Original Research

Association between forest and greenspace walking and stress-coping skills among workers of Tsukuba Science City, Japan: A cross-sectional study

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ABSTRACT

Objectives: Recently, "sense of coherence" (SOC) as a concept of stress-coping, has been gaining considerable attention. Although many studies have investigated the factors related to strong SOC, we found little evidence about the associations between SOC and habits that are easy to perform in everyday life. The aim our study was to examine the prevalence of workers who engage in forest walking and greenspace walking and examine their association with SOC score.

Study design: A cross-sectional study.

Methods: An anonymous, self-report web questionnaire was conducted in November 2017. The study population included 19481 workers belonging to the Tsukuba Science City Network and data of 6466 participants (3965 men and 2501 women) were analyzed.

Results: The percentage of participants who engage in forest and greenspace walking at least once a year were 55.9% and 75.9%, respectively. Associations between forest/greenspace walking and SOC score were calculated using Chi-squared tests. Multinomial logistic regression analyses with SOC score group (strong/middle/weak) as a dependent variable and forest/greenspace walking as explanatory variables were performed. Statistically significant positive associations were observed between strong SOC and those who engaged in forest/greenspace walking after adjusting for socioeconomic factors. The odds ratios for strong SOC were 3.65 (95% CI = 1.70–7.85) for forest walking at least once a week and 2.12 for greenspace walking (95% CI = 1.54–2.92) at least once a week.

Conclusions: Our findings suggested that forest/greenspace walking may enhance workers' stress-coping skills.

1. Introduction

Mental stress among workers has become a global issue. In the United States, the loss of productivity in the workplace due to mental illness is reported to be comparable to treatment costs of cardiovascular diseases and AIDS [1]. In Japan, the economic loss resulting from depressive disorders and suicide is estimated to be 2.7 trillion Japanese Yen [2]. To reduce mental stress among workers, it is important to focus not only on external factors (such as occupational stressors, job control, social support system, and rewards [3]), but also on internal factors (such as recognizing one's style of dealing with occupational stress [4]).

The focus of this study is one such internal factor, "sense of coherence" (SOC) [5], which is comprised of three inter-related components: meaningfulness, comprehensibility, and manageability [6]. Meaningfulness is the feeling that there is a meaning for life; comprehensibility is the feeling that one can recognize stress as understandable; and manageability is the feeling that one has enough resources to deal with the stress. Previous studies have shown that SOC is related to mental wellbeing [7] and reflects one's stress-coping skills [8]. People who have a stronger SOC might cope with life stressors more proactively [9], whereas weaker SOC might be predictive of depressive episodes [10]. Even in the workplace, SOC could be an indicator of a worker's stress coping skills [11]. Therefore, to deal with occupational stress more proactively and effectively, it is important to know what factors are

associated with SOC. Many studies have investigated the factors related to SOC [12–15]. Factors that have been reported to have a significant association between strong SOC include: educational background (college or graduate school graduates have stronger SOC than high school or junior high school graduates [12]) and marital status (those who are married have stronger SOC than those who are not [13]), whereas individual income reportedly has no significant bearing SOC score [14]. Education and marital-status, however, are factors that cannot be easily changed. Other more amendable factors that have been reported to have association with SOC include: smoking status (non-smokers have stronger SOC than smokers [15]) and physical exercise (those who exercise frequently have stronger SOC than those who excise infrequently [13]). While strenuous physical exercise might be difficult for the elderly and those with disabilities or undergoing treatment, gentler forms of exercise such as walking may have a beneficial effect on SOC and, unlike some other forms of stress-management such as Zen meditation [16], it requires no specific techniques or training.

There have been several studies about the preventive medical effects of forest/woodland and greenspace walking, including: a reduction of depression and tension after walking in forests for several hours [20]; a significant positive association between the frequency of going to the forest and self-reported health [21]; and greenspaces are associated with a reduction in psychological stress, especially where various species of plants are present [22]. Some studies [23,24], approaching this question from a human evolutionary perspective, have reasoned that humans feeling of comfort in nature, derives from the fact that human physiological functions have adapted to the natural environment throughout human evolutionary history.

With forests occupying 67% of the Japanese landmass [17] and greenspaces, such as city parks, increasing every year [18], access to natural environments for walking is relatively easy in Japan. Furthermore, a public opinion polls showing that 60.2% of respondents expressed a desire to have forest walking to promote mental and physical health [19], implying that this activity might be popular in Japan.

In this study, therefore, we examined the prevalence of forest walking and greenspace walking among Japanese workers and clarified their association with SOC as a stress-coping skill.

2. Methods

This study is a secondary analysis of data from the 7th living Condition and Workplace Stress Survey conducted in 2017 by the Tsukuba Science City Network. The survey methodology has been described in detail in previous reports [25–28]. Briefly, this anonymous survey assessed forest walking, greenspace walking, SOC score, sex, age, marital status, educational background, household income, smoking status, and physical exercise. The study population included 19481 people working in Tsukuba Science City, Japan. Since September 2016, the area to which Tsukuba City belongs has been designated "Japan Geopark" –a place to have interaction with forest and greenspaces [29]. Our analysis included workers aged between 20 and 59 years of age who responded to all survey items.

2.1. Questionnaire

Evaluation of forest walking was made based on the responses to the following question: "How often do you go for forest walking (including hiking, nature observation, mountain climbing, camping in the mountains, but not including visits to city parks)?" There were six answer options: "At least once a week," "2–3 times a month," "Once a month," "Several times a year," "Once a year," and "Hardly ever." For the analysis, the responses were divided into 4 categories: "None," "At least once a year," "At least once a month," and "At least once a week."

Evaluation of greenspace walking was made based on the responses to the following question: "How often do you go to greenspace (such as city parks, except for forests)?" There were seven answer options: "More than

Table 1
Descriptive characteristics of the participants.

Characteristics	n	(%)
Overall	6466	(100.0)
SOC score group		
Strong (69–91)	1134	(17.5)
Middle (44–68)	4391	(67.9)
Weak (13–43)	941	(14.6)
Sex		
Men	3965	(61.3)
Women	2501	(38.7)
Age group		
20-29	646	(10.0)
30-39	1812	(28.0)
40-49	2162	(33.4)
50-59	1846	(28.5)
Marital status		
Married	4483	(69.3)
Divorced/widowed	240	(3.7)
Never married	1743	(27.0)
Educational attainment		
Graduate school	3150	(48.7)
University	1727	(26.7)
College	757	(11.7)
High school	832	(12.9)
Annual household income, JPY		
12 million or more	997	(15.4)
8–12 milliion	2215	(34.3)
4–8 million	2304	(35.6)
4 million or less	950	(14.7)
Smoking status		
Never smoked	4681	(72.4)
Quit smoking	1093	(16.9)
Currently smoking	692	(10.7)
Physical exercise		
More than once a week	1082	(16.7)
Once a week	1888	(29.2)
Several times a month	1101	(17.0)
Less than once a month	2395	(37.0)
Forest walking		
At least once a week	153	(2.4)
At least once a month	760	(11.8)
At least once a year	2702	(41.8)
None	2851	(44.1)
Greenspace walking		
At least once a week	1092	(16.9)
At least once a month	1961	(30.3)
At least once a year	1858	(28.7)
None	1555	(24.0)

twice a week," "1–2 times a week," "2–3 times a month," "Once a month," "Several times a year," "Once a year," and "Hardly ever." For the analysis, the responses were divided into 4 categories: "None," "At least once a year," "At least once a month," and "At least once a week."

SOC was evaluated using the Japanese version of the SOC score, which consists of 13 items that are answered using a 7-point scale [30]. The sum of these scores (SOC score) can range from 13 to 91, with a higher score indicating a stronger SOC and, thus, greater ability to cope with stress [6]. The reliability and validity of this scale have been confirmed [31].

Respondents were categorized into four age groups: 20s (20–29 years), 30s (30–39 years), 40s (40–49 years), and 50s (50–59 years). Marital status included three options of: married, divorced/widowed, and never married. Educational background had four options of: high school, vocational college, university, and graduate school. Household income per year included four options of: 4 million yen or less, 4–8 million yen, 8–12 million yen, and 12 million yen or more. Smoking status had three options of: never smoked, quit smoking, and currently smoking. Physical exercise was measured with the questionnaire item: "How often do you exercise for more than 30 min?" There were five answer options: "more than twice a week," "twice a week," "once a

Table 2
Associations between forest walking, SOC score, and other factors.

	At least once a week	At least once a month	At least once a year	None	p-value
	2.4%	11.8%	41.8%	44.1%	
SOC score group					
Weak (13–43)	1.0%	7.4%	34.1%	57.5%	<0.01
Middle (44–68)	2.4%	12.0%	43.1%	42.6%	
Strong (69–91)	3.6%	14.3%	43.1%	39.0%	
Sex					
Men	2.8%	12.4%	42.3%	42.5%	<0.01
Women	1.7%	10.7%	41.0%	46.7%	
Age group					
20-29	1.5%	14.2%	39.0%	45.2%	<0.01
30-39	2.1%	11.7%	44.6%	41.6%	
40-49	2.5%	11.6%	43.4%	42.5%	
50-59	2.8%	11.2%	38.0%	48.0%	
Marital status					
Married	2.5%	12.0%	43.3%	42.2%	<0.01
Divorced/widowed	2.1%	7.1%	39.6%	51.3%	
Never married	2.1%	11.7%	38.2%	48.0%	
Educational attainment					
Graduate school	2.1%	12.4%	45.6%	59.4%	<0.01
University	3.1%	12.9%	41.2%	23.1%	
College	1.6%	9.4%	36.1%	5.7%	
High school	2.6%	8.9%	33.8%	54.7%	
Annual household income, JPY					
12 million or more	1.9%	10.8%	47.5%	39.7%	<0.01
8–12 milliion	2.4%	11.6%	42.9%	43.1%	
4–8 million	2.5%	12.1%	40.0%	45.5%	
4 million or less	2.4%	12.4%	37.5%	47.7%	
Smoking status					
Never smoked	2.2%	12.2%	42.7%	42.9%	<0.01
Quit smoking	3.6%	12.1%	41.4%	42.9%	
Currently smoking	1.7%	7.9%	36.4%	53.9%	
Physical exercise					
More than once a week	4.8%	14.2%	44.2%	36.9%	<0.01
Once a week	2.4%	14.4%	46.4%	36.8%	
Several times a month	1.4%	16.8%	44.8%	37.1%	
Less than once a month	0.9%	6.3%	36.5%	56.3%	

Statistical analyses were conducted with Chi-squared test.

Table 3
Associations between greenspace walking, SOC score, and other factors.

	At least once a week	At least once a month	At least once a year	None	p-value
	16.9%	30.3%	28.7%	24.0%	
SOC score group					
Weak (13–43)	12.0%	22.8%	27.9%	37.2%	<0.01
Middle (44–68)	16.7%	30.8%	29.5%	23.0%	
Strong (69–91)	21.6%	34.8%	26.3%	17.3%	
Sex					
Men	18.1%	32.7%	26.8%	22.5%	<0.01
Women	15.0%	26.6%	31.9%	26.5%	
Age group					
20-29	9.9%	29.7%	32.2%	28.2%	<0.01
30-39	19.0%	36.0%	25.0%	20.0%	
40-49	16.7%	30.4%	29.4%	23.5%	
50-59	17.6%	24.9%	30.4%	27.1%	
Marital status					
Married	18.6%	33.5%	28.3%	19.7%	<0.01
Divorced/widowed	13.3%	20.0%	37.5%	29.2%	
Never married	13.0%	23.7%	28.7%	34.7%	
Educational attainment					
Graduate school	19.0%	35.4%	26.9%	18.6%	<0.01
University	17.0%	29.4%	28.5%	25.1%	
College	12.5%	22.3%	34.7%	30.4%	
High school	12.5%	20.2%	30.6%	36.7%	
Annual household income, JPY					
12 million or more	20.5%	34.5%	26.8%	18.3%	<0.01
8–12 milliion	17.8%	31.4%	29.6%	21.2%	
4–8 million	15.6%	29.7%	28.4%	26.3%	
4 million or less	14.2%	25.1%	29.5%	31.3%	
Smoking status					
Never smoked	16.8%	31.1%	29.5%	22.7%	<0.01
Quit smoking	20.4%	30.2%	26.4%	23.0%	
Currently smoking	12.0%	25.6%	27.3%	35.1%	
Physical exercise					
More than once a week	28.6%	29.5%	23.5%	18.4%	<0.01
Once a week	18.1%	35.8%	27.7%	18.4%	
Several times a month	14.3%	39.6%	28.6%	17.5%	
Less than once a month	8.2%	24.3%	33.4%	34.1%	

Statistical analyses were conducted with Chi-squared test.

week," "1–3 times a month," and "less than once a month."

2.2. Statistical analysis

The respondents were classified into four groups based on the frequency of forest/greenspace walking. Because there is no definitive cut-off point for the SOC scale, we used the mean and standard deviation (SD) of the overall SOC score to define the groups. The participants with an SOC score lower than 44 (mean minus SD) were defined as the weak SOC group, whereas those with an SOC score higher than 68 (mean plus SD) were defined as the strong SOC group. Next, the associations between forest walking, greenspace walking, SOC score, sex, age, marital status, educational background, household income, smoking habit, and physical exercise were calculated using the Chi-squared test. Furthermore, multinomial logistic regression analyses with SOC score group (strong/middle/weak) as a dependent variable were performed, using forest/greenspace walking, socioeconomic factors, smoking habit, and physical exercise as explanatory variables. The odds ratios (ORs) for strong/middle SOC (base category; weak SOC) associated with forest and greenspace walking (reference; those who had no forest/greenspace walking) were calculated. Two-sided significance level was set at 5% in both tests, and SPSS statistics version 25 for Windows was used for all statistical analysis. As for a classification of SOC and statistical method of multinomial logistic regression analyses with SOC, the methodology described in previous studies was followed [4,11,32,33].

3. Results

Of the 19481 employees, data of 6466 participants (3965 men and 2501 women) who answered the above questions appropriately were analyzed. The percentage of employees analyzed was 33.2% and the mean age was 42.7 ± 9.4 years. Descriptive characteristics of the participants are shown in Table 1. The mean SOC score was 56.2 ± 12.7, and the percentage of participants in the weak (SOC score 13–43) and strong (SOC score 69–91) SOC groups was 14.6% and 17.5%, respectively. The percentage of participants who go forest and greenspace walking at least once a year was 55.9% and 75.9%, respectively.

Associations between forest/greenspace walking, and SOC score group, socioeconomic factors (such as educational background and household income), smoking status, and physical exercise are shown in

Table 4
Odds ratios for strong/middle SOC associated with forest/greenspace walking (base category; weak SOC).

	Crude model		Model 1		Model 2	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Strong SOC (69–91)						
Forest walking						
None	(ref.)		(ref.)		(ref.)	
At least once a year	1.30	(1.05–1.60)	1.35	(1.09–1.67)	1.31	(1.06–1.63)
At least once a month	1.75	(1.26–2.43)	1.83	(1.31–2.55)	1.96	(1.40–2.74)
At least once a week	3.06	(1.44–6.49)	3.04	(1.43–6.49)	3.65	(1.70–7.85)
Greenspace walking						
None	(ref.)		(ref.)		(ref.)	
At least once a year	1.78	(1.37–2.30)	1.80	(1.39–2.34)	1.60	(1.22–2.08)
At least once a month	2.59	(1.99–3.39)	2.82	(2.15–3.70)	2.10	(1.59–2.78)
At least once a week	2.69	(1.98–3.66)	2.74	(2.01–3.75)	2.12	(1.54–2.92)
Middle SOC (44–68)						
Forest walking						
None	(ref.)		(ref.)		(ref.)	
At least once a year	1.35	(1.14–1.60)	1.38	(1.16–1.63)	1.36	(1.14–1.61)
At least once a month	1.63	(1.23–2.17)	1.66	(1.25–2.21)	1.70	(1.28–2.27)
At least once a week	2.50	(1.24–5.02)	2.48	(1.23–5.01)	2.73	(1.35–5.54)
Greenspace walking						
None	(ref.)		(ref.)		(ref.)	
At least once a year	1.48	(1.22–1.80)	1.49	(1.23–1.81)	1.40	(1.15–1.71)
At least once a month	1.75	(1.42–2.15)	1.84	(1.49–2.27)	1.57	(1.27–2.00)
At least once a week	1.70	(1.32–2.19)	1.74	(1.35–2.24)	1.51	(1.17–2.00)
Nagelkerke R^2	0.04		0.06		0.09	

Statistical analyses were conducted with multinomial logistic regression.
Model 1. Adjusted for age group.
Model 2. Adjusted for sex, age group, marital status, educational attainment, annual household income, smoking status, and physical exercise.

Table 2 (forest walking) and Table 3 (greenspace walking). The percentage of those in the strong SOC group was significantly higher among participants who engage in forest/greenspace walking at least once a month.

The ORs for strong/middle SOC (base category; weak SOC) associated with forest and greenspace walking are shown in Table 4. Statistically significant positive associations were observed between forest/greenspace walking and strong/middle SOC after adjustment for sex, age, socioeconomic factors, smoking habits, and physical exercise. For those who go forest/greenspace walking at least once a week, the ORs for strong SOC after adjustment for age, socioeconomic factors, smoking habits, and physical exercise were 3.65 (95% CI = 1.70–7.85) and 2.12 (95% CI = 1.54–2.92), respectively.

4. Discussion

In this study, we surveyed the prevalence of workers who have forest/greenspace walking and their SOC scores. Regarding greenspace walking, our finding is similar to the 72.2% reported in a public opinion poll conducted in Japan [34]. The mean SOC score was also similar previous study which reported the mean SOC score among 2063 participants (956 men and 1107 women, mean age 50.0 ± 14.3) was 59.0 ± 12.2 [35]. Forest walking or greenspace walking at least once a week showed a significantly positive association with strong/middle SOC after adjustment for sex, age, socioeconomic factors, smoking habits, and physical exercise. Previous studies have shown that adolescents with a weak SOC may easily adopt poor health habits, such as smoking and drinking alcohol [36,37], while those who exercise frequently have stronger SOC than those who exercise infrequently [13]. thus, forest/greenspace walking can be considered as good health habits such as healthy eating or abstinence from drinking alcohol. Though there are many relaxation and stress management programs, they often require specific techniques and certain skills [16]. In contrast, forest/greenspace walking requires no specialized techniques, skills, or equipment, and can be easily adopted into daily life. Unfortunately, from 1965 to 2003, agricultural and forest land in Japan has decreased by about 219,000 ha [38]; so, for people living in urban areas, access to forest areas might be limited. However, the number of city parks has been increasing annually, reaching about

10.6 m^2/person in 2019 [18]. So, even in urban areas where it is difficult to access forests, people are likely to have access to city parks where they can enjoy greenspace walking.

It might be inferred from our findings that forest or greenspace walking at least once a week is associated with a strong SOC, that is, having effective stress-coping skills. Previous studies have shown that viewing trees from a hospital window promoted patients' recovery after surgery, which suggests that a visual factor alone can affect human health [39] and that forest environments could be viewed as therapeutic landscapes [20,40]. Therefore, the visual factor, that is, viewing the green environment may be one possible reason for the positive association between forest/greenspace walking and strong SOC. The results of this study, however, did not identify which factors of forest/greenspace walking were involved in the association with strong SOC; therefore, further studies exploring the reasons for this association are required.

Another possible explanation for the positive association between forest/greenspace walking and strong SOC could be one of the key concepts of SOC, that is, the salutogenic framework, which relates to an individual's generalized resistance resources [5]. A strong SOC implies a way of thinking that enables people to identify and use the resources that are available to them [41]. Therefore, the findings of present study indicate that forest/greenspace walking might be one such generalized resistance resource that can help people to cope with stress. Thus, the "Green City Life" policy, which promotes conservation and effective utilization of forests and greenspaces [42] could enrich generalized resistance resources and reduce mental stress among workers.

The present study has a number of strengths. Firstly, it is a large-scale epidemiological survey of adult workers, in which, for the first time in Japan, the association between forest/greenspace walking and SOC score was investigated. Secondly, we adjusted for the influences of socioeconomic factors (such as educational background and household income), as well as smoking habits, and physical exercise, which have been reported to affect SOC score in previous studies [36,37].

The limitations of this study should also be considered. First, this is a cross-sectional study; therefore, the causal relationships are unclear. Longitudinal studies to investigate how forest/greenspace walking can increase SOC may be meaningful. Second, most of the study respondents were researchers, whose educational attainment were graduate school

and university and their mean annual household income was higher than that of most workers. Therefore, generalization of our results requires caution. Third, because this study used data obtained from the Living Condition and Workplace Stress Survey, a mental health-related research project conducted by the Tsukuba Science City Network, there might be a possibility of sampling bias, as participants who are interested in mental health are more likely to have responded to this survey. Fourth, as we did not consider details of the forest/greenspace walking, such as duration of stay in the forest or greenspace, it might cause differential interpretation of the phenomenon among participants. Fifth, because this study is based on self-reported measures, objective evaluation of forest/greenspace walking would be useful to assess the effects. Finally, there might be other factors, such as recent life events, that may have also affected SOC score in respondents.

In conclusion, this cross-sectional study is the first to report association between forest/greenspace walking and SOC among workers in Japan. Forest/greenspace walking and SOC score showed a significantly positive association after adjustment for sex, age, socioeconomic factors, smoking habits, and physical exercise. The findings of this study suggest that forest/greenspace walking is a good health habit that could lead to better stress-management and mental health.

Ethical approval

The web survey contained clear statements that participation was entirely voluntary, that it was an anonymous survey, that the privacy of the respondent would be respected, and that the data would be strictly controlled. The purpose of and the use for the series of the studies conducted was available to the public via the Internet. This research proposal was reviewed and approved by the Ethics Committee of the Faculty of Medicine, University of Tsukuba (approval #1374). All procedures were conducted in accordance with the ethical standards of the national research committee and the Helsinki Declaration (or equivalent).

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Competing interests

T. Ikeda, D. Hori, Y. Arai, K. Muroi, Y. Ikeda, T. Takahashi, N. Shiraki, S. Doki, Y. Oi, S. Sasahara and I. Matsuzaki are volunteer members of the working group for the survey conducted by Tsukuba Science City Network. D. Hori, Y. Oi, S. Doki, S. Sasahara and I. Matsuzaki are volunteer members of the Occupational Health Committee of Tsukuba Science City Network.

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