

Sitting for long periods is associated with impaired work performance during the COVID-19 pandemic

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Abstract

Objectives: The unprecedented coronavirus disease 2019 (COVID-19) pandemic and the corresponding government state of emergency have dramatically changed our workstyle, particularly through implementing teleworking and social distancing. We investigated the degree to which people's work performance is affected and the association between sedentary behavior under the state of emergency and worsened work performance during the COVID-19 pandemic, as previous studies have suggested that sedentary behavior decreases work performance.

Methods: We used data from the Japan “COVID-19 and Society” Internet Survey (JACSIS) study, a cross-sectional, web-based, self-reported questionnaire survey. The main outcome was change in work performance after the COVID-19 pandemic compared with that before the pandemic. We analyzed the association between the change in work performance and sitting duration under the state of emergency, adjusted for work-related stress, participants' demographics, socio-economic status, health-related characteristics, and personality.

Results: The change of work environment from the pandemic decreased work performance in 15% of workers, which was 3.6 times greater than the number of workers reporting increased performance in 14 648 workers (6134 women and 8514 men). Although telework both improved and worsened performance (odds ratio [OR], 95% confidence interval [CI] = 2.0, 1.6-2.5 and 1.7, 1.5-1.9, respectively), sitting for long periods after the state of emergency was significantly associated only with worsened performance (OR, 95% CI = 1.8, 1.5-2.2) in a dose-response manner.

Conclusion: Sitting duration is likely a risk barometer of worsened work performance under uncertain working situations, such as the COVID-19 pandemic.

KEYWORDS

COVID-19 pandemic, long sitting behavior, stress, telework, work performance

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1 | INTRODUCTION

In 2020, 78 million people were infected by the coronavirus disease 2019 (COVID-19), and 1.7 million were killed by this virus worldwide.¹ The unprecedented pandemic has restricted international travel and threatened the collapse of medical care systems throughout the world. To save many people's lives, the government in general has implemented non-pharmaceutical interventions, including school closures, banning of mass gatherings, population stay-at-home orders, quarantine, and border control.² In response to government policies, most businesses have shortened their operation hours, closed temporarily or installed telework systems for working-from-home, online meetings, and web conferences. Work performance, which refers to how well an activity or job is done, is impacted by workplace environment and individual factors including physically demanding tasks, stress levels, extended working time, and healthy conditions. We supposed that the changes in work environment induced by the COVID-19 pandemic probably affected work performance. However, it is unclear exactly how work performance has been changed by the COVID-19 pandemic.

On 4 April, 2020, the Japanese government announced a state of emergency, in which they asked people to refrain from nonessential outings. The first target of the state was approximately 56 million people—about 45% of Japan's total population—in Tokyo, Chiba, Kanagawa, Saitama, Osaka, Hyogo, and Fukuoka. On 16 April, 2020, the target was spread to all 47 prefectures. People refrained from going out until the state of emergency was lifted on May 25, 2020 across Japan. However, the threat of COVID-19 had not still disappeared, and it was still necessary to keep attention to avoid being infected. Many companies downsized offices and continued teleworking even as the spread of COVID-19 slowed in Japan. We are continuing to develop a new workstyle in this challenging situation.

The new workstyle of teleworking has the potential to provide an ideal workstyle for each individual. This style can save on commuting time, remove the stress of commuting, allow the individual to control their working time and allow workers to participate in meetings from anywhere. Because this new work style also benefits companies by saving on the costs required to maintain an office, the currently arranged workstyle will partially remain even after COVID-19 is controlled. If the workstyle is appropriate for an individual, his/her work performance will improve even under challenging situations. However, the effect from the workstyle change on work performance remains unclear. In this context, we used data from a large internet survey to investigate changes in the work performance compared with work performance in January 2020, when COVID-19 had not yet reached Japan. In this study, sitting duration

was investigated as a risk factor of low work performance. Work-related sitting time was associated with lower work performance even before the COVID-19 pandemic.^{3,4} Because people lost many opportunities to go outside because of the quarantine and telework implementation, staying-at-home and working-from-home likely increased the duration of time workers spent sitting in a day. Some people who can take advantage of this work style change will have increased performance, but others will fail to maintain their performance under the self-quarantine. We considered that telework has advantages and disadvantages for work performance that are affected by several confounding factors. We hypothesized that a long sitting duration is a risk factor for decreased performance.

2 | METHODS

2.1 | Study design, setting, and data sources

We analyzed data from the Japan “COVID-19 and Society” Internet Survey (JACSIS) study, which is a cross-sectional, web-based, self-reported questionnaire survey administered by a large internet research agency (Rakuten Insight, Inc., which had approximately 2.2 million qualified panellists in 2019). The questionnaires were distributed to 224 389 panellists selected for each sex, age and prefecture category using simple random sampling (it covered all 47 prefectures, the first-tier administrative district in Japan). The panellists who consented to participate in the survey accessed the designated website and responded to the questionnaires and had the option not to respond or to withdraw at any point of the survey. The questionnaires were distributed starting on 25 August 2020, and distribution was completed on 30 September 2020, when the number of respondents met the target numbers for each sex, age, and prefecture category, which had been determined in advance according to the population distribution in 2019. There were 28 000 total respondents aged 15-79 years.

2.2 | Study population

Of the 28 000 participants in the JACSIS, we analyzed 14 648 workers (6134 women and 8514 men). We firstly excluded 2518 participants with invalid answers to validate data quality as previously described.^{5,6} Next, we excluded 10 028 participants with the following employment statuses: unemployed, full-time homemaker, retired, and student. Finally, 806 participants who answered “unknown” to the question of work performance change, which was the main outcome, were excluded.

2.3 | Main measures

2.3.1 | Work performance change

We investigated differences in work performance during the last 30 days compared with work performances in January 2020 using a 5-point scale ranging from 1 to 6 (1, significantly improved; 2, improved; 3, no change; 4, worsened; 5, significantly worsened and 6, unknown). We categorized the participants into three groups: improved performance (1 or 2), no change (3), and worsened performance (4 or 5).

2.3.2 | Sitting duration

The participants reported their mean sitting time per day during April and May 2020, which covered all the days under the state of emergency. We generated quintile time categories as follows: <2 , ≥ 2 and <4 , ≥ 4 and <6 , ≥ 6 and <8 and ≥ 8 hours. The participants also reported their mean sitting duration from June to this survey, which represents the time after the state of emergency was lifted.

2.4 | Potential confounders

Work performance is a multidimensional outcome influenced by several factors. Telework opportunity and the type of job are important factors affecting work performance change during the COVID-19 pandemic. Previous studies of work performance have shown that work-related stress has a large impact on performance.⁷ We measured job demands, job control, social support, and satisfaction corresponding to the demands-resource⁸ and the effort-reward imbalance⁹ models as described previously.¹⁰ We also collected information on confounding variables, including the respondents' demographics, socio-economic status (SES), health-related characteristics, personality, and living prefecture (the first-tier administrative district in Japan).

2.4.1 | Telework opportunity

The participants, who had not experienced any teleworking, reported whether any types of remote working, including working-from-home were implemented after April 2020. We also asked whether the telework opportunities were increased for people who had experienced teleworking before May 2020. The number of people, who reported the opportunities were implemented or increased, was counted as a total number of people with overall telework experience.

2.4.2 | Type of job

The participants selected their main job category from three types of jobs: blue-collar, sales, and desk work.

2.4.3 | Work-related stress

We used the New Brief Job Stress Questionnaire (New BJSQ) to evaluate work-related stress.¹¹ The BJSQ is a validated self-reported questionnaire developed by the Japanese Ministry of Health, Labour and Welfare and its research group, and it has been widely used in Japan as a regular annual screening survey for high psychosocial stress in the workplace, which is mandatory for enterprises with 50 or more employees. We assessed the degree of job demands using six items and the degree of job control using three items on a 4-point Likert scale ranging from 1 (strongly disagree) to 4 (strongly agree). A higher score suggests greater burden of job demands and a greater work controllability. Social support from supervisors and co-workers was assessed by three items, respectively, and the total score (social support at work) was calculated. Social support at home (from family) was also reported by three items. Likewise, job satisfaction and home satisfaction were assessed using the same scale. A higher score suggests better social supports and satisfaction.

2.4.4 | Adjustment variables

Demographic factors

The demographic factors assessed included age (categorized as 15-19, 20-29, ..., 70-79 years), gender (female or male), and body mass index (BMI; <18 , ≥ 18 and <25 , ≥ 25 and <30 and ≥ 30 kg/m²).

Socio-economic factors

Socio-economic status was evaluated by the highest education level achieved (junior high school, high school, vocational school, junior or technical college, university, graduate school or others), marital status (married or common law, single, divorced or widowed), living status (alone, with children or with parents), employment status (company executive, owner of a family-operated business, employee of a family-operated business, management level employee, full-time employee, contract employee, part-time employee/on-the-side worker, student, retired, full-time homemaker or unemployed) and business (construction business, education business, electric/gas/water business, farming/forest/fisheries business, finance business, healthcare service, hotel business, information and communication business, insurance business, manufacturing business, mining industry, public service, real estate business, restaurant business with

alcohol, restaurant business without alcohol, retailing business, transport business, welfare service, wholesale business and others).

Health-related characteristics

Health-related characteristics included smoking status (non-smoker, ex-smoker or current smoker), alcohol consumption (never, ex-drinker, social drinker, <23 g per day, ≥23 and <46 g per day or ≥46 g per day), sleep duration (<4 hours, ≥4 and <6 hours, ≥6 and <8 hours, ≥8 and <10 hours, ≥10 hours or unknown), eight comorbidities (chronic pain, hypertension, diabetes, asthma, coronary disease, stroke, chronic obstructive pulmonary disease and cancer) and psychological distress. The Kessler Psychological Distress Scale (K6), which is composed of six items on a 5-point scale of frequency from 0 (none of the time) to 4 (all of the time), was used to assess mental health during the past 30 days. A higher total score represents more severe mental distress. We defined psychological distress by a cut-off of 13 points as described previously.¹²

Personality

We used the Japanese version of the Ten-Item Personality Inventory (TIPI-J), which is composed of ten items, to assess the following five aspects of an individual's personality: extraversion, agreeableness, conscientiousness, neuroticism, and openness.^{13,14} Each aspect was measured by two items using a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree).

2.5 | Statistical analysis

The participants' characteristics are shown in Table S1. First, we examined the similarity of the reported sitting duration under the state of emergency (from April to May) and after its lift (from June to the survey) and the associations of living status, telework opportunity, type of job, work-related stress, and job and home satisfaction with sitting duration. Second, we analyzed the associations of changes in work performance (improved, no change and worsened) with the sitting duration, telework opportunity and job-related measures including type of job, work-related stress and job and home satisfactions. We also compared the demographic characteristics, SES, health-related characteristics and personality among the groups with different changes in work performance. The chi-square test was used to analyze the categorical data, and a one-way analysis of variance (ANOVA) was used for the continuous data. Next, job-related measures were compared between workers with and without telework experience to identify working backgrounds associated with telework. Effect sizes were calculated depending on the statistical analysis methods (Cohen's *d* and *w* corresponded to

the ANOVA and Chi-square test, respectively). Finally, we performed multivariable logistic regression analyses to identify associations between the sitting duration under the state of emergency, telework experience and job-related measures and improved or worsened work performance compared with the group of no change, adjusted for demographic characteristics, SES, health-related characteristics, personality, and living prefecture. Sensitivity analyses were performed using the sitting duration after the state of emergency was lifted (from June to the survey) instead of during the state of emergency (from April to May). The associations between the sitting duration and work performance change were also examined in groups stratified by telework experience. All statistical analyses were performed using JMP Pro version 13.2 (SAS Institute, Cary, NC, USA).

2.6 | Ethics

All procedures were conducted in accordance with the ethical standards of the Declaration of Helsinki of 1975, as revised in 2013. The study protocol was reviewed and approved by the Research Ethics Committee of the Osaka International Cancer Institute on 19 June 2020 (approval number: 20084). The internet survey agency respected the Act on the Protection of Personal Information in Japan. All participants provided web-based informed consent before answering the online questionnaire. A credit point (E-Points) for internet shopping and cash conversion was given to the participants as an incentive.

3 | RESULTS

As shown in Table S1, 80.6% of workers reported that their work performance did not change compared with their work performance before the COVID-19 pandemic, and 3.6 times more people reported worsened performance than people who reported improved performance (15.1% and 4.2%, respectively).

Several background information was associated with the change of work performance (Table 1). Younger people showed a greater number of people with both improved and worsened work performance. A greater number of men reported both improved and worsened work performance compared to women. While age and gender did not show specific associations with the change of work performance, the BMI category showed a dose-dependent association. The rate of people with improved performance was greater in people with smaller BMI, and the rate of those with worsened performance was greater in those with greater BMI. People who graduated university or graduate university showed a greater number of people with improved as well as worsened

TABLE 1 Participants' characteristics stratified by change in work performance

	Change in work performance		
	Improved	No change	Worsened
Subjects, n (%)	618 (4.2)	11 812 (80.6)	2218 (15.1)
Age (years), n (%)			
15-19	17 (12.0)	101 (71.1)	24 (16.9)
20-24	80 (10.8)	529 (71.4)	132 (17.8)
25-29	92 (7.2)	945 (73.7)	245 (19.1)
30-34	91 (6.7)	1032 (75.9)	237 (17.4)
35-39	75 (5.0)	1186 (79.7)	228 (15.3)
40-44	77 (4.3)	1433 (79.7)	289 (16.1)
45-49	64 (3.2)	1634 (80.5)	331 (16.3)
50-54	38 (2.3)	1400 (83.4)	240 (14.3)
55-59	32 (2.2)	1216 (83.8)	204 (14.1)
60-64	21 (1.8)	1002 (85.4)	151 (12.9)
65-69	14 (1.8)	695 (89.1)	71 (9.1)
70-74	12 (2.4)	445 (89.2)	42 (8.4)
75-79	5 (2.2)	194 (87.0)	24 (10.8)
Gender, n (%)			
Male	368 (4.3)	6740 (79.2)	1406 (16.5)
Female	250 (4.1)	5072 (82.7)	812 (13.2)
Body mass index (kg/m ²), n (%)			
<18	77 (5.0)	1246 (81.4)	207 (13.5)
≥18 and <25	420 (4.2)	8110 (80.8)	1502 (15.0)
≥25 and <30	101 (4.0)	2011 (80.3)	393 (15.7)
≥30	17 (3.0)	429 (76.7)	113 (20.2)
Highest education, n (%)			
Junior high school	6 (4.8)	107 (84.9)	13 (10.3)
High school	125 (3.6)	2940 (84.5)	414 (11.9)
Vocational school	56 (3.0)	1545 (82.3)	276 (14.7)
Junior or technical college	58 (4.2)	1176 (84.2)	162 (11.6)
University	319 (4.7)	5349 (78.1)	1183 (17.3)
Graduate school	52 (5.9)	668 (75.4)	166 (18.7)
Others	2 (6.1)	27 (81.8)	4 (12.1)
Marital status, n (%)			
Married or common-law	326 (3.7)	7169 (82.4)	1210 (13.9)
Single	257 (5.6)	3560 (76.9)	814 (17.6)
Divorced	26 (2.4)	890 (83.0)	157 (14.6)
Widowed	9 (3.8)	193 (80.8)	37 (15.5)
Living status, n (%)			
Alone	151 (4.9)	2401 (77.1)	564 (18.1)
With child(ren)	201 (3.7)	4463 (81.8)	791 (14.5)
With parent(s)	161 (5.0)	2570 (79.5)	500 (15.5)

(Continues)

TABLE 1 (Continued)

	Change in work performance		
	Improved	No change	Worsened
Employment status, n (%)			
Company executive	46 (5.7)	616 (76.1)	148 (18.3)
Contract employee	53 (4.2)	1055 (83.5)	156 (12.3)
Employee of a family-operated business	7 (3.8)	147 (79.5)	31 (16.8)
Full-time employee	274 (4.3)	5062 (78.8)	1092 (17.0)
Management level employee	82 (4.6)	1421 (79.2)	291 (16.2)
Owner of a family-operated business	60 (4.4)	1115 (81.3)	196 (14.3)
Part-time employee/on-the-side worker	96 (3.4)	2396 (85.7)	304 (10.9)
Business category, n (%)			
Construction business	29 (3.6)	665 (83.5)	102 (12.8)
Education business	40 (5.1)	614 (78.3)	130 (16.6)
Electric/gas/water business	13 (6.0)	176 (81.1)	28 (12.9)
Farming/forest/fisheries business	4 (2.8)	125 (87.4)	14 (9.8)
Finance business	19 (4.8)	315 (79.6)	62 (15.7)
Healthcare service	29 (2.7)	915 (84.1)	144 (13.2)
Hotel business	11 (8.1)	105 (77.2)	20 (14.7)
Information and communication business	43 (5.8)	542 (72.7)	161 (21.6)
Insurance business	8 (3.1)	193 (74.0)	60 (23.0)
Manufacturing business	113 (4.6)	1918 (78.4)	415 (17.0)
Mining industry	2 (11.8)	14 (82.4)	1 (5.9)
Public service	44 (4.6)	774 (80.4)	145 (15.1)
Real estate business	11 (3.2)	295 (84.5)	43 (12.3)
Restaurant business with alcohol	13 (4.9)	210 (78.4)	45 (16.8)
Restaurant business without alcohol	11 (6.2)	152 (85.4)	15 (8.4)
Retailing business	40 (3.5)	930 (82.3)	160 (14.2)
Transport business	16 (2.7)	508 (84.4)	78 (13.0)
Welfare service	16 (2.5)	531 (83.4)	90 (14.1)
Wholesale business	22 (4.3)	421 (82.6)	67 (13.1)
Others	134 (4.5)	2409 (80.8)	438 (14.7)
Smoking status, n (%)			
Never smoker	133 (3.9)	2705 (78.7)	598 (17.4)
Ex-smoker	208 (5.0)	3302 (78.6)	693 (16.5)

(Continues)

TABLE 1 (Continued)

	Change in work performance		
	Improved	No change	Worsened
Current smoker	277 (4.0)	5805 (82.8)	927 (13.2)
Alcohol consumption, n (%)			
Never	99 (4.3)	1972 (85.2)	243 (10.5)
Ex-drinker	243 (5.3)	3614 (78.4)	751 (16.3)
Social drinker	177 (4.0)	3539 (79.4)	740 (16.6)
Drinker \leq 23 g	18 (3.1)	465 (81.2)	90 (15.7)
Drinker $>$ 23 and \leq 46 g	32 (2.8)	953 (81.9)	178 (15.3)
Drinker $>$ 46 g	49 (3.2)	1269 (82.7)	216 (14.1)
Sleep duration, n (%)			
$<$ 4 h	120 (8.1)	1102 (74.1)	265 (17.8)
\geq 4 and $<$ 6 h	95 (3.4)	2201 (78.6)	505 (18.0)
\geq 6 and $<$ 8 h	288 (3.6)	6646 (82.0)	1176 (14.5)
\geq 8 and $<$ 10 h	96 (5.7)	1371 (81.7)	211 (12.6)
\geq 10 h	9 (8.0)	86 (76.1)	18 (15.9)
Comorbidity, n (%)			
Chronic pain	56 (3.8)	1077 (72.1)	361 (24.2)
Hypertension	62 (2.7)	1839 (80.7)	377 (16.6)
Diabetes	36 (4.5)	626 (77.6)	145 (18.0)
Asthma	36 (6.8)	374 (70.7)	119 (22.5)
Coronary disease	26 (9.5)	186 (67.6)	63 (22.9)
Stroke	13 (10.5)	76 (61.3)	35 (28.2)
COPD	16 (13.6)	64 (54.2)	38 (32.2)
Cancer	16 (7.1)	150 (66.7)	59 (26.2)
Psychological distress	144 (11.3)	651 (51.2)	477 (37.5)
Ten-Item Personality Inventory (TIPI-J), mean (SD)			
Extraversion	8.2 (2.5)	7.9 (2.3)	7.5 (2.5)
Agreeableness	9.3 (2.2)	9.3 (1.9)	9.1 (2.1)
Conscientiousness	8.1 (2.3)	8.1 (2.0)	7.6 (2.2)
Neuroticism	7.8 (2.2)	7.8 (2.0)	8.5 (2.2)
Openness	8.5 (2.1)	7.9 (1.9)	7.9 (2.1)

Abbreviation: SD, standard deviation.

performance. Single marital status showed the highest rate of both improved and worsened performance. Among the seven employment statuses, company executives showed the highest rate of both improved and worsened performance. More than one-fourth of people working in an information and communication and in an insurance business reported that work performance was worsened. People with improved performance increased in ex-smokers, but those with worsened one increased in never smokers and ex-smokers. Regular

drinkers showed a smaller number of people with improved performance, but ex-drinkers and social drinkers showed a greater number of those with worsened one. Short sleepers whose sleep duration was $<$ 6 hours reported greater number of people with worsened performance, but people with less sleep duration than four hours showed the greatest rate of improved performance. Comorbidity was associated with the change of work performance. In particular, people with chronic pain and hypertension showed an increased number of people with worsened performance and a decreased number of those with improved performance, while the other comorbidities increased people with both improved and worsened performance. In terms of personality, people with improved performance showed more extraversion and openness, while those with worsened performance showed less extraversion, agreeableness, and consciousness personalities and more neuroticism.

The sitting durations while under the state of emergency and after its lift were significantly associated, and 10 926 workers (74.6%) reported the same categories of sitting duration before and after the state of emergency (Table S2). People living alone reported a longer sitting duration, whereas people with child(ren) and/or parent(s) reported a shorter sitting duration. Telework opportunity significantly increased sitting duration. Desk workers reported a significantly longer sitting duration, whereas blue-collar workers reported a shorter sitting duration. Workers with a long sitting duration had smaller job demands, greater job control and were more likely to report job dissatisfaction, whereas low social support and less home satisfaction were observed in workers with both long and short sitting durations.

As shown in Table 2, the highest rate of improved performance and the lowest rate of worsened performance were both found in the workers with $<$ 2 hours of sitting duration for both sitting duration in April and May and from June to the survey. Having any telework opportunities (implementation, increased and overall experience) was associated with increased rates of both improved and worsened performance. The smallest rate of performance change was found in blue-collar workers, whereas both sales and desk work had an increased rate of people with worsened performance. People with improved performance showed greater job demands, job control and social support. Conversely, people with worsened performance showed less job control and social support but greater job demands. Job and home satisfaction showed dose-dependent associations with changes in work performance. The rate of improved performance increased and the rate of worsened performance decreased in people who were satisfied with their job and home.

Table S3 shows differences in job-related measures associated with telework experience. Telework was implemented for a higher proportion of desk workers and fewer blue-collar

TABLE 2 Sitting duration and confounding factors related to work stratified by change in work performance

	Change in work performance			P-value
	Improved n = 618	No change n = 11 812	Worsened n = 2218	
Sitting duration (April-May), n (%)				
<2 h	157 (5.2)	2512 (82.5)	375 (12.3)	<.001
≥2 and <4 h	122 (4.3)	2322 (82.2)	381 (13.5)	
≥4 and <6 h	92 (3.4)	2231 (81.8)	404 (14.8)	
≥6 and <8 h	92 (3.9)	1897 (79.6)	395 (16.6)	
≥8 h	136 (4.7)	2139 (74.6)	594 (20.7)	
Unknown	19 (2.4)	711 (89.0)	69 (8.6)	
Sitting duration (June-Survey), n (%)				
<2 h	159 (5.3)	2462 (82.3)	372 (12.4)	<.001
≥2 and <4 h	140 (4.2)	2720 (82.3)	446 (13.5)	
≥4 and <6 h	94 (3.6)	2106 (81.2)	395 (15.2)	
≥6 and <8 h	85 (3.8)	1770 (79.8)	364 (16.4)	
≥8 h	121 (4.4)	2050 (74.8)	570 (20.8)	
Unknown	19 (2.4)	704 (88.7)	71 (8.9)	
Telework, n (%)				
Implementation	183 (6.7)	1939 (71.1)	607 (22.2)	<.001
Increased	221 (7.1)	2183 (69.7)	730 (23.3)	<.001
Overall experience	305 (6.9)	3161 (71.5)	955 (21.6)	<.001
Type of job, n (%)				
Blue-collar	133 (3.4)	3297 (84.5)	470 (12.1)	<.001
Sales	175 (4.9)	2835 (78.9)	583 (16.2)	
Desk work	310 (4.3)	5680 (79.4)	1165 (16.3)	
Work-related stress, mean (SD)				
Job demands	15.1 (4.5)	13.8 (4.1)	15.2 (4.1)	<.001
Job control	8.8 (2.3)	7.9 (2.3)	7.5 (2.4)	<.001
Social support at work	10.0 (4.5)	8.6 (4.4)	7.7 (4.1)	<.001
Social support at home	6.4 (2.4)	5.8 (2.4)	5.3 (2.5)	<.001
Job satisfaction, n (%)				
Unsatisfied	59 (2.9)	1471 (71.7)	522 (25.4)	<.001
Slightly unsatisfied	122 (2.8)	3427 (78.5)	816 (18.7)	
Slightly satisfied	292 (4.4)	5612 (84.1)	769 (11.5)	
Satisfied	145 (9.3)	1302 (83.6)	111 (7.1)	
Home satisfaction, n (%)				
Unsatisfied	43 (2.9)	1059 (72.5)	359 (24.6)	<.001
Slightly unsatisfied	116 (3.5)	2589 (77.2)	649 (19.4)	
Slightly satisfied	279 (3.9)	5895 (82.9)	934 (13.1)	
Satisfied	180 (6.6)	2269 (83.3)	276 (10.1)	

Note: Chi-square test and ANOVA was performed for categorical data and continuous data respectively.

Abbreviation: ANOVA, analysis of variance.

workers. Workers with telework experience showed statistically significantly smaller job demands, higher job control and higher social support compared with those without telework opportunities. A higher rate of people teleworking also

experienced both job and home satisfaction compared with those who were not teleworking.

As shown in Table 3, the multivariable logistic regression analysis indicated that a longer sitting duration during the state

	Improved performance			Worsened performance		
	OR	95% CI (LL, UL)	P-value	OR	95% CI (LL, UL)	P-value
Sitting duration (April-May)						
<2 h	1		—	1		—
≥2 and <4 h	1.30	(0.97, 1.73)	.079	1.29	(1.09, 1.54)	.004
≥4 and <6 h	1.06	(0.77, 1.47)	.709	1.51	(1.26, 1.81)	<.001
≥6 and <8 h	1.17	(0.84, 1.64)	.352	1.61	(1.34, 1.93)	<.001
≥8 h	1.19	(0.86, 1.64)	.305	1.83	(1.53, 2.19)	<.001
Telework experience	2.04	(1.63, 2.55)	<.001	1.73	(1.50, 2.00)	<.001
Type of job						
Blue-collar	1		—	1		—
Sales	1.00	(0.74, 1.34)	.981	1.34	(1.10, 1.63)	.004
Desk work	0.81	(0.60, 1.09)	.159	1.15	(0.95, 1.39)	.151
Work-related stress						
Job demands	1.21	(1.10, 1.33)	<.001	1.31	(1.24, 1.38)	<.001
Job control	1.27	(1.14, 1.41)	<.001	0.94	(0.89, 1.00)	.038
Social support at work	1.00	(0.98, 1.02)	.910	0.98	(0.97, 0.99)	.008
Social support at home	1.07	(1.02, 1.13)	.005	0.99	(0.97, 1.02)	.550
Job satisfaction						
Unsatisfied	1		—	1		—
Slightly unsatisfied	0.86	(0.60, 1.24)	.429	0.80	(0.69, 0.94)	.005
Slightly satisfied	1.21	(0.85, 1.71)	.288	0.56	(0.47, 0.66)	<.001
Satisfied	1.89	(1.25, 2.85)	.002	0.42	(0.32, 0.55)	.001
Home satisfaction						
Unsatisfied	1		—	1		—
Slightly unsatisfied	1.00	(0.66, 1.51)	.997	1.00	(0.84, 1.20)	.982
Slightly satisfied	0.96	(0.64, 1.42)	.822	0.85	(0.71, 1.01)	.068
Satisfied	1.19	(0.77, 1.82)	.437	0.74	(0.59, 0.92)	.007

Note: ORs in workers with improved and worsened performance were generated compared to the group with no work performance change, respectively. Adjusted for age, gender, body mass index, highest education level achieved, marital status, living status, employment status, business, smoking status, alcohol consumption, sleep duration, comorbidities, psychological distress, personality and living prefecture.

Abbreviations: CI, confidence interval; LL, lower limit; OR, odds ratio; UL, upper limit.

TABLE 3 Multivariable logistic regression analysis of the work performance change based on the sitting duration from April to May

of emergency was significantly associated with worsened work performance. The odds ratios (ORs) of worsened performance compared with a sitting duration of <2 h increased for longer sitting durations. Conversely, the sitting duration was not statistically associated with improved work performance. Telework experience significantly improved performance but also worsened performance, suggesting that teleworking was an unspecific factor associated with work performance. More sales workers displayed worsened performance compared with blue-collar

workers, and none of the job types was associated with improved work performance. Greater job demands significantly improved and worsened work performance, whereas better job control significantly increased the rate of people who reported improved performance and decreased the rate who reported worsened performance. Furthermore, improved performance was associated with better social support at home, whereas a decrease of worsened performance was associated with better social support at work. People with job satisfaction had a significantly lower OR

TABLE 4 Multivariable logistic regression analysis of work performance change based on the sitting duration from June to the survey

	Improved performance			Worsened performance		
	OR	95% CI (LL, UL)	P-value	OR	95% CI (LL, UL)	P-value
Sitting duration (June-Survey)						
<2 h	1		—	1		—
≥2 and <4 h	1.11	(0.84, 1.46)	.476	1.22	(1.03, 1.45)	.021
≥4 and <6 h	1.05	(0.76, 1.44)	.771	1.50	(1.25, 1.80)	<.001
≥6 and <8 h	1.12	(0.80, 1.58)	.512	1.54	(1.27, 1.87)	<.001
≥8 h	1.04	(0.74, 1.44)	.837	1.78	(1.47, 2.15)	<.001
Telework experience	2.04	(1.63, 2.55)	<.001	1.75	(1.52, 2.02)	<.001
Type of job						
Blue-collar	1		—	1		—
Sales	1.00	(0.74, 1.35)	.995	1.34	(1.10, 1.63)	.004
Desk work	0.82	(0.61, 1.10)	.187	1.13	(0.93, 1.37)	.221
Work-related stress						
Job demands	1.21	(1.10, 1.33)	.0351	1.31	(1.23, 1.38)	<.001
Job control	1.27	(1.14, 1.41)	<.001	0.94	(0.89, 1.00)	.041
Social support	1.11	(1.01, 1.23)	<.001	0.91	(0.85, 0.96)	.002
Job satisfaction						
Unsatisfied	1		—	1		—
Slightly unsatisfied	0.86	(0.60, 1.24)	.419	0.80	(0.69, 0.94)	.005
Slightly satisfied	1.20	(0.85, 1.70)	.297	0.56	(0.47, 0.66)	<.001
Satisfied	1.87	(1.24, 2.82)	.003	0.41	(0.32, 0.54)	<.001
Home satisfaction						
Unsatisfied	1		—	—		—
Slightly unsatisfied	1.00	(0.66, 1.51)	1.000	1.00	(0.83, 1.20)	.986
Slightly satisfied	0.96	(0.65, 1.42)	.834	0.84	(0.70, 1.01)	.064
Satisfied	1.19	(0.77, 1.82)	.434	0.74	(0.59, 0.92)	.007

Abbreviations: CI, confidence interval; LL, lower limit; OR, odds ratio; UL, upper limit.

of worsened performance and a higher OR of improved performance. The OR of worsened performance also decreased with home satisfaction, but the improved performance was not statistically associated with home satisfaction. Similar results were identified in the model using the sitting duration from June to the survey (Table 4). The significant dose-dependent association between sitting duration and worsened work performance was also identified in workers stratified by telework experience and type of job (Tables S4 and S5).

4 | DISCUSSION

Changes in the work environment after the COVID-19 pandemic generated a global consensus to accept several types

of workstyles including teleworking. This study showed that while 4.2% of people reported improved work performance, 3.6 times as many people reported worsened work performance than those reporting improved performance. These findings would be temporal numbers, because we have to accept and adapt to this challenging situation. Therefore, it is important to investigate the risk factors affecting work performance change to improve the performance as fast as possible.

Sitting duration both under the state of emergency and after it was lifted was associated with worsened work performance in a dose-response manner. These findings were consistent with a previous epidemiological study that identified a significant association between higher job performance and lower occupational sitting times.¹⁵ Although people with a

longer sitting duration had relatively smaller work demands, the longer sitting duration had a significantly greater OR of worsened work performance, indicating that sitting duration is a risk barometer for impaired work performance.

Sitting duration included the time spent both working and not working because these values were not discriminated between in this survey, suggesting people with long sitting duration had few opportunities of physical activity. People with physical inactivity are presumably hard to maintain work performance, as sedentary behavior links to negative mental health,^{16,17} which is associated with impaired performance.¹⁸ Physical activity increases self-esteem and protects mental illnesses. People with long sitting duration are possibly losing the chance of recovery from the state of impaired performance.

Sitting duration could also be extended by impaired performance due to a lack of communication in a working group and/or a change in the working situation induced by the COVID-19 pandemic when the subject had a fixed quota of work per day. Conversely, a long sitting duration when not working might be a risk factor for decreased performance. For example, a previous study identified significant associations for time spent in sedentary behavior before and after work and presenteeism.¹⁹ Before the COVID-19 pandemic, people enjoyed many types of leisure when not working. However, quarantine and entertainment restrictions during the state of emergency limited several leisure activities. Since leisure activities can facilitate recovery from job stress and work performance,²⁰ the limited leisure after the COVID-19 pandemic might lead to decreased performance and increased sedentary behavior.

One study evaluated the effectiveness of planned daily breaks from sitting.²¹ They compared taking short breaks (one to two minutes every half hour) to taking long breaks (two 15-minute breaks per workday). Short breaks reduced time spent sitting at work on average by 40 minutes per day compared to long breaks, implicating good performance could be achieved with appropriate breaks.

Time management abilities might explain the association between sitting duration and work performance change. Given that telework increases both job control and sitting duration, people who sit for long periods of time may have enough reserved time to adjust a balance between work and leisure. However, a long sitting duration was associated with worsened performance, while job control should improve performance. This inconsistency might be a result of time management skills, which can affect the association between job control and work performance.²² Since social distancing was prioritized by the COVID-19 pandemic, team communication might be sacrificed, and job control might depend on the individual. People who lack proper time management skills may fail to control the balance between work and life and impair their work performance, resulting in a prolonged

sitting duration. Limited communication would also impair performance in sales.

Telework was accelerated globally through the COVID-19 pandemic.^{23,24} This study indicates that telework experience was associated with job control, social support, job satisfaction, and home satisfaction. Although these indexes of work-related stress improved performance,^{8,9} telework itself increased both the rate of people with worsened performance and the rate of people with improved performance. The effects of telework experience on both worsened and improved performance remained even after adjusting for work-related stress, suggesting that there are some unmeasured factors that affect performance in telework experience. Work efficiency can be impaired by non-ideal surroundings in telework including an uncomfortable chair, low-speed internet access and the presence of disturbers at home. The relationship between home satisfaction and work performance would reflect the presence of good surroundings when working-from-home.

Our study has some limitations. First, original questions were used for the main measures. A single non-validated question was asked for the sitting duration in this study. Change in overall work performance was also assessed by a single non-validated question respectively, because this was a preliminary cross-sectional study focusing on the change after COVID-19 pandemic. We did not breakdown work performance into component factors. In addition, we had no data on work performance before the pandemic, and we could not assess the exact degree of work performance change, suggesting the recall bias could not be removed. Further longitudinal study using a validated questionnaire will be required to identify the detail of work performance change. Second, as with any observational study, we could not fully account for unmeasured confounders, and our study was unable to identify the exact mechanisms of the association between sitting duration and work performance change. Third, given the cross-sectional design of our study, we could not identify the causal relationship between the sitting duration and work performance change. Instead, of a long sitting duration worsening work performance, it was possible that people who had decreased performance were more likely to be more sedentary. Finally, our study sample was collected through a web-based survey, indicating that our findings may not be generalizable to the population with limited access or literacy to the internet.

In conclusion, the change in the work environment due to the COVID-19 pandemic decreased work performance in 15% of people, which was 3.6 times greater than the proportion of people who displayed increased performance. This study indicated that the longer the sitting duration after the state of emergency, the higher the rate of people with decreased work performance. Although more and more workstyles including telework will be required even after the COVID-19 pandemic, caution must be maintained because there is still an uncertain effect on work performance. Further

studies should focus on determining the risk factors associated with a long sitting duration to improve performance in the post COVID-19 context.

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AUTHOR CONTRIBUTIONS

KW designed the study, analyzed the data, and drafted the manuscript. KY and AS critically revised the first draft for important intellectual content. TT conducted the JACSIS and collected the data. All authors contributed to the final manuscript.

CONFLICT OF INTEREST

All authors have no competing interests to report.

DISCLOSURES

Approval of the research protocol: The study protocol was reviewed and approved by the Research Ethics Committee of the Osaka International Cancer Institute on 19 June 2020 (approval number: 20 084). *Informed consent:* All participants provided web-based informed consent before answering the online questionnaire. *Registry and the registration no. of the study/trial:* N/A. *Animal studies:* N/A.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to ethical restrictions.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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