preparation.

2.2 Experimental conditions

We established two conditions: working in designated seating areas based on a schedule (hereinafter referred to as "seating schedule") and participation in a mental health program.

2.2.1 Seating schedule Before the start of the experiment, participants worked in a free address style. The participants were divided into five teams (I–V) based on their sectors. The number of participants in each team is listed in Table 1. During the experiment, each team worked in three types of seating areas with different features, views, and other characteristiecs; these were accordingly labeled as "Table seats," "Window seats," and "Booth seats.". Fig. 2 shows the features of each seating area, and Fig. 3 shows the seating arrangement.

From the first to the fourth week of the experiment, all participants were designated a seating area used for regular office work. After the first 4 weeks, the participants were divided into two groups. The "change group" had scheduled

Table 1 Team Composition

Team	Num of people	Age				Sex	
		21-30	31-40	41-50	> 51	M	F
I	5	0	0	4	1	4	1
II	7	0	3	2	2	5	2
III	5	0	2	0	3	4	1
IV	8	0	5	2	1	6	2
V	5	1	1	1	2	5	0

Table 2 Seating Arrangement

Group	Team	Seating schedule				
		Week 1-4 (9/25-10/20)	Week 5-6 (10/23-11/3)	Week 7-8 (11/6-11/17)	Week 9-10 (11/20-12/1)	Week 11-12 (12/4-12/15)
Change group	I	Table A	Window	Booth	Table E	Free
	II	Table C	Table E	Window	Booth	Free
	III	Table D	Booth	Table E	Window	Free
Fixed group	IV	Table B				
	V	Table G				

White table	Highdesk and chair	Enclosed
Display : available	Display : None	Display : available
View : Inside	View: Outside	View : None

Fig. 2 Features of Seating Areas

changes to Table, Window, and Booth seats in a specified order (Table 2) for 2 weeks at a time, and for the last 2 weeks, they freely chose their seating area. The "fixed group" had no schedule in which the seating area was changed during the experimental period, remaining in a fixed seating area (Table 2).

2.2.2 Mental health programs During the experimental period, the participants participated in a mental health program provided by specialized businesses. The mental health program consisted of viewing educational content for stress reduction and health promotion using a dedicated app (hereinafter referred to as "the app"), having one-to-one and group coaching sessions with a specialist, completing questionnaire-based psychological surveys, and receiving individual feedback in the app. During the mental health program, participants attended sessions and completed questionnaires on a regular basis while wearing wristwatch-type wearabl devices throughout the experiment, which

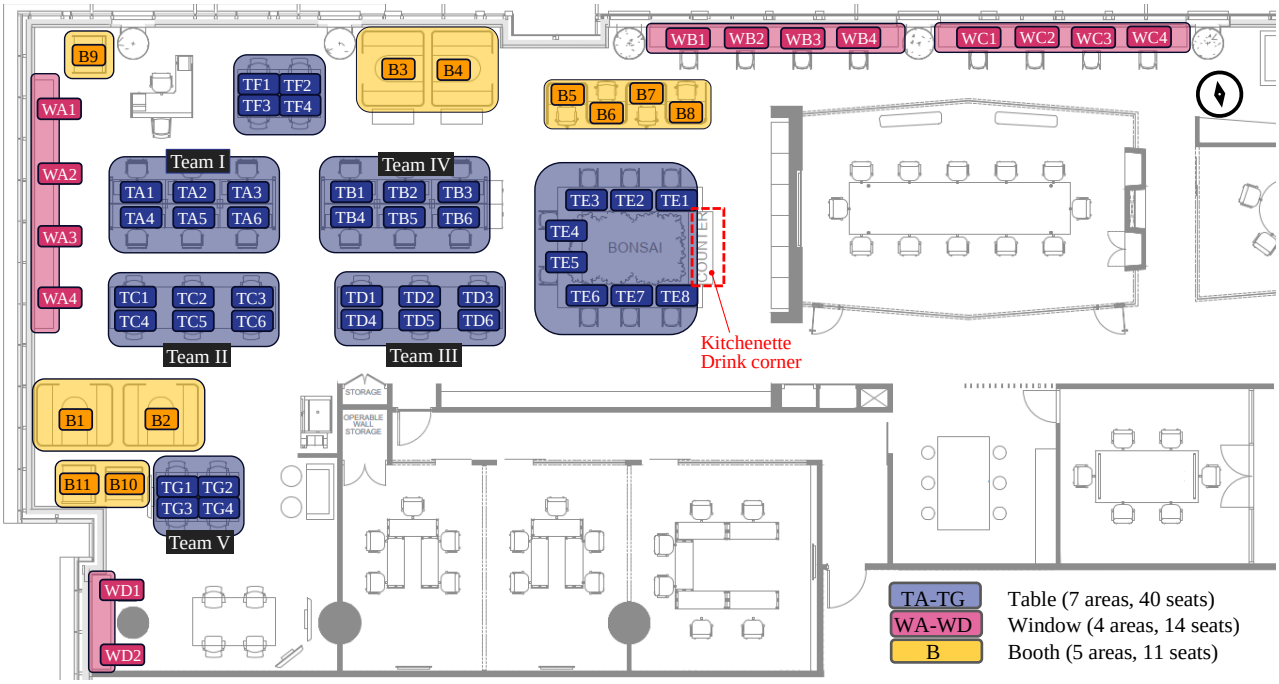

Fig. 3 Seating Map and Seat Number

Table 3 Measurement Items

Items		Details of items	Method	Frequency
Seating record	Seating area	Seat code	Questionnaire	Every day
Health data	Step	Step count	Wearable device	Every day
	Sleep	Sleep duration, Sleep latency, Sleep efficiency		
		Sleep quality	Questionnaire	*pre*, *post*
	App usage	Time spent using the mental health program dedicated app	Access log	Continuous measurement
Well-being	WHO-5	Cheerful and happy, Calm and relaxed, Active and vigorous, Fresh and rested, Filled with interesting things	Questionnaire	*pre*, *post*, Thoroughout the experiment
	SWBS	Subjective well-being level		*initial*, *post*
Work engagement	WOS-5	Absenteeism, Presenteeism, Work engagement, Ligfe satisfaction, Workplace distress	Questionnaire	*pre*, *post*, Thoroughout the experiment
	UWES	Energy, Immersion, Enthusiasm		*initial*, *post*
Office environment	General information, Workstyle	Years of service, Frequency of working at office , Main task, Place to conduct regular task, Prefer place to conduct tasks, Place to relax	Questionnaire	*initial*, *post*
	Satisfaction with indoor environment quality	Light environment, Thermal comfort, Air quality, Sound environment		
	Perception of indoor environment quality	Brightness, Temperature, Humidity		
	Impact on intellectual productivity	Light environment, Thermal comfort, Air quality, Sound environment		
	Satisfaction with amenities	Drinking water(accessbility, taste), Healthy eating environment		
	Satisfaction with ergonomic elements of office furniture	Workstation（adjustability, ease to focus, size, userability), Size of personal cabinet storage)		
	Satisfaction with office desgin	Office layout, Size of office, Ceilling height, Space openness, Variety of space, Ease of colloaboration, Other people's eye, Office aesthetics, Greeneries		
	Satisfaction with maintenance	Housekeeping, Cleanliness		
	Organization's workplace wellness	Wellness program		
	Office wellbeing	Items contribute to office wellbeing		

captured their biometric data. The individual feedback from the app was presented as a real-time dashboard report with biological and behavioral information, such as sleep quality, number of steps recorded by the wearable device, and well-being scores obtained from various psychological surveys. Recommendations for improving well-being scores were also presented.

2.3 Measurement items

The measurement parameters are listed in Table 3. Data were collected before the experiment started, during, and after the experiment ended. Based on the schedule of data collection, hereinafter the data collected before the experiment are marked as "*pre*," the data collected at the beginning of the experiment as "*initial*," and the data collected after 3 days following the completion of the experiment as "*post*."

(1) Seating record: As shown in Fig. 2, the seats were labeled with codes: the seven areas of the Table seats were labeled TA to TG, respectively, totaling 40 seats; the four areas of the Window seats were labeled WA to WD, respectively, totaling 14 seats; and the five areas of the Booth seats were labeled B, totaling 11 seats. Seating records were collected using a web-based questionnaire distributed every evening during the experiment. Participants reported in the questionnaire the code of the seat where they spent most of their day.

(2) Health data: Health data were collected from the wearable device, including participants' step count, sleep duration, sleep latency, and sleep efficiency (the ratio of sleep duration to time spent in bed), along with sleep quality data collected from a web questionnaire distributed regularly, and time spent using the app.

(3) Well-being: We measured using two indicators: the WHO-5[12] and the Subjective Well-Being scale (hereinafter referred to as 'SWBS'). Well-being and work engagement as detailed in (4) have various indicators, and results can vary depending on the purpose and methodology of the evaluation. Therefore, multiple metrics that are commonly used in many studies and evaluations were employed.

The WHO-5 is an indicator developed by the World Health Organization (WHO) and applied in the annual World Happiness Report published by the United Nations. The WHO-5 was obtained from a survey involving the following five statements (or states) as responses from the experience of participants over the preceding 2 weeks: "I have felt cheerful and good spirits," "I have felt calm and relaxed," "I have felt active and vigorous," "I woke up feeling fresh and rested," and "My daily life has been filled with things that interest me." Scores were calculated based on the numerical values reported by the participants related to the frequency of experiencing the five states, each on a scale of 0–5. The maximum score was 100, with a score of less than 29 regarded as "depressed," between 30 and 50 as "at risk of depression," and 50 or more as "positive well-being." The WHO-5 was collected periodically from a web questionnaire distributed to the participants during the experimental period.

The SWBS is a numerical measure of the level of well-being that participants feel in their workplace, ranging from 0 to 10, and is one of the items in the occupant survey required by the WELL certification[13]. These data were collected twice, *initial* and *post*, via a web-based questionnaire at the same time as the office environment evaluation (5).

(4) Work engagement: Work engagement was measured using two indicators: the Workplace Outcome Suite[14] (WOS) and the Utrecht Work Engagement Scale[15] (UWES). The WOS is applied as a comprehensive tool for relative evaluation and comparative research. The WOS was calculated from the number of hours of absence reported in the last month, in addition to the level of participants' perception of four items: presenteeism (poor performance), work engagement, life satisfaction, and workplace distress, each on a scale of 1–5. The WOS was collected from a web questionnaire distributed to participants periodically during the experiment.

(5) Office environment evaluation: Office environment evaluation items were developed by adding unique items to the occupant survey, which is a Precondition of the WELL certification. Participants reported their satisfaction with each office environment on a five- or three-point scale from "(extremely) dissatisfied" to "(extremely) satisfied." Perception of the indoor office environment was reported on a five-point scale from "very dark" to "very bright" for brightness, "very cold" to "very hot" for temperature, and "very sweaty" to "very dry" for moisture levels in the air (humidity). The impact of the office environment on intellectual productivity was also reported on a three-point scale from "interfere" to "enhance." Data were collected twice, *initial* and *post*, via a web-based questionnaire.

3. Seating record

Fig. 4 shows the results of the daily seating report. Twenty-eight participants (93%) declared their seating record during the experiment. There were 1336 records of which 851 (64%) had a seat code reported. Records without seat codes were from leave days, telecommuting days, and days worked outside the target seating area. The numbers of declared uses of each seating area are shown in Fig. 5. The breakdown of reported seating areas included 628 (74%) for Table seats, 109 (13%) for Window seats, and 114 (13%) for Booth seats.

The proportion of each team sitting in their designated seating areas across the experimental period was 94%, 100%, 66%, 100%, and 85% for Team I, II, II, IV, and V, respectively (Table 4).

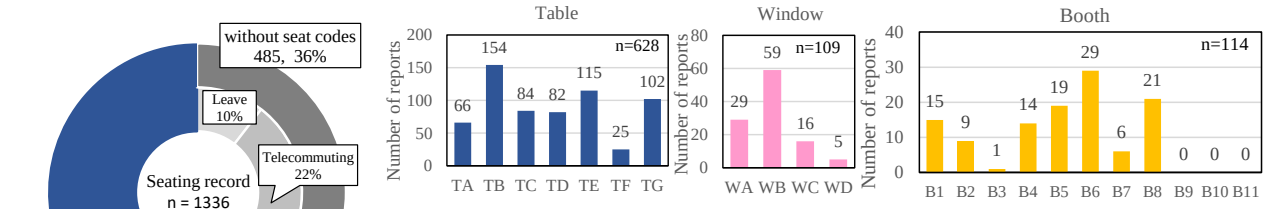

Fig. 4 Results of Daily Seating Report

Fig. 5 Number of Reported Seating Area

Table 4 Rate of Seating Designated Area [%]

Team	I	II	III	IV	V
Week 1-4	79	93	85	100	71
Week 5-6	96	100	52	100	100
Week 7-8	100	100	59	100	70
Week 9-10	100	100	70	100	100
Week 11-12	Free	Free	Free	100	73
Entire Period	94	100	66	100	85

Table 5 Adopted Statistical Test

Test	Purpose	Conditions
t test	To determine if there is a significant difference between the means of two groups.	Independences, Normality, Homogeneity of variances, Continuous variable
Mann-Whitney U test	To determine if there is a significant difference between the medians of two groups.	Independences, Not assume normality or equal variances, Ordinal variable
Multi-way ANOVA	To examine the effects of multiple independent variables on a dependent variable.	Independences, Normality, Homogeneity of variances
Kolmolgov-Smirnov test	Normality	Continuous variable
F test	Homogeneity of variance of 2 groups	Continuous variable
Bartlett test	3Homogeneity of variance of 3 or more groups	Continuous variable

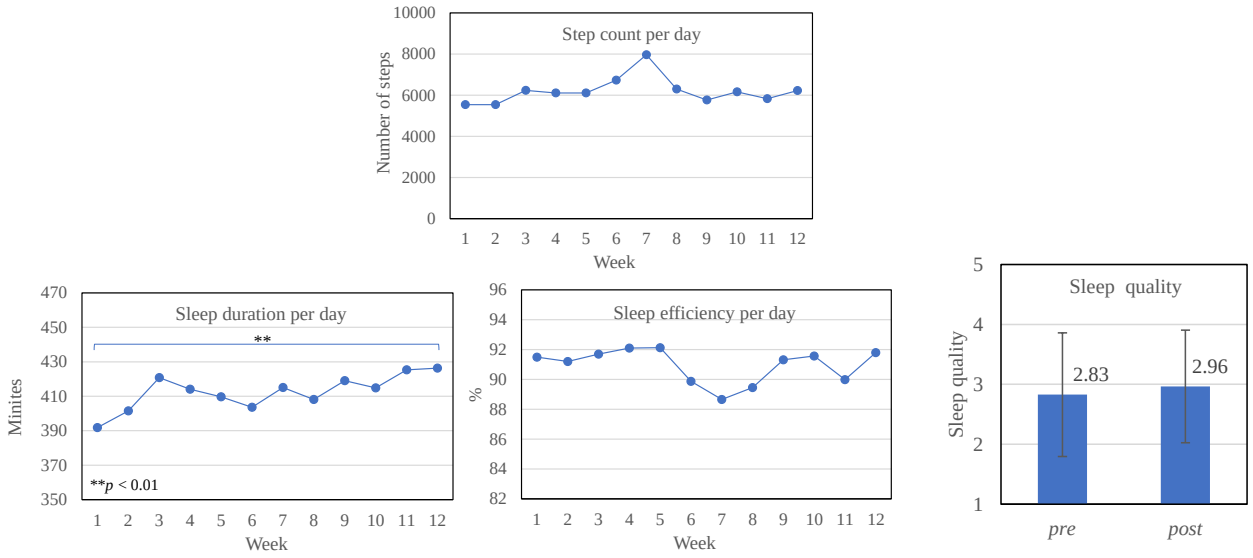

Fig. 6 Results of Health Record

4. Health data

The health data obtained from the 29 participants are shown in Fig. 6. Throughout this section and in the subsequent analyses, statistical tests were conducted using the methods listed in Table 5, appropriate to the objectives and conditions of the data. A probability (*p*-value) of less than 5% was considered to observed differences are not due to chance. The rate of change for each health measure was obtained by subtracting the baseline value obtained earlier from the value obtained later, and then dividing the result by the baseline value. A positive rate of change indicated an improvement in the evaluation, whereas a negative rate of change indicated a decline in the evaluation.

The average number of steps taken per day did not change substantially throughout the experimental period. Sleep duration increased throughout the experimental period, with a statistically significant difference between weeks 1 and 12. Sleep efficiency (higher values indicate higher efficiency) varied throughout the experimental period, but the differences were not statistically significant. Sleep quality improved by 4.8% in post- as compared to pre-intervention, but there was no statistically significant difference.

5. Well-being and work engagement

We investigated the impact of the seating schedules and mental health programs on well-being and work engagement.

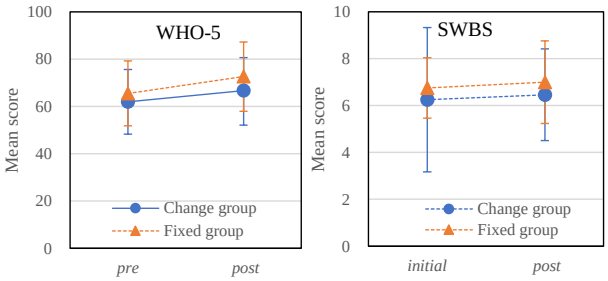

Fig. 7 Well-being Score based on Seating Schedule

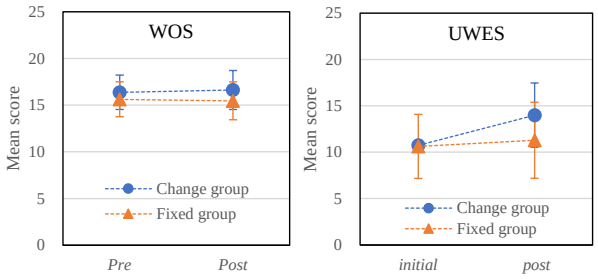

Fig. 8 Work Engagement Score based on Seating Schedule

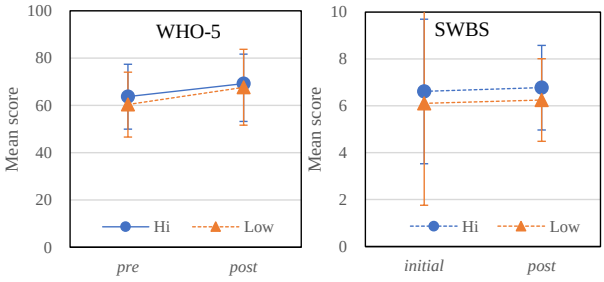

Fig. 9 Well-being Score based on App Usage Duration

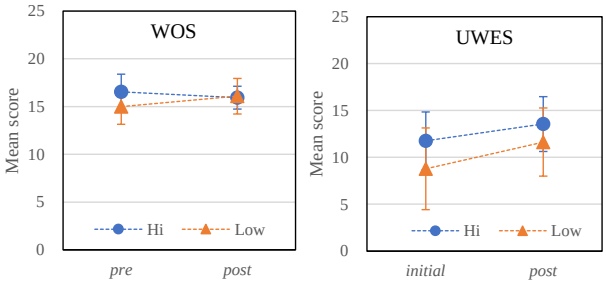

Fig. 10 Work Engagement Score based on App Usage Duration

5.1 Effect of seating schedules

To investigate the effect of seating schedules, the differences between the change group, with scheduled changes to seating, and the fixed group, with no changes to seating, were analyzed. There were 17 participants in the change group and 13 in the fixed group (Table 1).

5.1.1 Well-being The scores of the change group and the fixed group for the well-being indicators WHO-5 and SWBS are shown in Fig. 7.

(1) WHO-5 The mean score of the change group increased by 7.7%, from 62.0 in *pre* to 66.8 in *post*. The fixed group increased by 10.8%, from 65.5 in *pre* to 72.6 in *post*. Scores increased in both groups from *pre* to *post*, but the fixed group scored higher in both *pre* and *post*.

(2) SWBS The mean score of the change group increased by 3.4%, from 6.3 in *initial* to 6.5 in *pre*. The fixed group increased by 3.7%, from 6.8 in *initial* to 7.0 in *post*. Both groups showed increased scores in *post*, but the fixed group scored higher in both *initial* and *post*. While the fixed group originally had a higher level of well-being, the difference between the groups was small and could be considered within the range of error.

5.1.2 Work engagement The scores of the change group and the fixed group for the work engagement indicators WOS and UWES are shown in Fig. 8.

(1) WOS The mean score of the change group increased by 1.5%, from 16.4 in *pre* to 16.6 in *post*. The fixed group decreased by 1.0%, from 15.6 in *pre* to 15.5 in *post*. Although the change group scored slightly higher in both *pre* and *post*, the results for both groups were nearly the same.

(2) UWES The mean score of the change group increased by 30.2%, from 10.8 in *initial* to 14.0 in *post*. The fixed group increased by 6.2%, from 10.6 in *initial* to 11.3 in *post*. Both groups increased their scores in *post*, but the change group scored higher in both *initial* and *post*.

In contrast to the level of well-being, the change group originally had higher levels of work engagement than the fixed group. Additionally, the UWES tended to increase at a higher rate in the change group than in the fixed group throughout the experiment.

5.2 Effect of mental health program

We assumed that the effectiveness of the mental health program was influenced by the duration of app use. Among the participants from whom appropriate data were obtained, we classified those who used the app for 300 minutes or more as the “high usage group” (hereinafter referred to as group H) and those who used it for less than 300 minutes as the “low usage group” (hereinafter referred to as group L).

5.2.1 Well-being The scores for the well-being indicators WHO-5 and SWBS for group H and group L are shown in Fig. 9.

(1) WHO-5 The mean sore of group H increased by 8.7% from 63.7 in *pre* to 69.2 in *post*. The mean score of group L increased by 12.2% from 60.3 in *pre* to 67.7 in *post*. Group H scored higher *pre* and *post*, and both groups increased in *post* compared to *pre*.

(2) SWBS The mean score of group H increased by 2.5% from 6.6 in *initial* to 6.8 in *post*. The mean score of group L increased by 2.3% from 6.1 in *initial* to 6.3 in *post*.

Group H scored higher in *the initial* and *post*, and both groups increased their scores in *post* compared to *pre*.

Table 6 Results of Multi-way ANOVA

Factors	Well-being		Work engagement	
	WHO-5	SWBS	WOS	UWES
Seating schedule (Seating)	N.S.	N.S.	N.S.($p < 0.1$)	N.S.
App usage (App)	N.S.	N.S.	N.S.($p < 0.1$)	$p < 0.05$
Time course (Time)	N.S.	N.S.	N.S.	N.S.
Seating x App	N.S.	N.S.	N.S.	N.S.
Seating x Time	N.S.	N.S.	N.S.	N.S.
App x Time	N.S.	N.S.	N.S.	N.S.
Seating x App x Time	N.S.	N.S.	N.S.	N.S.

N.S.: Not significant x Test of interaction; a conbined impact on dependant variables that goes beyond their indivdual effects.

5.2.2 Work engagement The scores for the work engagement indicators WOS and UWES for group H and group L are shown in Fig. 10.

(1) WOS The mean score of group H decreased by 3.7% from 16.5 in *pre* to 15.9 in *post*. The mean score of group L increased by 7.2% from 15.0 in *pre* to 16.1 in *post*. Group H scored higher than group L both *pre* and *post*. While the score of Group H decreased from *pre* to *post*, that of Group L increased from *pre* to *post*.

(2) UWES The mean score of group H increased by 15.2% from 11.8 in *initial* to 13.6 in *post*. The mean score of group L increased by 32.4% from 8.8 in *initial* to 11.6 in *post*. Group H scored higher than group L. Both groups showed an increase from *pre* to *post*.

Both indicators were scored higher in Group H at both *pre*/*initial* and *post*. Participants who originally had higher levels of well-being and work engagement may have been more interested in the mental health program and actively used it.

5.3 Comparison of the effects of seating schedule, app usage duration, and time course

To investigate the effects of the seating schedule, app usage duration, and duration of participation in the experiment (hereinafter referred to as the "time course") on well-being and work engagement indicators, a multi-way analysis of variance (ANOVA) was conducted with scores for each indicator as objective variables (dependent variables) and the seating schedule, app usage duration, and time course as explanatory variables (independent variables). The test results are listed in Table 6.

Although the three independent variables showed a tendency to increase WHO-5 and SWBS scores, none were statistically associated with the well-being indicators (hereafter referred to as the "main effect").

For the work engagement indicators, only app usage duration showed a significant main effect in increasing UWES scores. Although not statistically significant, app usage duration and seating schedule showed some effect in increasing the WOS scores. No main effect of time course was observed for either the UWES or WOS.

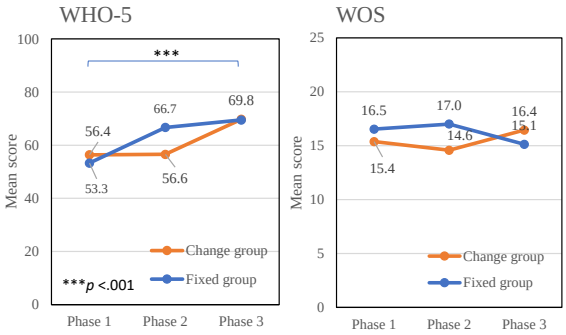

Fig.11 Score of WHO-5 and WOS based on Phase

The multi-way analysis of variance shows no statistically significant synergistic effects (hereinafter referred to as "interaction") for either well-being indicators or work engagement indicators when multiple variables were combined.

5.4 Effect of free choice of seating area

To investigate the effects of the free choice of seating area on well-being and work engagement, the experimental period was divided into three phases based on the seating schedule. Weeks 1 to 4, in which the regularly used seating area was designated, were designated "Phase 1;" Weeks 5 to 10, in which the change group changed seating areas according to instructions, "Phase 2;" and weeks 11 to 12, in which the change group freely choose their seating area, "Phase 3." The indicators analyzed were the WHO-5 for well-being and the WOS for work engagement. The UWES and SWBS were excluded because there were only *initial* and *post* data available for them, making it impossible to compare Phases 2 and 3. Fig. 11 shows the WHO-5 and WOS scores according to the experimental phase.

(1) WHO-5 The mean scores of the change group were 56.4 for Phase 1, 56.6 for Phase 2, and 69.8 for Phase 3. Those of the fixed group were 53.3, 66.7, and 69.5, respectively. The change group increased by 0.3% from Phase 1 to Phase 2, and by 18.9% from Phase 2 to Phase 3, during free-choice scheduling. The fixed group increased by 20.1% from Phase 1 to Phase 2, and by 4.1% from Phase 2 to Phase 3. Scores tended to increase in both groups as the phases progressed.

It is presumed that the WHO-5 scores did not increase in the change group because of the psychological or physical load of having a designated seating area in Phase 2. Accordingly, in Phase 3, the WHO-5 scores increased in this group because of the influence of being able to freely choose their seating area. The fixed group did not change their seating schedule throughout the experimental period; therefore, there was less

psychological or physical load, and the positive effects of the mental health program experience emerged in Phase 2. However, the positive effects plateaued in Phase 3 and there was no further increase in WHO-5 scores in the fixed group.

The effects of seating area change and phase (time course) associated with participation in the experiment on WHO-5 were tested using a multi-way ANOVA. A main effect of phase was found; however, no effect of the seating schedule was found.

(2) WOS The mean WOS score for the change group was 15.4 for Phase 1, 14.6 for Phase 2, and 16.4 for Phase 2. The respective scores for the fixed group were 16.5, 17.0, and 15.1. The change group decreased by 5.5% from Phase 1 to Phase 2 but increased by 11.4% from Phase 2 to Phase 3. The fixed group increased by 2.8% from Phase 1 to Phase 2 but decreased by 12.4% from Phase 2 to Phase 3. From Phase 2 to Phase 3, the change group increased, whereas the fixed group decreased.

Several presumptions are made regarding the changes in WOS scores. As for the WHO-5 scores, the change group was affected by the psychological or physical load of being designated a seating area in Phase 2, which inhibited the increase in WOS scores. However, the change group increased their scores in Phase 3 because they were able to freely choose their seating area. The fixed group scores decreased from Phase 2 to Phase 3. Although there were no changes to the seating schedule during these phases, and therefore minimal psychological and physical burden, participant boredom and fatigue may have negatively affected their commitment to the experiment.

The effects of the seating schedule (with or without changes in the seating area) and phase (time course) on the WOS scores were tested. No effect was observed under either condition.

The change group showed increased scores from Phase 2 to Phase 3 for both the WHO-5 and WOS. No statistically significant differences were found, but the free choice of seating contributed to improved well-being and work engagement.

6. Evaluation of office environment

The number of valid responses to the office environment evaluation questionnaire was 22 (73%) at *initial* and 20 (67%) at *post*. The number of responses to both questionnaires was 15 (50%).

6.1 Results of questionnaire survey

To analyze ordinal-scale items with options for ranking, such as satisfaction with the office environment, perception, and impact on intellectual productivity, integers were assigned in ascending order with the lowest rating of 1 in line with the rank order of evaluation (e.g., the highest value of 5 for a 5-level evaluation). Table 7 shows the mean values of the ordinal items at *initial* and *post*, the rate of change, and the results of the statistical test. Items with an absolute change rate more than 5% and statistically significant differences are indicated below

(1) Satisfaction of indoor environmental quality Satisfaction with the sound environment and air quality increased by 6.9% and 5.6%, respectively. Conversely, satisfaction with the light environment decreased by 8.1%.

(2) Perception of indoor environmental quality Perception of temperature changed by 5.7% towards “cold.” Perception of humidity changed by 7.2% towards “dry.”

(3) Impact on intellectual productivity Perceptions that the thermal and sound environment increased intellectual productivity were enhanced by 7.2% and 7.6%, respectively.

(4) Satisfaction with amenities Satisfaction with the taste of drinking water and healthy eating environment increased by 5.6% and 8.5%, respectively. Conversely,

Table 7 Results of Occupant Survey

Items		*initial*	*post*	Rate of change	Test results
Satisfaction with indoor environment quality	Light environment	4.14	3.80	-8.1%	N.S.
	Thermal comfort	2.68	2.75	2.5%	N.S.
	Air quality	3.41	3.60	5.6%	N.S.
	Sound environment	3.27	3.50	6.9%	N.S.
Perception of indoor environment quality	Brightness (desk)	3.64	3.55	-2.4%	N.S.
	Brightness (room)	3.50	3.55	1.4%	N.S.
	Temperature	1.91	1.80	-5.7%	N.S.
	Dry/wet	2.29	2.45	7.2%	N.S.
Impact on intellectual productivity	Light environment	2.27	2.30	1.2%	N.S.
	Thermal comfort	1.82	1.95	7.2%	N.S.
	Air quality	2.09	2.15	2.8%	N.S.
	Sound environment	2.05	2.20	7.6%	N.S.
Satisfaction with amenities	Drinking water(accessbility)	2.82	2.50	-11.3%	$p < 0.05$
	Drinking water(taste)	3.41	3.60	5.6%	N.S.
	Healthy eating environment	3.32	3.60	8.5%	N.S.
Satisfaction with ergonic elements of office furniture	Workstation (adjustability)	3.32	3.60	8.5%	N.S.
	Forcused workstation	3.23	3.40	5.4%	N.S.
	Size of workstation	2.77	2.80	1.0%	N.S.
	Desk usability	2.18	2.60	19.2%	N.S.
	Size of personal cabinet storage	2.09	1.90	-9.1%	N.S.
Satisfaction of office design	Office layout	3.41	3.80	11.5%	N.S.
	Size of office	2.82	2.85	1.1%	N.S.
	Ceilling height	2.95	2.85	-3.5%	N.S.
	Space oppenness	2.64	2.70	2.4%	N.S.
	Variety of space	2.45	2.45	-0.2%	N.S.
	Ease of collaboration	2.50	2.60	4.0%	N.S.
	Other people's eye	1.82	2.10	15.5%	N.S.
	Office aesthetics	3.68	3.95	7.3%	N.S.
	Greeneries	3.86	4.20	8.7%	N.S.
Satisfaction with maintenance	Housekeeping	3.86	4.05	4.8%	N.S.
	Cleanliness	4.09	4.15	1.4%	N.S.
Organization's workplace wellness	Welness program	3.14	3.55	13.2%	N.S.

N.S: Not significant

satisfaction with accessibility to drinking water decreased by 11.3%.

We examined the impact of the seating schedule on the accessibility to drinking water, which showed a statistically significant difference. The mean satisfaction levels for the change and fixed groups are shown in Fig. 12.

Although no interaction was found, satisfaction with accessibility to drinking water decreased by 13.1% in the change group and by 6.5% in the fixed group. It is presumed that changes in the seating area during the experiment negatively affected the accessibility of drinking water.

(5) Satisfaction with ergonomic factors Satisfaction with adjustability of workstations, usability of workstations, and workstations for concentration increased by 8.5%, 5.4%, and 19.2%, respectively. Conversely, satisfaction with cabinet size decreased by 9.1%.

(6) Satisfaction with office design Satisfaction in terms of the "other people's eye" (privacy), office layout, aesthetics, and greenery increased by 15.5%, 11.5%, 7.3% and 8.7%, respectively.

(7) Satisfaction with maintenance No item had a change rate of 5% or more.

(8) Organizational wellness policies Satisfaction with wellness programs increased by 13.2%. Participation in mental health activities may also have had an impact.

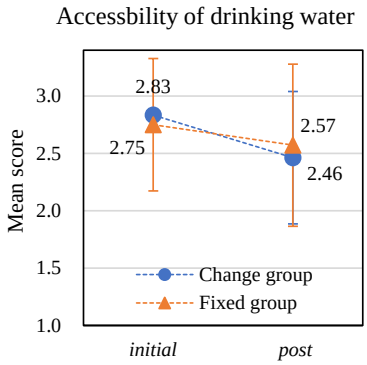

Fig. 12 Satisfaction with Accessibility of Drinking Water

6.2 Changes in evaluation viewpoint

We used principal component analysis (PCA) to compare the aggregated characteristics of survey responses between *initial* and *post* to examine changes in office environment evaluations resulting from participation in the experiment. PCA uses the correlations between variables in the original dataset to transform the data into a new set of variables (principal components). This reduces the number of variables while retaining the original information.

The questionnaire items were categorized into items relating to the quality of the indoor environment (sound, light, thermal environment, etc.), items relating to office design and furniture, and items relating to amenities, operation, and maintenance. The evaluation criteria for the extracted principal components are those with a statistically significant principal component variance of 1.0 or higher, and a cumulative contribution rate of 60% or more. The characteristics of the target principal components are listed in Table 8.

(1) Indoor environment quality Similar findings in tendency were observed for *initial* and *post*. In both periods, the first principal component (with the highest explanatory power) was a group that rated the quality of the indoor environment highly in general, the second principal component was a group that rated the thermal environment low and

Table 8 Features of Targeted Principal Components

Items	*Initial*				*Post*			
		Characteristics	CV	PV		Characteristics	CV	PV
Indoor environment quality	1	・High evaluation in general	3.79	0.47	1	・High evaluation in general	3.40	0.42
	2	・Low evaluation of thermal comfort; Interference with intellectual productivity	1.11	0.14	2	・Low evaluation of thermal comfort; Interference with intellectual productivity	1.80	0.23
	3	・Light environment interferes with intellectual productivity	0.96	0.12	3	・Light environment interferes with intellectual productivity	1.20	0.15
		Cumulative Proportion		0.61		Cumulative Proportion		0.80
Design and furniture	1	・High evaluation of size, varieties and openness	2.61	0.20	1	・High evaluation in general	4.06	0.29
	2	・Low evaluation in general	2.32	0.19	2	・High evaluation of furniture (ease of connsentration, adjustability) ・Low evaluation of oppeness and ceilling height	2.66	0.19
	3	・High evalutio of finiture	1.67	0.17	3	Low evaluatio of aesthetic and greenery	1.62	0.12
	4	・Low evaluation of ease of collaboration	1.43	0.12	4	・High evaluation of spacial diversity and ease of collaboration ・Low evaluation of layout	1.23	0.09
Amenities, operation and maintenance	1	・High evaluation in general	1.93	0.39	1	・High evaluation of hygiene management	2.22	0.44
	2	・Low evaluation of hygiene management	1.59	0.31	2	・High evaluation of drinking water (taste) ・Low evaluation of healthy eating environment	1.19	0.24
		Cumulative Proportion		0.70		Cumulative Proportion		0.68

CV: component variance, PV: proportion of variance

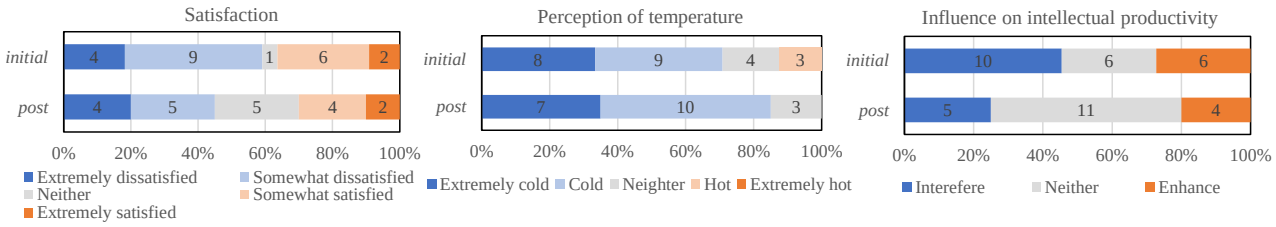

Fig.13 Evaluation of Thermal Comfort

reported that it interfered with intellectual productivity, and the third principal component was a group that reported that the light environment interfered with intellectual productivity.

(2) Office design and furniture The tendency was different between *initial* and *post*. In *initial*, the first principal component was a group with a high evaluation of size, variety, and openness; the second was a group with a low evaluation of office design in general; the third was a group with high satisfaction with office furniture; and the fourth was a group with low satisfaction with the ease of collaborative work. In *post*, the first principal component group had high satisfaction with office design and office furniture in general; the second had a high evaluation of office furniture in terms of ease of concentration and adjustability, but a low evaluation of openness and ceiling height; the third had a low evaluation of aesthetics and greenery; the fourth had a high evaluation of spatial diversity and ease of collaboration, but a low evaluation of the layout. Office furniture tended to be rated higher in *post* than in *initial*. It is presumed that participant awareness of office furniture increased when they used different desks and chairs during the experiment.

(3) Amenities, operation and maintenance The tendency was different between *initial* and *post*. In *initial*, the first principal component was a group with a high overall evaluation of the items, and the second was a group with a low evaluation of hygiene management. In *post*, the first principal component group had a high evaluation of the taste of the drinking water and allowed the evaluation of a healthy eating environment. The office had a kitchenette and a beverage corner within the workspace, but it did not have a cafeteria. Office workers used external restaurants or takeout services for meals. The reason for the improvement in the taste evaluation of drinking water in the post-experimental phase is unknown. However, it is presumed that the mental health program during the experiment increased awareness of health-related factors, such as drinking water and dining environment, which contributed to enhanced well-being.

Overall, evaluation of the quality of the office indoor environment did not change substantially as a result of participation in the experiment. However, there was an increase in the awareness of office furniture and its impact on health.

6.3 Differences from Japanese office environment evaluation

Fig. 13 shows that participants were particularly dissatisfied with the thermal environment of the office, indicating that it impacted on their productivity. Previous studies on office environment comfort and intellectual productivity in Japan have indicated low satisfaction with the office thermal environment throughout the year, impeding intellectual productivity[16]. In terms of humidity of the office environment, in this experiment conducted in perpetually tropical Singapore, the dissatisfaction factor was “coldness” due to excessive cooling of the workplace, while comparative studies indicate that the dissatisfaction factor in Japan during the summer was mainly the heat of the workplace. Onsite interviews conducted concurrently with this experiment revealed that there is a tendency in Singapore to believe that a higher air conditioning temperature setting would compromise the luxurious feel of the building environment.

Despite an increase in reports of feeling “cold” in the *post* evaluations, the number of negative reports regarding the impact on thermal satisfaction and intellectual productivity decreased between *initial* and *post*. This experiment was conducted as a field experiment in an actual office environment, making it difficult to control the conditions, and the sample size was not sufficient. Therefore, it was not possible to establish a clear causal relationship regarding whether the seating schedule or the mental health program had a greater impact, or if there were other influencing factors. Nevertheless, while thermal comfort is considered important in office environments in both Japan and Singapore, it appears that the factors contributing to dissatisfaction with the thermal environment differ across the two countries. Considering the well-being of offices suitable for the environment and culture of Southeast Asia, including Singapore, these findings are important.

7. Summary

This study focused on the diversity of workspaces and mental health programs as strategies to achieve well-being in an office environment. The findings of the experiment are as follows:

1) Higher usage of the dedicated mental health program app was associated with increased scores for well-being and work engagement indicators. In particular, app use

was associated with significantly increased UWES scores.

2) WHO-5 and WOS scores increased as a result of the experiment in the group with a free choice of seating. Although these scores were not significantly different from those of the group who experienced the scheduled seat change, the results suggest that free choice of seating may contribute to improved well-being and work engagement.
3) The results suggest that participation in the experiment increased awareness of office furniture and improved evaluation of the health aspects of office environment.
4) As per studies from Japan, our results suggest that low satisfaction with thermal comfort interferes with intellectual productivity. In Japan, the dissatisfaction factor during the summer season is "hot" whereas in our study in Singapore, it was "coldness due to excessive cooling of the workplace."

We will continue to conduct research and gather evidence that will contribute to the realization of "well-being" offices suitable for the environment and culture of Southeast Asia.

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