Association of habitual exercise with adults' mental health following the Fukushima Daiichi nuclear power plant accident: the Fukushima Health Management Survey

Nobuaki Moriyama [a,*], Tetsuya Ohira [b], Masaharu Maeda [b], Hirooki Yabe [c], Itaru Miura [c], Atsushi Takahashi [b], Mayumi Harigane [a,b], Naoko Horikoshi [a,b], Kanako Okazaki [b], Motohiko Miyachi [d], Yuko Gando [d], Kenji Kamiya [b,e], Seiji Yasumura [a,b], on behalf of the Mental Health Group of the Fukushima Health Management Survey

[a] Department of Public Health, Fukushima Medical University School of Medicine, Fukushima, Japan
[b] Radiation Medical Science Center for the Fukushima Health Management Survey, Fukushima Medical University, Fukushima, Japan
[c] Department of Neuropsychiatry, Fukushima Medical University School of Medicine, Fukushima, Japan
[d] Department of Physical Activity Research, National Institutes of Biomedical Innovation, Health and Nutrition, Tokyo, Japan
[e] Research Institute for Radiation Biology and Medicine, Hiroshima University, Hiroshima, Japan

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ABSTRACT

Introduction: The Great East Japan Earthquake and the Fukushima Daiichi nuclear power plant accident in March 2011 impacted survivors' mental health. This study examined whether exercise habits and mental health conditions were associated, and whether the degree of the effect varied depending on time.
Methods: A self-administered questionnaire was sent annually to former residents (born before April 1, 1998) in registered evacuation areas. Exercise habit was evaluated by participants' exercise frequency, and responses were categorized into "almost never," "once a week," and "twice a week and more." Data were tracked during three periods: fiscal year (FY) 2011–2012, 2012–2013, and 2013–2014. The association between baseline habitual exercise and new onset of psychological distress was assessed using the Japanese version of the Kessler 6-item Psychological Distress Scale and logistic regression analysis.
Results: A total of 1304 (5.7%) of 22,741, 1060 (4.7%) of 22,709, and 759 (3.6%) of 21,220 respondents had psychological distress in FY 2011–2012, 2012–2013, and 2013–2014, respectively. An association between exercise and psychological distress was observed in men in FY 2011–2012 (*P* for trend: 0.010) and in women in FY 2013–2014 (*P* for trend: 0.026). "Almost never" was associated with onset of psychological distress in men in FY 2011–2012 [odds ratio (OR): 1.317, 95% confidence interval (CI): 1.054–1.645] and in women in FY 2013–2014 (OR: 1.296, 95% CI: 1.027–1.636).
Conclusions: Exercise habit was associated with psychological distress, and its effect in time varied according to sex.

1. Introduction

Mental health is defined as "a state of well-being in which every individual realizes his/her own potential, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to her or his community" (WorldHealth Organization, n. d.). Promotion of mental health contributes to overall health; therefore, it is recognized as an essential component of health promotion and included as one of the Sustainable Development Goals of the United Nations (United Nations, n.d.). Thus, actions to identify protective or inhibiting factors of mental health have recently accelerated.

Previous studies have focused on various lifestyle factors such as obesity, exercise, and drinking as factors associated with mental health (Jonsdottir, Rödjer, Hadzibajramovic, Börjesson, & Ahlborg, 2010; Xu, Anderson, & Courtney, 2010). In particular, exercise has recently been reported to lead to moderate increases in self-reported positive-activated

affect (Reed & Buck, 2009) and to alleviating symptoms of depression (Craft & Perna, 2004). The mechanisms by which exercise positively affects mental health include physiological and biochemical effects. Exercise may also be an alternative to psychotherapy for improving mental health (Mikkelsen, Stojanovska, Polenakovic, Bosevski, & Apostolopoulos, 2017). The government of Japan established exercise guidelines for citizens in which exercise is recommended for citizens of all ages, and performing exercise for 30 min or more at least two days a week is encouraged (Ministry of Health, Labour and Welfare, 2013).

The Great East Japan Earthquake (GEJE) and the Fukushima Daiichi nuclear power plant accident that occurred in March 2011 had a significant impact on the mental health of affected citizens (Maeda & Oe, 2017). In adults who lived in evacuation zones designated by the government, the proportion of individuals with psychological distress was 14.6% in the fiscal year (FY) 2011 (Yabe et al., 2014). After that, the proportion gradually decreased between FY 2011 and FY 2013 (Oe et al., 2018), which may indicate that the mental influence of the disaster has diminished over time from the acute period of the disaster. However, the proportion remains higher than that of the general population which has not been affected by the GEJE (Yabe et al., 2014).

Regarding mental health in post-disaster situations, physical activity is regarded as one of the conditions related to behavioral health and should be addressed to prevent short- and long-term negative consequences (Waters & Copeland, 2020). Following the earthquake which struck the city of Bam, Iran in 2003 and tornados that occurred in Tuscaloosa, US in 2011, researchers examined interventions that encouraged affected children to get involved in an exercise program as post-disaster psychological rehabilitation (Kunz, 2009; Wahl-Alexander, 2015). While no quantitative outcome data were available, their reports concluded that the physical activity programs implemented were beneficial for the mental health of the participants following natural disasters. Furthermore, a previous study reported that psychological distress could be persistent, and delayed onsets of serious mental illness were observed from the results of an annual check in 2012 and 2013 (Kanehara et al., 2016). Prolonged serious psychological distress could threaten citizens' chronic health; for instance, it was reported that psychological distress was a risk factor for withdrawal from hypertension treatment one year after the GEJE (Nakaya et al., 2017). Therefore, we believe that monitoring the mental health of affected people is necessary.

In the case of the GEJE, lack of exercise coupled with evacuation has been recognized as one of the secondary health issues following the radiation accident (Tsubokura, 2018). Thus, the association of mental health deterioration with inactive lifestyles is a matter of concern in post-disaster contexts, and grasping the actual situation following the GEJE could provide an important roadmap in this regard. Previous studies found an association between exercise habits and mental health after the nuclear accident. Itagaki et al. (2017) reported that children aged 6–15 years who do not have exercise habits were at a higher risk of mental problems, and Oe et al. (2016a) reported that lower frequency in exercise as of 2011 caused a serious trajectory of emotional distress symptoms in children aged 6–12 years. Thus, an association between exercise habit and mental health in juveniles has been previously reported. However, it is unknown whether the same association is found in adult local residents in the affected areas following an accident. In addition, the cause of stress in affected people following disasters is believed to change over time from the damage caused by the disaster itself to the situation of the evacuation life (Goldmann & Galea, 2014). Therefore, the effect of habitual exercise on mental health seems to be all the more significant as time passes.

This study focused on the association between the exercise habits of adult residents living in evacuation zones in Fukushima Prefecture after the nuclear accident and their mental health level after the disaster. This study had two purposes: 1) to examine whether exercise habits and mental health conditions were associated, and 2) to examine whether the degree of the effect varied depending on time. We hypothesized that

1) there is an association between frequency of habitual exercise and mental health after a year, and 2) the effect of habitual exercise on mental health persists even after some time from the disaster has elapsed. Additionally, the analysis was stratified by sex since the proportion of individuals with mental health problems was higher in women than men (Yabe et al., 2014), and the effect of physical activity for decreased depression varies depending on sex (Zhang & Yen, 2015). Elucidating this association could provide information to health care workers engaging in mental health support regarding protective effects of exercise habits for preventing mid-to long-term psychological distress following large-scale disasters.

2. Methods

This study is part of a longitudinal study to monitor the mental health status of evacuees following the Fukushima Daiichi nuclear power plant accident. Details of this study are described elsewhere (Yasumura et al., 2012). In this study, data collected in fiscal year (FY) 2011 through FY 2014 were analyzed. The study population comprised residents who were registered in the 13 municipalities categorized as evacuation areas, Hirono Town, Naraha Town, Tomioka Town, Kawauchi Village, Okuma Village, Futaba Town, Namie Town, Katsurao Village, Minamisoma City, Tamura City, Kawamata Town, Iitate Village, and a part of Date City. The target population was 180,604 in FY 2011, 184,507 in FY 2012, and 185,859 in FY 2013. A self-administered mental health questionnaire was sent to the target population. In this survey, it was explained to the participants in writing that the survey results would be totaled and reported after analysis, and only those who returned the self-recorded questionnaire were considered to have provided consent to participate in the study. This study was approved by the ethics review committee of Fukushima Medical University (No. 1316, No. 2148).

To assess the mental health status of participants, the Kessler 6-item Psychological Distress Scale (K6) (Kessler et al., 2003) in its validated Japanese version (Furukawa et al., 2008) was administered. The K6 consists of six brief questions about depression and anxiety symptoms during the past 30 days. All items were measured on a five-point scale from zero (never) to four (all of the time), and the total score, with higher scores representing worse mental health status, was calculated (range: 0–24). Scores of 13 or more were classified as probable threshold distress.

Participants' exercise habits were evaluated by asking "Do you usually do exercise?" Respondents chose the closest answer among "almost every day," "2 to 4 times a week," "about once a week," and "almost never." The answer of "almost every day," and "2 to 4 times a week," were combined as "twice a week and more," to follow the definition adopted in the National Health and Nutrition Survey annually conducted by the Ministry of Health, Labour, and Welfare (2018) in Japan for recommended exercise habits: engaging in exercise for more than 30 min per occasion, two or more times per week, continued for more than one year. Thus, the answers were divided into three groups.

Subjective health was assessed by the standard single-item question "How would you rate your present health status? Respondents chose one answer from "very good," "good," "normal," "bad," and "very bad." In this study, data on age, sex, job status (full time, part time, working/not working), academic background (university or graduate school, junior college or vocational school, high school, junior high school or lower), and presence of the experience of close relatives' death (only in data from FY 2011), and unemployment due to the disaster were also obtained.

2.1. Statistical analysis

In order to examine the effect of habitual exercise on mental health conditions a year later, we tracked data for two consecutive fiscal years. The outcome represented the possibility of a new onset of threshold
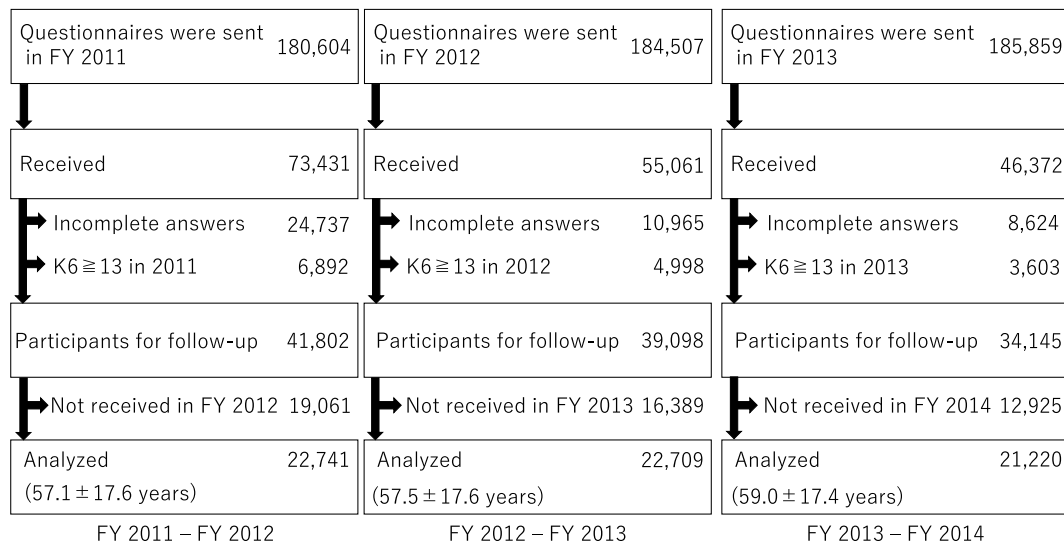
Questionnaires were sent in FY 2011	180,604		Questionnaires were sent in FY 2012	184,507		Questionnaires were sent in FY 2013	185,859
Received	73,431		Received	55,061		Received	46,372
→ Incomplete answers	24,737		→ Incomplete answers	10,965		→ Incomplete answers	8,624
→ K6 ≧ 13 in 2011	6,892		→ K6 ≧ 13 in 2012	4,998		→ K6 ≧ 13 in 2013	3,603
Participants for follow-up	41,802		Participants for follow-up	39,098		Participants for follow-up	34,145
→ Not received in FY 2012	19,061		→ Not received in FY 2013	16,389		→ Not received in FY 2014	12,925
Analyzed (57.1 ± 17.6 years)	22,741		Analyzed (57.5 ± 17.6 years)	22,709		Analyzed (59.0 ± 17.4 years)	21,220
FY 2011 – FY 2012			FY 2012 – FY 2013			FY 2013 – FY 2014	

Fig. 1. Flow of participants recruitment and analysis
FY, fiscal year; K6, score from the score from the Kessler 6-item Psychological Distress Scale.

distress (K6≧13) in the following year. The main possible factor of psychological distress was the frequency of exercise in the previous year. We tracked data from three terms: (1) FY 2011 to FY 2012, (2) FY 2012 to FY 2013, and (3) FY 2013 to FY 2014. In this study, data of individuals who had participated in the previous fiscal year and responded also in the following year were included. Individuals with missing data or with scores of K6≧13 in the previous year were excluded.

A logistic regression analysis in which the dependent variable was a new onset of psychological distress in the following year was performed. Exercise habits represented by frequency of exercise were included as explanatory variables, and age, presence of the experience of close relatives' death, unemployment, job status, and academic background were considered as covariates (Model 1). Another model (Model 2) that added the K6 score of the previous year to Model 1 was constructed. The analyses were stratified according to sex. A probability value of < 0.05 was considered statistically significant. All data analyses were performed using IBM SPSS Statistics for Windows, version 21 (IBM Corporation, Armonk, NY, USA).

3. Results

Fig. 1 shows the participants selection process in all three FYs considered.

Table 1 shows participants' baseline data for FY 2011–2012. Table 2 shows data regarding new onsets of psychological distress occurred among participants in FY 2011–2012. Odds ratios of each variable for onset of psychological distress were listed in Supplementary Table 1. Multiple logistic regression analysis found that exercise frequency was associated with psychological distress: exercise frequency of "almost never" was associated with more frequent onset of psychological distress compared with "twice a week and more" in men. An association between frequency of exercise and the onset of psychological distress was observed in men (Table 2).

Table 3 shows the baseline data for FY 2012–2013. Table 4 shows the data regarding new onsets of psychological distress occurred among participants in FY 2012–2013. Odds ratios of each variable for onset of psychological distress were listed in Supplementary Table 2. Multiple

Table 1
Baseline characteristics of participants according to exercise frequency (FY 2011–2012) n = 22,741.

	Total	Exercise frequency		
		Twice a week and more	Once a week	Almost never
N	22,741	7858	3079	11,804
Age, years	54.9 ± 17.5	61.7 ± 17.0	56.1 ± 17.4	50.0 ± 16.3
Sex men	10,221 (44.9)	3959 (50.4)	1497 (48.6)	4765 (40.4)
Subjective health				
ery good	1064 (4.7)	381 (4.9)	142 (4.6)	541 (4.6)
Good	3703 (16.3)	1298 (16.5)	548 (17.8)	1857 (15.7)
Normal	14,981 (65.9)	5182 (65.9)	1989 (64.6)	7810 (66.2)
Bad	2834 (12.4)	950 (12.1)	377 (12.2)	1507 (12.8)
Very bad	159 (0.7)	47 (0.6)	23 (0.8)	89 (0.7)
Close relatives' death, yes	4263 (18.7)	1589 (20.2)	556 (18.1)	2118 (17.9)
Unemployment following the accident, yes	4787 (21.1)	1594 (20.3)	608 (19.7)	2585 (21.9)
Job status				
Full time	7179 (31.6)	1370 (17.4)	1003 (32.6)	4806 (40.7)
Part time	1683 (7.4)	391 (5.0)	231 (7.5)	1061 (9.0)
No	13,879 (61.0)	6097 (77.6)	1845 (59.9)	5937 (50.3)
K6 score	4.4 ± 3.8	4.2 ± 3.8	4.5 ± 3.7	4.5 ± 3.8
Educational background				
Junior high school or lower	4127 (18.1)	1861 (23.7)	566 (18.4)	1700 (14.4)
High school	11,772 (51.8)	4019 (51.1)	1640 (53.2)	6113 (51.8)
Junior college or vocational school	4378 (19.3)	1218 (15.5)	520 (16.9)	2640 (22.4)
University or graduate school	2464 (10.8)	760 (9.7)	353 (11.5)	1351 (11.4)

Note: Values are mean±SD or *n* (%). K6, score from the Kessler 6-item Psychological Distress Scale.

Table 2
Gender-specific multivariable-adjusted odds ratios for onset of psychological distress (FY 2011–2012).

Exercise frequency	Men n = 10,221				Women n = 12,520			
	Twice a week and more	Once a week	Almost never	P for trend	Twice a week and more	Once a week	Almost never	P for trend
N	3959	1497	4765		3899	1582	7039	
K6≥13, n	170	62	291		226	103	452	
Rate/1000 persons	42.9	41.4	61.1		58.0	65.1	64.2	
Age-adjusted OR (95% CI)	1.000 (Reference)	0.978 (0.725–1.319)	1.486 (1.213–1.821)	<0.001	1.000 (Reference)	1.181 (0.928–1.504)	1.253 (1.054–1.488)	0.011
Multivariable OR (95% CI), Model 1	1.000 (Reference)	0.947 (0.698–1.284)	1.328 (1.072–1.645)	0.006	1.000 (Reference)	1.142 (0.894–1.459)	1.160 (0.973–1.383)	0.106
Multivariable OR (95% CI), Model 2	1.000 (Reference)	0.921 (0.674–1.258)	1.317 (1.054–1.645)	0.010	1.000 (Reference)	1.144 (0.889–1.473)	1.166 (0.973–1.398)	0.105

Note: OR, odds ratio; CI, confidence interval; K6, score from the score from the Kessler 6-item Psychological Distress Scale.
Model 1: age (continuous variable), subjective health (very good, good, normal, bad, very bad), close relatives' death (no/yes), unemployment following the accident (no/yes), job status (working/not working), educational background (university or graduate school, junior college or vocational school, high school, junior high school or lower).
Model 2: Model 1+K6 score at baseline.

Table 3
Baseline characteristics of participants according to exercise frequency (FY 2012–2013) n = 22,709.

	Total	Exercise frequency		
		Twice a week and more	Once a week	Almost never
N	22,709	8629	3563	10,517
Age, years	56.9 ± 17.5	62.9 ± 16.6	57.4 ± 17.2	51.8 ± 16.7
Sex men	10,349 (45.6)	4345 (50.4)	1597 (44.8)	4407 (41.9)
Subjective health				
Very good	924 (4.1)	409 (4.7)	145 (4.1)	370 (3.5)
Good	4144 (18.2)	1699 (19.7)	624 (17.5)	1821 (17.3)
Normal	14,774 (65.1)	5531 (64.1)	2361 (66.2)	6882 (65.4)
Bad	2704 (11.9)	941 (10.9)	409 (11.5)	1354 (12.9)
Very bad	163 (0.7)	49 (0.6)	24 (0.7)	90 (0.9)
Unemployment following the accident, yes	5014 (22.1)	1925 (22.3)	740 (20.8)	2349 (22.3)
Job status				
Full time	7459 (32.9)	1871 (21.7)	1208 (33.9)	4380 (41.7)
Part time	2031 (8.9)	575 (6.7)	297 (8.3)	1159 (11.0)
No	13,219 (58.2)	6183 (71.6)	2058 (57.8)	4978 (47.3)
K6 score	4.1 ± 3.7	3.9 ± 3.7	4.2 ± 3.7	4.3 ± 3.7
Educational background				
Junior high school or lower	4720 (20.8)	2309 (26.8)	739 (20.8)	1672 (15.9)
High school	11,562 (50.9)	4324 (50.1)	1782 (50.0)	5456 (51.9)
Junior college or vocational school	4075 (17.9)	1216 (14.1)	639 (17.9)	2220 (21.1)
University or graduate school	2352 (10.4)	780 (9.0)	403 (11.3)	1169 (11.1)

Note: Values are mean±SD or n (%). K6, score from the score from the Kessler 6-item Psychological Distress Scale.

logistic regression analysis found no association between frequency of exercise and onset of psychological distress (Table 4).

Table 5 shows the baseline data for FY 2013–2014. Table 6 shows data regarding new onsets of psychological distress occurred among participants in FY 2013–2014. Odds ratios of each variable for onset of psychological distress were listed in Supplementary Table 3. Multiple logistic regression analysis found that "almost never" was associated with more frequent onsets of psychological distress compared with "twice a week and more" in women. An association between frequency of exercise and the onset of psychological distress was observed in women (Table 6).

4. Discussion

The first hypothesis of this study, that there is an association between frequency of habitual exercise and mental health after a year, was correct in a certain period in both men and women. A previous study examining the association of frequency of physical activity with mental health in normal times suggested that more frequent physical activity was associated with a lower risk of psychological distress among UK citizens aged 16 and over (mean age: 45.2 years) (Hamer, Stamatakis, & Steptoe, 2009). The present results are in accordance with this finding,

and it is possible that engaging in frequent exercise could have promoted better mental health even in the aftermath of the GEJE.

The second hypothesis, regarding the persistency of the effect of exercise on mental health over time, was not proven: the association between exercise habits and psychological distress was observed in different periods among men and women. A relatively closer result to the hypothesis was obtained for women. A previous study examining the association between regular physical activity and depressive symptoms found that mildly and moderately depressed women will benefit the most from regular physical activity (Zhang & Yen, 2015). In the present study, for individuals not identified as having psychological distress, that is, individuals with relatively mild psychological distress, the effect of habitual exercise on reducing the occurrence of new psychological distress was seen in women. This may be explained by the same mechanisms as in previous studies. A previous study examining the association between mental health recovery and lifestyle in Fukushima residents using the trajectory model found an association between changes in physical activity and mental health recovery (Orui, Naka-jima, et al., 2018). Furthermore, the suicide rate, which strongly reflects psychological distress among female residents in evacuation areas, was reported to decline slightly during the first year and then increase significantly over the subsequent three-year period (Orui, Suzuki, et al.,

Table 4

Gender-specific multivariable-adjusted odds ratios for onset of psychological distress (FY 2012–2013).

Exercise frequency	Men $n = 10,349$				Women $n = 12,360$			
	Twice a week and more	Once a week	Almost never	*P* for trend	Twice a week and more	Once a week	Almost never	*P* for trend
N	4193	1518	4198		4073	1865	5802	
K6≥13, *n*	152	79	209		211	101	308	
Rate/1000 persons	36.3	52.0	49.8		51.8	54.2	53.1	
Age-adjusted OR (95% CI)	1.000 (Reference)	1.467 (1.108–1.942)	1.420 (1.139–1.771)	0.002	1.000 (Reference)	1.099 (0.861–1.404)	1.168 (0.968–1.410)	0.107
Multivariable OR (95% CI), Model 1	1.000 (Reference)	1.346 (1.011–1.792)	1.196 (0.951–1.505)	0.149	1.000 (Reference)	1.053 (0.823–1.348)	1.031 (0.851–1.248)	0.769
Multivariable OR (95% CI), Model 2	1.000 (Reference)	1.254 (0.933–1.684)	1.145 (0.903–1.453)	0.290	1.000 (Reference)	1.008 (0.782–1.300)	1.004 (0.825–1.223)	0.967

Note: OR, odds ratio; CI, confidence interval; K6, score from the score from the Kessler 6-item Psychological Distress Scale.

Model 1: age (continuous variable), subjective health (very good, good, normal, bad, very bad), unemployment following the accident (no/yes), job status (working/not working), educational background (university or graduate school, junior college or vocational school, high school, junior high school or lower).

Model 2: Model 1+K6 score at baseline.

Table 5

Baseline characteristics of participants by exercise frequency (FY 2013–2014) $n = 21,220$.

	Total	Exercise frequency		
		Twice a week and more	Once a week	Almost never
N	21,220	8367	3305	9548
Age, years	58.4 ± 17.4	64.2 ± 16.2	58.9 ± 16.8	53.1 ± 16.9
Sex men	9749 (45.9)	4168 (49.8)	1524 (46.1)	4057 (42.5)
Subjective health				
Very good	834 (3.9)	372 (4.4)	116 (3.5)	346 (3.6)
Good	3925 (18.5)	1631 (19.5)	623 (18.9)	1671 (17.5)
Normal	13,514 (63.7)	5302 (63.4)	2100 (63.5)	6112 (64.0)
Bad	2807 (13.2)	1027 (12.3)	445 (13.5)	1335 (14.0)
Very bad	140 (0.7)	35 (0.4)	21 (0.6)	84 (0.9)
Unemployment following the accident, yes	4374 (20.6)	1819 (21.7)	647 (19.6)	1908 (20.0)
Job status				
Full time	6080 (28.7)	1446 (17.3)	984 (29.8)	3650 (38.2)
Part time	1831 (8.6)	523 (6.2)	273 (8.2)	1035 (10.9)
No	13,309 (62.7)	6398 (76.5)	2048 (62.0)	4863 (50.9)
K6 score	3.8 ± 3.6	3.6 ± 3.5	4.0 ± 3.6	4.0 ± 3.7
Educational background				
Junior high school or lower	4388 (20.7)	2167 (25.9)	633 (19.1)	1588 (16.6)
High school	10,823 (51.0)	4282 (51.2)	1701 (51.5)	4840 (50.7)
Junior college or vocational school	3688 (17.4)	1142 (13.6)	556 (16.8)	1990 (20.9)
University or graduate school	2321 (10.9)	776 (9.3)	415 (12.6)	1130 (11.8)

Note: Values are mean±SD or *n* (%). K6, score from the score from the Kessler 6-item Psychological Distress Scale.

2018). Thus, a delayed decline in mental health can occur, which may last a certain period. Since the effect of frequent exercise habits on mental health was found to be clearer in later periods in women, we believe long-term support for preventing psychological distress by encouraging them to engage in frequent physical activity is necessary.

However, it is necessary to be careful when applying this association in male citizens because periods in which there was a significant association between habitual exercise and psychological distress varied between men and women. Psychological distress is reported to be associated with a lack of informational support specifically in men following the GEJE (Ishiguro et al., 2019). A previous study suggested that older residents in Fukushima Prefecture who experienced evacuation had lower social capital, which impacted health indicators, than did local non-evacuees after the GEJE (Moriyama, Iwasa, Tsubokura, Kuroda, & Yasumura, 2019). In addition, an association between habitual exercise and mental health was observed in full-time workers, but not in others, in men, indicating that this association varied according to socioeconomic status specifically in men (Nagasu, Kogi, & Yamamoto, 2019). Since the early phase of the recovery process from the GEJE, citizens experienced a great deal of change in their surrounding situation, which might amplify the association between habitual exercise and psychological distress in this specific period in men.

Regarding other variables, results of association with mental health were also in line with previous studies conducted in post-disaster situations. The prevalence of psychological distress was reported to be higher in women than in men in Fukushima residents (Oe et al., 2016b), which was consistent with a previous finding that women are more likely to suffer from anxiety and stress-related disorders (Bangasser & Valentino, 2014). Consistently, in our study a larger impact of the disaster on psychological status in women persisted from the accident until FY 2014, suggesting that psychological distress occurs more frequently in women than in men. The experience of close relatives' death and unemployment due to the disaster were also associated with new onsets of psychological distress. The results are also consistent with the results of previous studies that found an association between psychological distress and having dead or missing family members and lost jobs due to the GEJE (Suzuki, Fukasawa, Obara, & Kim, 2014).

Based on the results of this study, we suggest that exercise habit is beneficial for preventing the onset of psychological distress in women from a mid-to long-term perspective and in men in the relatively early phase of the reconstruction process. Therefore, support, especially for inactive individuals, to encourage them to exercise more frequently than they did before should be considered. In post-disaster situations, physical activity levels tend to decrease (Moriyama, Urabe, Onoda, Maeda, & Oikawa, 2017). Thus, a strategy to maintain the frequency of citizens' habitual exercise should be considered as preparation for any disasters

Table 6

Gender-specific multivariable-adjusted odds ratios for onset of psychological distress (FY 2013–2014).

Exercise frequency	Men $n = 9749$				Women $n = 11,471$			
	Twice a week and more	Once a week	Almost never	*P* for trend	Twice a week and more	Once a week	Almost never	*P* for trend
n	4060	1485	3908		4061	1708	5239	
K6≥13, *n*	108	39	149		138	73	252	
Rate/1000 persons	26.6	26.3	38.1		34.0	42.7	48.1	
Age-adjusted OR (95%	1.000	1.029	1.530	0.001	1.000	1.307	1.567	<0.001
CI)	(Reference)	(0.708–1.495)	(1.179–1.986)		(Reference)	(0.977–1.747)	(1.255–1.956)	
Multivariable OR (95%	1.000	0.974	1.313	0.044	1.000	1.178	1.350	0.009
CI), Model 1	(Reference)	(0.668–1.421)	(1.002–1.722)		(Reference)	(0.878–1.582)	(1.077–1.692)	
Multivariable OR (95%	1.000	0.896	1.200	0.182	1.000	1.078	1.296	0.026
CI), Model 2	(Reference)	(0.609–1.319)	(0.908–1.586)		(Reference)	(0.796–1.459)	(1.027–1.636)	

Note: OR, odds ratio; CI, confidence interval; K6, score from the score from the Kessler 6-item Psychological Distress Scale.

Model 1: age (continuous variable), subjective health (very good, good, normal, bad, very bad), unemployment following the accident (no/yes), job status (working/ not working), educational background (university or graduate school, junior college or vocational school, high school, junior high school or lower).

Model 2: Model 1+K6 score at baseline.

in the future. Furthermore, examinations of past natural disasters have revealed that physical activity programs were effective for improving children's mental health because being able to engage with coaches and others during sport and play in a supportive environment was more important than just doing it for fun (Kunz, 2009). One program conducted following Hurricane Katrina aimed to reduce stress in affected school-age children by helping them develop a sense of community through cooperative challenges and group-building exercises (Carson, 2008). Thus, in addition to the general positive effects of exercise, implementing exercise sessions allowing individuals in areas that have suffered large-scale disasters to join together is desirable for improving survivors' mental health through building social ties.

The strength of this study consists in being a new attempt to explore the association between habitual exercise and psychological distress in former residents following the GEJE and to examine whether it could vary according to sex and phases of the recovery process. Furthermore, previous studies investigating the association between habitual exercise and mental health after disasters have focused on children or adolescents; this relationship remains unexplored in the context of adults. Thus, the novel findings of this study could facilitate the provision of mental health support for adults following large-scale disasters.

Several limitations should be considered when interpreting this study's results. First, a previous study suggested that depressive symptoms and behaviors are complex and bidirectional (Gigantesco, Ferrante, Baldissera, & Masocco, 2015); poor mental health could cause lower frequency of exercise habits. Although this study was a prospective cohort study, reverse causality in relation to that assumed in this study should also be considered. Second, information on the type, duration, and intensity of exercise that participants engaged in was not collected. Thus, reported exercise frequency might be biased by participants' varying ideas about what "exercise" means, and their responses might not reflect their actual exercise habits through the past year. In addition, we could not adjust for these aspects of exercise, although they could affect mental health. Third, in the analyses conducted in this study, exercise habits before the baseline in each analysis were not considered; thus, any change in frequency of habitual exercise was not taken into account; however, past exercise habits before the baseline may have little effects. Lastly, it is possible that there was some selection bias in that responders to this questionnaire survey may not represent the target population of this study. A previous study suggested that non-respondents of the Fukushima Health Management Survey had a significantly higher proportion of psychological distress compared to the respondents (Horikoshi, Iwasa, Yasumura, & Maeda, 2017). Thus, the survey item measurements from responders of this study might be better compared with those of the whole population.

5. Conclusions

There was an association between frequency of habitual exercise and new onsets of psychological distress in the early phase in men and the relatively chronic phase in women who lived in evacuation zones following the GEJE.

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Declaration of competing interest

The authors have no conflict of interest to disclose.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi. org/10.1016/j.mhpa.2021.100388.

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