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Research Article

Medicine for novel therapy

Health Management of Remote Workers Using Tele-Exercise During The COVID-19 Pandemic in Japan

Tetsuaki Oda [1,4*], Chikako Oda [2], Yuji Furui [3] and Yumi Kanegae [4]

[1]Graduate School of Technology Management, Ritsumeikan University, Osaka, Japan*

[2]Department of Medical Information and Life Sciences, Graduate School of New Areas, The University of Tokyo, Tokyo, Japan

[3]Institute for Future Initiatives, University of Tokyo, Tokyo, Japan

[4]Core Research Facilities, Research Center for Medical Sciences, The Jikei University School of Medicine, Tokyo, Japan*

Abstract: Health management is increasingly recognized as a vital business resource aimed at enhancing employee well-being. The COVID-19 pandemic has significantly influenced lifestyle habits, underscoring the need for effective health management strategies tailored to the changing work environment. This study aims to explore the impact of tele-exercise interventions on remote workers group (G1). It compares the effects of tele-exercise with those of traditional face-to-face exercise group (G2). Over three months, G1 engaged in a 30-minute weekly exercise program tailored for remote execution, while G2 participated in traditional, in-person sessions. The analysis included ANOVA to assess the differences over time between G1 and G2, Correlation Analysis to examine the relationships among the measured variables within each group, and Correspondence Analysis to explore the association patterns between the groups' responses and the variables of interest. The ANOVA revealed a significant difference in Daily Stress (DS) levels between G1 and G2, with G1 showing higher DS levels. Correlation analysis indicated a strong negative relationship between Body Mass Index (BMI) and Sleep Quality (SQ) in G1, and a strong positive relationship between DS and Satisfaction of Life (SL). Correspondence Analysis showed that that G1 was encompassed in a job and life satisfaction area, and G2 was encompassed in a sleep and stress for weight control area. This study concluded that both groups initially experienced weight gains and increased sleep duration due to remote work. Daily Stress was found to be significantly higher in G1 than in G2, possibly due to the isolation of tele-exercise. Correlation analyses highlighted the influence of time on relationship between BMI and SQ, and DS and SL. The study emphasizes stress management and good sleep quality in remote work, with exercise interventions promoting well-being and productivity.

Keywords: Health management, Tele-exercise intervention, Remote Workers

***Corresponding Author**

Tetsuaki Oda , Graduate School of Technology Management, Ritsumeikan University, Osaka, Japan and Core Research Facilities, Research Center for Medical Sciences, The Jikei University School of Medicine, Tokyo, Japan

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1. INTRODUCTION

In an era where reaching 100 years of age is not uncommon[1], extending healthy life expectancy becomes paramount[2]. Additionally, in societies experiencing aging populations and declining birth rates, there is a heightened emphasis on health management. This approach views employee health as a critical business resource, aiming to enhance the productivity of a constrained workforce[3]. Consequently, efforts to promote health management and initiatives focused on health enhancement are intensifying, reflecting the urgent need to adapt to these demographic shifts and their impact on the workforce[4]. In the realm of health management, absenteeism refers to situations where employees are absent from work due to ill health, while presenteeism describes instances where employees are present at work but exhibit reduced productivity as a result of ill health. In the realm of health management, absenteeism refers to situations where employees are absent from work due to ill health[5], while presenteeism describes instances where employees are present at work but exhibit reduced productivity as a result of ill health. Traditionally, company workforce management has concentrated on addressing the productivity losses associated with absenteeism. However, there is a growing acknowledgment that presenteeism may result in more significant economic losses[6]. This recognition is supported by a meta-analysis on the effects of flexible working arrangements, which suggests that the risk of presenteeism diminishes with telework. Moreover, the shift to remote work has led to an increase in daily stress and disruptions to regular sleep patterns[7,8]. Additionally, limitations on in-person communication have had negative effects on job satisfaction and overall happiness[9]. As the COVID-19 pandemic has prompted changes in working styles and communication methods, including widespread adoption of video conferencing and other remote techniques, it is believed that these changes have significant implications for remote workers. Although prior research, has addressed changes in physical activity levels and mental health, it does not explore the relationship between these elements and participants' interest or concern as a result of tele-exercise and face-to-face exercise. This study aims to empirically analyze the impact of exercise interventions via tele-exercise on the lifestyle habits of remote workers and investigate the relationship between these factors and participants' interests or concerns resulting from both tele-exercise and face-to-face exercise. Regarding the implementation of exercise intervention via tele-exercise, evidence from a 6-month exercise-centric intervention employing a tele monitoring system indicated a reduction in the severity of metabolic syndrome. This suggests that such interventions could not only decrease the risk of cardiovascular and metabolic diseases among high-risk employees but also enhance mental health, work capacity, and productivity-related outcomes[10]. Inspired by these findings, this study embarked on an empirical examination of two groups subjected to exercise guidance interventions (Group 1: tele-exercise group, Group 2: face-to-face exercise group), taking these considerations into account.

2. MATERIALS AND METHODS

2.1 Study Place

JEXER Fitness Club, Minami-Otsuka, Toshima-ku, Tokyo 170-0005.

2.2 Study Period

3 months [July to October in 2021]

2.3 Study Design

Prospective multivariate analysis study.

2.4 Subject Recruitment

JEXER Fitness Club members and the former members who fulfil both inclusion and exclusion criteria.

2.5 Inclusion Criteria

・Remote workers aged between 20–65 years.

・Remote workers with Body Mass Index (BMI) of 25 or higher.

2.6 Exclusion Criteria

・Remote workers who are less than three months post-fracture injury or surgery.

・Remote workers presenting with a malignant tumour.

2.7 Participants

This study received approval from the Ethics Committee of the University of Tokyo (Registration Number: 20-385, April 8, 2021). It involved healthy adult members and non-members of JEXER, a fitness club operated by JR East Sports. The participants were divided into two groups: one for tele-exercise and another for face-to-face exercise, with each group consisting of 8 participants. The face-to-face group was composed of 7 males and 1 female, selected through a randomized sampling method. JEXER provides both face-to-face and remote exercise options. The standard class size for face-to-face sessions at JEXER is 8 participants (5 males and 3 females), a size that allows for effective observation and communication by a trainer. Accordingly, the tele-exercise group was also set to 8 participants to maintain consistency in group size and to facilitate comparison between the two exercise modalities. The selection criteria for participants included both men and women aged between 20 to 65 years, a range that encompasses the majority of the working-age population in Japan. Additionally, candidates were required to have a Body Mass Index (BMI) of 25 or higher, aligning with the Japan Ministry of Health, Labour and Welfare's definition of obesity. The frequency of engaging in remote work and the willingness to participate in the study were also considered as important factors in the selection process.

2.8 Measures

The questionnaire was designed to gather information on various aspects such as presenteeism, weight, sleep, stress, job satisfaction, and happiness, as elaborated in Table 1. Demographic data were collected on age, gender (male, female), height, weight, BMI, and the number of remote work days a month. To standardize the physical and questionnaire data, ratio scale (BMI, PST, ST) and ordinal scale (the other measures) were determined relative to the program's onset.

- Presenteeism (PST): Percentage (0-100%) was asked participants to estimate their work performance in the past 4 weeks when not sick or injured.
- Absenteeism (AST): Absent days from work in the past 4 weeks due to illness or injury.
- Adequate Exercise (AE): Physical activity change (1: significantly decrease-5: significantly increase) due to remote work.
- Weight Control (WC): Weight change (1: significantly decrease-5: significantly increase) due to remote work.
- Daily Stress (DS): Daily stress level (1: not at all-5: extremely).
- Stress Relief (SR): Stress control level (1: not at all-5: extremely).
- Stress due to Remote Work (SRW): Remote work stress level (1: significantly decrease-5: significantly increase).
- Sleep Time (ST): Average of sleep length (hours and minutes).
- Adequate Rest (AR): Sufficient sleep for rest (1: not at all-5: extremely).
- Sleep Quality (SQ): Sleep quality due to remote work (1: significantly deteriorated-5: significantly improved).
- Sleep due to Remote Work (SRW): Sleep duration due to remote work (1: significantly decrease-5: significantly increase).
- Purpose in Work (PW): A sense of purpose in work (1: not at all-5: extremely).
- Recommendation of Workplace (RW): Recommendation of workplace to an acquaintance (1: not at all-5: extremely).
- Satisfaction of Life (SL): Life satisfaction (1: not at all-5: extremely).

2.9 Methods and Analysis

Participants received detailed information about the study and, upon signing informed consent, the tele-exercise group embarked on an exercise program facilitated by a JEXER trainer. This program, conducted for 30 minutes weekly over a span of three months from July to October 2021, comprised squats, push-ups, and planks, tailored for JEXER members to perform indoors without the need for exercise equipment. At the initiation of the exercise program, baseline data including participants' height, weight, and Body Mass Index (BMI) were recorded, and the questionnaire was administered (Time1, Baseline: July 2021). The same set of measurements was taken, and the questionnaire was redistributed one month into the program (Time2, Midpoint: August 2021), and once more upon completing three months of the program (Time3, Study endpoint: October 2021). The collected ratio and difference data for each dimension were analyzed using a Two-way repeated measures Analysis of Variance (ANOVA) to identify any significant mean differences between the two groups, G1 (tele-exercise group) and G2 (face-to-face exercise group), across the three time points (Time1 to Time3). A significance level of $P < 0.05$ was predetermined. ANOVA serves as a statistical technique to test if there are significant differences in the mean values across three specific time intervals (Time1, Time2, and Time3) between the two distinct groups, G1 and G2. Correlation analysis, using the Pearson method, was conducted on the collected data from both groups for each measured dimension. Correlation analysis is a statistical approach to determine the existence and strength of a relationship between two variables or datasets. This analysis helps to understand how one dimension may influence or relate to another within the context of the study. In addition, correspondence analysis (CA) is a form of multivariate analysis that is conducted to visualize and interpret categorical data, showing relationships and patterns among survey responses. CA is a technique used to represent the dimensions of cross-tabulated data in a two-dimensional graphical format to facilitate understanding of the complex relationships among these dimensions. Through CA, it is possible to categorize participants' responses and visually display prevailing trends and associations in a scatter plot format. Statistical analyses, including ANOVA, correlation analysis, and CA, were performed using SPSS version 29.0 (IBM). Figure 1 demonstrates that, although both Group 1 (G1, tele-exercise) and Group 2 (G2, face-to-face) initially had 8 participants each, the analysis ultimately included data from 5 participants in G1 and 7 participants in G2. This reduction was due to the exclusion of participants who did not complete the questionnaire, thereby ensuring that the analysis was based only on fully gathered data sets.

Table1: The questionnaire and abbreviations

Question	Category	Abbreviation
In the past 4 weeks, what percentage of your full potential (when not sick or injured) would you say you have applied to your work?	Presenteeism	PST
Has remote work caused your level of physical activity to decrease or increase?	Adequate Exercise	AE
Has remote work caused your weight to decrease or increase?	Weight Control	WC
To what extent do you feel stressed on a daily basis?	Daily Stress	DS
Are you able to alleviate and manage stress?	Stress Relief	SR
Has remote work caused your level of stress to decrease or increase?	Stress due to Remote Work	SRW
On average, how many hours and minutes do you sleep?	Sleep Time	ST
Do you feel that your sleep is sufficient for rest and rejuvenation?	Adequate Rest	AR
Has remote work caused the quality of your sleep to deteriorate or improve?	Sleep Quality	SQ
Has remote work caused the duration of your sleep to decrease or increase?	Sleep Duration	SD
Do you feel a sense of purpose in your work?	Purpose in Work	PW
Would you recommend your current workplace to an acquaintance?	Recommendation of Workplace	RW
How satisfied are you with your life overall?	Satisfaction of Life	SL

Table 1 illustrates the items of the questionnaire with category and abbreviation. Ratio scale (BMI, PST, ST) were standardized by the ratio of the value of endpoint to start point. Ordinal scale (the other measures) were standardized by the difference between the value of endpoint to start point.

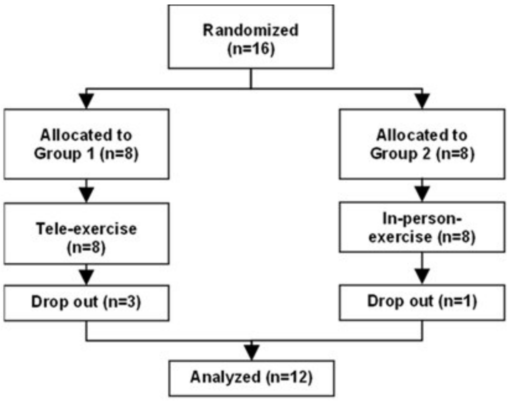

Fig.1 Methods and Process of the Analysis

Figure 1 illustrates that schematic overview of the study design and analytical process. Initially, 16 participants were randomized into two groups, with 8 allocated to the tele-exercise group (Group 1) and 8 to the face-to-face exercise group (Group 2). The figure details participant flow through the study, including dropouts, resulting in 5 participants in Group 1 and 7 in Group 2 for final analysis. This figure elucidates the methodological framework and participant engagement throughout the study period.

3. RESULTS

3.1 Baseline Characteristics

The initial number of participants was 8 in both the tele-exercise group (G1) and the face-to-face exercise group (G2). Ultimately, the analysis included data from 5 participants (all male) in G1 and 7 participants (5 males and 2 females) in G2. The participant attributes are detailed in Table 2. All p-values were two-sided, and statistical significance was assessed at the 0.05 level. Given that the p-values for all assessed characteristics exceeded 0.05, it can be concluded that groups G1 and G2 have no statistically significant differences in their characteristics, indicating substantial equivalence between the two groups.

Table2: Baseline characteristics of participants mean±SD or n (percentage)

Characteristics	G1 (N=5)	G2 (N=7)	p-Value
Age: mean (±SD)	49.2 (±6.04)	37.57 (±10.85)	0.057
Sex: n (%)			0.764
Male	5 (100.00%)	5 (71.43%)	
Female	0 (0.00%)	2 (28.57%)	
Height (cm): mean (±SD)	174.4 (±7.61)	170.14 (±9.85)	0.446
Weight (kg): mean (±SD)	85.8 (±4.75)	78.76 (±13.29)	0.251
BMI: mean (±SD)	28.36 (±1.52)	27.00 (±0.79)	0.456
Number of remote work days a month: mean (±SD)	13.6 (±3.97)	12.43 (±2.17)	0.804

Table 2 illustrates descriptive statistics and p-value of t-test for the baseline of groups G1 and G2. All p-values were two-sided, and statistical significance was assessed at the 0.05 level. Groups G1 and G2 have no statistically significant differences in their characteristics, indicating substantial equivalence between the two groups.

3.2 At the Start of Experiment

3.2.1 Weight Control

Figure 2 displays the outcomes of a survey question regarding changes in weight attributed to remote work, illustrated through a box-and-whisker plot that centers on the overall median. Respondents selected from the following options to describe their weight changes: 1) significantly decreased, 2) slightly decreased, 3) remained the same, 4) slightly increased, 5) significantly increased. As of July 2021, at the commencement of the exercise guidance program, participants from both the tele-exercise group (G1) and the face-to-face exercise group (G2) reported experiencing weight gain due to the shift to remote work.

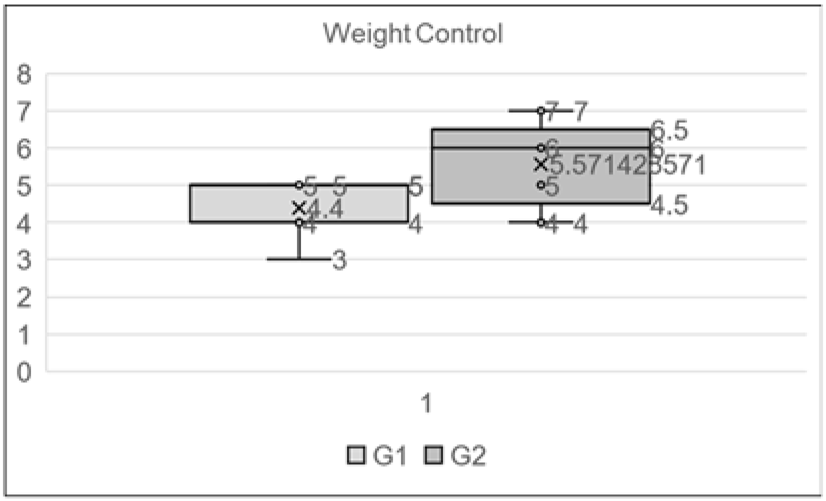

Fig.2 The weight changes work before experiment

Figure 2 illustrates a box-and-whisker plot indicating participant-reported weight changes attributed to shifting to remote work prior to the experiment commencement in July 2021. Responses were categorized into five distinct options, ranging from significantly decreased to significantly increased weight. Both groups reported a general trend towards weight gain, highlighting the impact of remote work on physical health.

3.2.2 Sleep Duration

Figure 3 illustrates the results of a survey question regarding changes in sleep duration as a result of remote work, depicted in a box-and-whisker plot that focuses on the overall median. Participants chose from the following options to indicate their experience with sleep duration changes: 1) significantly decreased, 2) slightly decreased, 3) remained the same, 4) slightly increased, 5) significantly increased. At the onset of the exercise guidance program in July 2021, individuals in both the tele-exercise group (G1) and the face-to-face exercise group (G2) reported experiencing increased sleep durations due to the adoption of remote work practices.

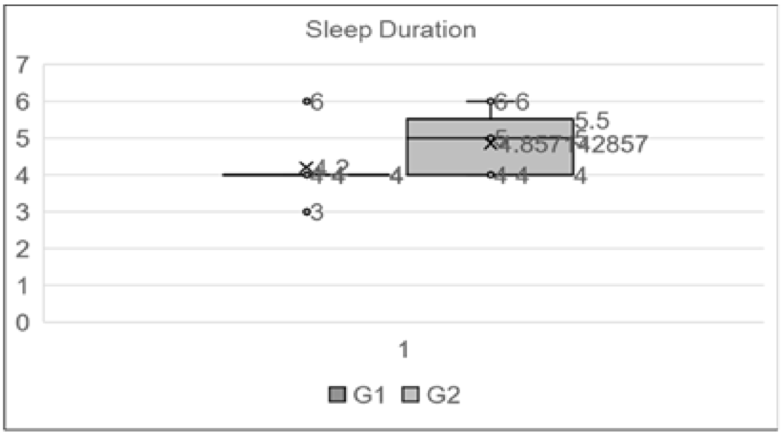

Fig.3 The sleep duration due to remote work before exercise

Figure 3 illustrates a box-and-whisker plot indicating participant- reported sleep duration changes attributed to shifting to remote work prior to the experiment commencement in July 2021. Responses were categorized into five distinct options, ranging from significantly decreased to significantly increased sleep duration. Both groups reported a trend towards increased sleep duration at the study's outset. Both groups reported a general trend towards increased sleep duration, highlighting the impact of remote work on physical health.

3.3 Work-related determinants of health

Many participants highlighted how remote working induced stress. This was often linked to absence from work, less sleep quality, and less life satisfaction. The tele-exercise group (G1) showed high correlation between daily stress and absent days from work (Correlation Coefficient: 0.92), and the face-to-face exercise group (G2) showed high correlation between stress due to remote work and less sleep quality (CC: -0.81) and less life satisfaction (CC: -0.91) as the baseline. At the endpoint, daily stress got better for four participants (33.3%), worse for one participant (8.3%), and no change for (58.3%). Stress due to remote work got better for four participants (33.3%), worse for two participants (16.7%), and no change for (50.0%).

3.4 Pandemic specific factors

The COVID-19 pandemic has led to a surge in remote working, significantly impacting employees' lifestyle habits. For instance, the period of home confinement brought on by COVID-19 saw many individuals experiencing weight gain, attributed to a lack of physical activity and increased food intake driven by stress[11]. Furthermore, a global survey on changes in physical activity during the COVID-19 pandemic highlighted a widespread decline in physical activity levels, which further decreased during lockdown periods[12]. This shift underscores the need for effective strategies to address the challenges of maintaining physical health under the new norms of work and life brought about by the pandemic.

3.5 Two-way repeated measures ANOVA

3.5.1 Within-Subjects Contrast

A Within-Subjects Contrast analysis was conducted to examine the differences across various items in relation to the time term and the interaction between time and group. This analysis revealed that there were no significant differences in any of the items of G1 and G2, across the three time points (Time1 to Time3).

3.5.2 Between-Subjects Effects

A Within-Subjects Contrast analysis was conducted to Table 3 details the Between-Subjects Effects, revealing a significant difference between G1 and G2 in the Between-Subjects Effects test, specifically for Daily Stress (DS). For the other measured items, however, there were no significant differences observed between G1 and G2. Figure 4 showcases the progression of Estimated Marginal Means of Daily Stress (DS). According to the data presented in Figure 4, a marked difference in DS levels was noted between G1 and G2, with G1 experiencing significantly higher Daily Stress in comparison to G2.

Table3 Between-Subject Effects

Source	Measure	Type III Sum of Squares	df	Mean Square	F	Sig.
Groups	BMI	0	1	0	0.191	0.671
	PRS	0.001	1	0.001	0.022	0.885
	AE	0.003	1	0.003	0.001	0.974
	WC	0.35	1	0.35	0.691	0.425
	DS	4.229	1	4.229	8.917	0.014*
	SR	1.679	1	1.679	0.657	0.436
	SRW	1.906	1	1.906	0.966	0.349
	ST	0.001	1	0.001	0.057	0.817
	AR	0.42	1	0.42	0.374	0.554
	SQ	1.029	1	1.029	0.719	0.416
	SD	0.457	1	0.457	0.448	0.519
	PW	0.096	1	0.096	0.039	0.848
	RW	0.003	1	0.003	0.002	0.962
	SL	0.714	1	0.714	0.364	0.560

***** *Correlation is significant at the 0.05 level.*

Table 3 illustrates the Between-Subjects Effects, revealing a significant difference between G1 and G2 in the Between-Subjects Effects test, specifically for Daily Stress (DS). For the other measured items, however, there were no significant differences observed between G1 and G2.

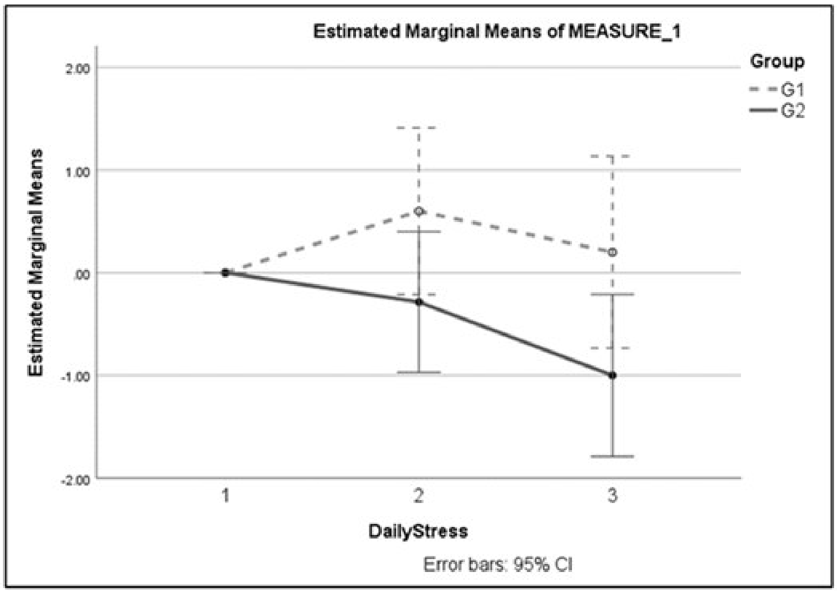

Fig.4 Significance of DS (Daily Stress) between G1 and G2

Figure 4 illustrates estimated marginal means of daily stress (DS) levels between the tele-exercise group (G1) and the face-to-face exercise group (G2) throughout the study. The plot shows significant differences in DS levels, with G1 having higher DS levels than G2, highlighting the limitations of the potential stress reduction benefits of the tele-exercise sessions, while highlighting the potential stress reduction benefits of face-to-face exercise sessions.

3.5.3 Correlation

A correlation relationship quantifies the degree to which two variables are related, gauged by the correlation coefficient ranging from -1 to +1. A value of +1 signifies a perfect positive correlation, -1 denotes a perfect negative correlation, and 0 indicates no correlation at all. For the purpose of this analysis, items demonstrating all four pairs of correlation coefficients (at Time2, Midpoint, in August 2021 and Time3, Study endpoint, in October 2021) as significant ($p < 0.05$) are identified as possessing high robust correlation. According to Table 4 and Table 5, for G1, the items showing high robust correlation are Body Mass Index (BMI) and Sleep Quality (SQ), with all four pairings (BMI2-SQ2, BMI2-SQ3, BMI3-SQ2, BMI3-SQ3) exhibiting significant negative correlation coefficients. Additionally, Daily Stress (DS) and Satisfaction of Life (SL) displayed all four pairings (DS2-SL2, DS2-SL3, DS3-SL2, DS3-SL3) with significant positive correlation coefficients. The presence of significant correlation coefficients in all four pairs between pairs of items indicates a high robust positive or negative correlation. For G2, no items were identified where all four pairs of correlation coefficients were significant, suggesting the observed high robust correlations of BMI-SQ and DS-SL may be specific to the tele-exercise group (G1). This finding highlights the unique impact of tele-exercise on certain health and well-being metrics among participants in G1.

Table 4: Correlation between BMI and SQ for G1

	BMI2	BMI3	SQ2	SQ3
BMI2	1	.974**	-.995**	-.995**
	Sig. (2-tailed)	0.005	<.001	<.001
	N	5	5	5
BMI3	.974**	1	-.988**	-.988**
	Sig. (2-tailed)	0.005	0.002	0.002
	N	5	5	5
SQ2	-.995**	-.988**	1	1.000**
	Sig. (2-tailed)	<.001	0.002	<.001
	N	5	5	5
SQ3	-.995**	-.988**	1.000**	1
	Sig. (2-tailed)	<.001	0.002	<.001
	N	5	5	5

***** Correlation is significant at the 0.01 level (2-tailed).***

Table 4 illustrates a strong correlation between Body Mass Index (BMI) and Sleep Quality (SQ), with all four pairings (BMI2-SQ2, BMI2-SQ3, BMI3-SQ2, BMI3-SQ3) exhibiting significant negative correlation coefficients.

Table 5: Correlation between DS and SL for G1

	BMI2	BMI3	SL2	SL3
DS2	1	0.875	.885*	.889*
	Sig. (2-tailed)	0.052	0.01	0.005
	N	5	5	5
DS3	0.875	1	.958*	.975**
	Sig. (2-tailed)	0.052	0.01	0.005
	N	5	5	5
SL2	.885*	.958*	1	.998**
	Sig. (2-tailed)	0.046	0.01	<.001
	N	5	5	5
SL3	.889*	.975**	.998**	1
	Sig. (2-tailed)	0.044	0.005	<.001
	N	5	5	5

**** Correlation is significant at the 0.05 level (2-tailed).***
***** Correlation is significant at the 0.01 level (2-tailed).***

Table 5 illustrates a strong correlation between Daily Stress (DS) and Satisfaction of Life (SL), with significant positive correlations across the pairings (DS2-SL2, DS2-SL3, DS3-SL2, DS3-SL3).

3.6 Correspondence Analysis

Correspondence Analysis (CA) is a sophisticated multivariate statistical method designed for visualizing and interpreting categorical data. It excels at revealing the intricate relationships and patterns within survey responses by displaying categorical data in a graphical manner. This technique elucidates how different survey items relate to each other within a multidimensional space, thus providing insights into the underlying structure of the data. Figure 5 showcases the outcomes of a Correspondence Analysis performed on the average responses from both groups G1 and G2 to a survey utilizing a 7-point Likert scale. The scale included items such as AE, WC, DS, SR, SRW, AR, SQ, SD, PW, RW, and SL. As illustrated in Figure 5, the analysis grouped certain survey items closely together, suggesting an interrelation among them within the specified areas: AR and DS are clustered together, indicating a rest for stress relief area (A1); PW, RW, and SL are clustered together, indicating a job and life satisfaction area (A2); and WC, SR, SQ, SD are clustered together, indicating a sleep and stress for weight control area (A3). Indeed, the proximity of certain survey items in the Correspondence Analysis indicates that respondents perceive these items as interconnected, reflecting their particular interest in and focus on these areas. Such patterns of response can help identify key areas for intervention and support, aligning health management strategies more closely with participant needs and preferences. Table 6, summarizing the results of the Correspondence Analysis, showcases a significant explanatory power with a contribution rate of 0.861 across Dimensions 1 and 2.

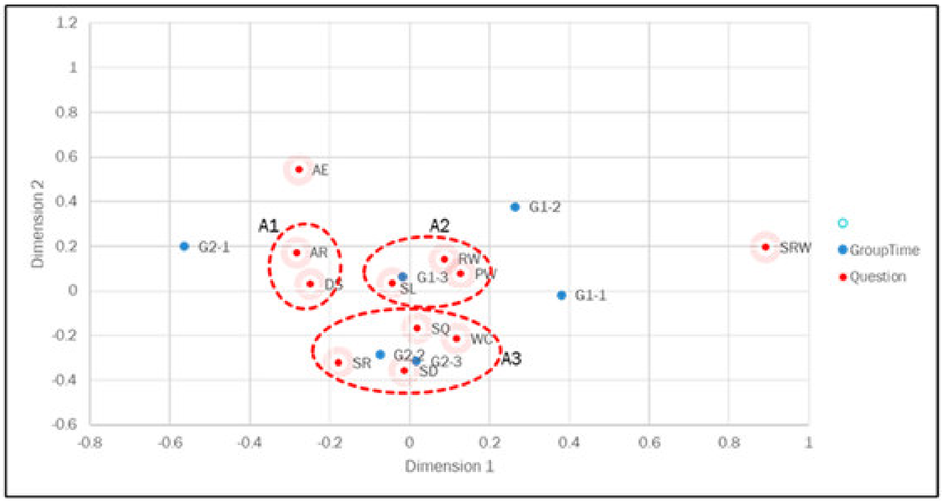

Fig.5 Corresponding Analysis

Figure 5 illustrates the results of the Correspondence Analysis based on average survey responses from both groups using a 5-point Likert scale. The analysis identifies clusters of related survey items, indicating patterns in participant responses regarding stress relief, job and life satisfaction, and sleep and stress management for weight control. The graphical representation facilitates understanding of the complex relationships between different aspects of participants' interests.

Table 6 Summary of Corresponding Analysis

Dimension	Singular Value	Inertia	Chi-Square	Sig.	Accounted for	Cumulative	Standard Correlation
1	0.088	0.008			0.575	0.575	0.006
2	0.062	0.004			0.286	0.861	0.006
3	0.033	0.001			0.083	0.944	
4	0.022	0.000			0.036	0.980	
5	0.016	0.000			0.020	1.000	
Total	0.014		387.352	<.001	1.000	1.000	

Chi-square with 50 degrees of freedom.

Table 6 illustrates the results of the Correspondence Analysis, showcasing significant explanatory power with a contribution rate of 0.861 across Dimensions 1 and 2.

4. DISCUSSION

4.1 At the Start of the Exercise Program

As illustrated in Figures 2 and 3, at the onset of the exercise program, both the tele-exercise group (G1) and the face-to-face exercise group (G2) exhibited weight gain and extended sleep durations, attributed to the shift to remote work. In response to the COVID-19 pandemic, the Japanese government declared a nationwide emergency on April 16, 2020. Subsequently, an expert panel advised the government to implement behavior modifications, including an 80% reduction in public mobility, is couragement of non-essential outings, and the adoption of telework. These measures, aimed at curbing the virus's spread, inadvertently led to lifestyle changes resulting in increased reports of weight gain and longer sleep durations due to reduced physical activity and the elimination of commute times[13].This global trend of weight gain during lockdowns has been observed in various reports stemming from the coronavirus pandemic[14]. Our study, conducted in July 2021, corroborates these findings, indicating that the decrease in physical activity associated with remote work and the consequent reduction in commuting time have likely contributed to weight gain and longer sleep durations[15].

4.2. *Two-way repeated measures ANOVA*

Figure 4 reveals a notable disparity in Daily Stress (DS) levels between the tele-exercise group (G1) and the face-to-face exercise group (G2). G1, which participates in tele-exercise without external outings or social interaction during workouts, reported an increase in DS. This uptick in stress is attributed to the extended periods spent indoors. Conversely, G2 engages in outing and interpersonal communication during their exercise sessions, which correlates with their reduced DS levels. There were significant variations in participant engagement and outcomes[16]. In our study, despite engaging in physical activity, G1 did not experience stress relief, suggesting that exercise alone may not be sufficient to counteract the mood and behavioral challenges associated with COVID-19 confinement. Our study also found no significant link between changes in physical activity patterns and mood states. In light of the restrictions imposed due to COVID-19, it appears unlikely that individual physical activity patterns could single-handedly alleviate mood and behavioral impairments[17]. Moreover, it is found no significant linking perceived changes in physical activity to anxiety levels, even when comparing twins who reported increased activity against those with no change[18].

4.3 Correlation

Within the tele-exercise group (G1), all four combinations of Body Mass Index (BMI) and Sleep Quality (SQ) demonstrated significantly negative correlation coefficients. Similarly, all four combinations of Daily Stress (DS) and Satisfaction of Life (SL) exhibited significantly positive correlation coefficients. These findings of our study suggest that tele-exercise participants can achieve quality sleep by managing weight effectively through tele-exercise. Moreover, tele-exercise participants may attain life satisfaction even amidst heightened levels of Daily Stress. For example, one study found a negative correlation between men's Body Mass Index (BMI) and sleep quality, as determined by polysomnographic records. This relationship was quantified using the Pearson correlation coefficient test, indicating that higher BMI values were associated with poorer sleep quality. Another study highlighted that both shorter sleep duration and greater night-to-night variability in sleep duration were linked to an increased BMI[19]. Additionally, research indicates that inadequate sleep mediates the relationship between long working hours and obesity[20]. The tele-exercise group (G1) posits that by adeptly managing moderate levels of Daily Stress, they could boost work productivity, which may, in turn, elevate life satisfaction. Previous studies have shown that improvements in job performance-stemming from heightened work commitment and task competence, contribute to increased life satisfaction[21]. Additionally, the research suggests that higher work satisfaction positively correlates with overall life satisfaction[22]. In our study, in contrast to the tele-exercise group (G1), the face-to-face exercise group (G2) did not demonstrate significant correlation coefficients for the examined combinations. This indicates that factors other than face-to-face exercise might influence BMI, Sleep Quality, Daily Stress, and Satisfaction of Life within G2. Some previous study discusses the limited efficacy of face-to-face interventions in improving sleep quality and other related outcomes compared to other forms of intervention[23,24].

4.4 Correspondence Analysis

In our study, the tele-exercise group (G1) showed significant involvement in the job and life satisfaction area (A2) at the Study endpoint (Time3). Meanwhile, the face-to-face exercise group (G2) showed significant involvement in the sleep and stress for weight control area (A3) at both the Midpoint (Time2) and Study endpoint (Time3). Notably, G1 demonstrated a pronounced interest in job satisfaction and life satisfaction at the conclusion of the study. Numerous studies have reported significant improvements in Quality of Life (QoL) among office workers participating in supervised physical exercise programs. For instance, a study found that a 17-week online exercise program, led by a physiotherapist, positively influenced office workers' perceptions of their QoL[25]. In our study, the face-to-face exercise group (G2) showed a marked interest in stress relief and sleep quality at both the Midpoint and the Study endpoint. The data of our study revealed that the face-to-face exercise intervention significantly ameliorated depressive symptoms, reduced anxiety, and enhanced the quality of life, while also diminishing psychological stress and its associated symptoms[26]. Additionally, a meta-analysis suggests that face-to-face exercise training can moderately improve sleep quality by decreasing sleep latency and reducing reliance on sleep medication[27].

5. CONCLUSION

It was noted that both groups initially experienced weight gain and increased sleep duration due to remote work. Daily Stress was found to be significantly higher in G1 than in G2, possibly due to the isolation of tele-exercise. Correlation analyses highlighted the influence of time on various factors, and some correlations suggested potential ways to enhance work productivity and control obesity. In conclusion, the study revealed differences between the two exercise groups in terms of stress levels and highlighted the importance of managing stress and maintaining good sleep quality in remote work settings. It also suggested that exercise interventions could have positive effects on participants' well-being and productivity.

6. LIMITATIONS OF STUDY

While the sample size of 16 participants may seem relatively small, it is a realistic and appropriate number from the perspective of observation and communication for a pilot study. Furthermore, many studies with small sample sizes have been published, indicating the value of such preliminary investigations in setting the groundwork for larger-scale research. Although the sample size is deemed realistic and suitable for exploratory studies from observational and communicational perspectives, the study is constrained by its small sample size and the fact that it was conducted at a single institution. Additionally, there is a potential for selection bias, as the participants who chose to partake in this study might not represent the broader population. These factors constitute limitations of the current study. Consequently, the efficacy results observed need to be validated through a larger-scale study to ensure broader applicability and reliability.

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8. ETHICAL STATEMENT

This study received ethical approval from the Ethics Committee of the University of Tokyo (Registration Number: 20-385, April 8, 2021) and was conducted after obtaining written informed consent from all participants, who were fully informed about the study. All participants were aware of the survey and study, consented to provide required data along with informed consent prior to their participation. The authors declare that (s)he has no relevant or material financial interests that relate to the research described in the manuscript.

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10. CONFLICT OF INTEREST

Conflict of interest declared none

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