



Title	Changes in social activities and the occurrence and persistence of depressive symptoms : Do type and combination of social activities make a difference?
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**Title: Changes in social activities and the occurrence and persistence of depressive symptoms: do type and combination of social activities make a difference?**

**ABSTRACT**

**Objective:** We aimed to explore the association between changes in social activities and the occurrence/persistence of depressive symptoms and investigate the difference in effect sizes among the types and combinations of social activities.

**Methods:** The study adopted a valid 15-item Geriatric Depression Scale to assess depressive symptoms in 2480 community-dwelling adults aged 64/65 years. Changes in social-related, learning, and personal activities were classified into four categories: continued low frequency (CLF), increased frequency (IF), decreased frequency (DF), and continued regular frequency (CRF)<sup>1</sup>. Relative ratios (RRs) and 95% confidence intervals (95% CI) were calculated using a modified Poisson regression model.

**Results:** Those without depressive symptoms at baseline and who engaged in social-related ( $RR_{IF} = 0.56 (0.39, 0.81)$ ,  $RR_{CRF} = 0.55 (0.41, 0.74)$ ), learning ( $RR_{IF} = 0.63 (0.44, 0.89)$ ,  $RR_{CRF} = 0.62 (0.46, 0.85)$ ), and personal activities ( $RR_{IF} = 0.37 (0.24, 0.57)$ ,  $RR_{CRF} = 0.41 (0.30, 0.56)$ ) at IF or CRF were less likely to develop depressive symptoms. Those with depressive symptoms at baseline, engaging in personal activities at IF ( $RR=0.67 (0.51, 0.87)$ ) and CRF ( $RR= 0.80 (0.65-1.00)$ ) were less likely to have persistent depressive symptoms. Participation in all three activities consistently at a regular frequency was inversely associated with the occurrence/persistence of depressive symptoms.

**Conclusions:** The effect of personal activities was more manifest in preventing depressive symptoms than the other two kinds, regardless of depressive symptoms at baseline. Regularly engaging in a combination of all three activities at baseline and follow-up was associated with the occurrence and persistence of depressive symptoms.

**KEYWORDS**

social-related activity, learning activity, personal activity, occurrence of depressive symptoms, persistence of depressive symptoms

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<sup>1</sup> CLF: continued low frequency, IF: increased frequency, DF: decreased frequency, CRF: continued regular frequency

## 1. Introduction

Depressive disorders in older adults are associated with an increased risk of comorbidity and mortality (Blazer, 2003). In Japan, the prevalence of depressive disorders among adults aged 65 years and over increases with age (GHDx). Among all people with mood disorders (e.g., manic depression and depression), the percentage of the average length of hospitalization for older adults aged 65 years and over has increased from 55% in 2017 to 60% in 2021 (Ministry of Health). This trend is raising concern for causing a huge burden not only for the depressed patients but also for their families and the medical and social resources. With the rapid aging of its population, Japan needs to take measures for potential interventions for depressive disorder among community-dwelling older adults to reduce the social burden.

The main predictors of depressive disorders in older adults include somatic diseases, functional or mental impairment, a history of depressive disorders, and lack of social participation (Djernes, 2006). Social participation, from which people could get social support, establish social networks and connections, has been demonstrated to have protective effects against depressive symptoms among older adults (Nakagomi et al., 2020; Shiba et al., 2021; Watanabe et al., 2019), but the effect size is related to intensity and type of social participation. For example, informal social activities (date a friend, talking face-to-face with friends or children) have greater effects on reducing the risks of developing depressive symptoms compared with formal activities (religious or volunteer activities) (Seung Hee & Kim, 2014; Steger & Kashdan, 2009).

Nevertheless, the same type of social activity may produce inconsistent results in terms of effects on depressive symptoms in different participants. An European study on adults aged 50 years and over found that participation in religious and pollical/community activities is associated with decreased and increased depressive symptoms after four years, respectively (Croezen et al., 2015). An Asian study on adults aged 60 years and over reported the opposite results: attending religious activities is associated with increased depressive symptoms, but participating in social gatherings is associated with a decrease in depressive symptoms after four years (Min et al., 2016). This suggested that the association between social activities and depressive symptoms may differ not only across different types of social activities, but also across different social cultures (Min et al., 2016). Thus, in examining the effects of social activities on depressive symptoms, although the specific types of social activities are easier to explore in terms of their effect on depressive symptoms, research on the comparison between different studies and the generalization across different races has been limited. Therefore, combining multiple social activities into a scale or measurement would be significant in exploring the protection or intervention of depressive symptoms. First, participation in multiple social activities allows older adults to occupy various roles increasing their self-esteem and then benefit their mental health (Choi et al., 2021). Moreover, different types of social activities may act differently on depressive symptoms, and there may be a cumulative or compensatory effect among multiple types of social activities. For example, engaging in more diverse activities with positive effects implies greater benefits on depressive

symptoms; and increased participation in socializing with others may counteract the harmful effects of negative activities (Chao, 2016).

Although previous studies have explored the association between changes in social activity and depressive symptoms, (Chao, 2016; Choi et al., 2015) these studies have only either the linear relation between changes in social activities without considering the occurrence of or improvement in depressive symptoms, or considered changes in individual social activity, and not the changes in the combination of different types of social activities.

The current study assessed social activities for community-dwelling older adults using a set of questions and divided them into three types based on the internal consistency of these activity types: social-related, learning, and personal activities. We explored the association between frequency changes in social activities and both the occurrence and persistence of depressive symptoms. We further explored the types and combinations of multiple types of social activities that have a greater influence on depressive symptoms.

## **2. Methods**

### *2.1 Study design and participants*

This study was carried out as part of the New Integrated Suburban Seniority Investigation (NISSIN) project, an ongoing prospective cohort study. The participants were age-specific (64/65 years old) community-dwelling residents living in Nisshin City, Aichi Prefecture. From 1996 to 2005, participants were invited to attend a comprehensive health check and complete a self-administered questionnaire; a total of 3,073 participants who provided informed consent were included. From 2002 to 2011, these participants were invited to participate in a second comprehensive health check and complete the self-administered questionnaire. Details of the project design are provided elsewhere. (Kitamura et al., 2009) Of all the eligible participants ( $n = 3,073$ ), we excluded 161 participants with missing values for the covariates and 50 participants who had invalid response ( $n = 1$ ) and missing values ( $n = 49$ ) to the Geriatric Depression Scale (GDS) at baseline. We also excluded participants who relocated ( $n = 123$ ) or died ( $n = 97$ ) before follow-up. In addition, participants who did not attend the check-ups ( $n = 145$ ), who had missing values of GDS questionnaires ( $n = 17$ ) at follow-up were also excluded. Thus, in this study, we included a total of 2,480 participants, of whom 1,958 had no depressive symptoms and 522 had depressive symptoms at baseline (Fig.1).

### *2.2 Assessment of depressive symptoms*

We used a valid 15-item GDS to assess the depressive symptoms at baseline and follow-up (Yatomi, 1994). The total score was calculated as the sum of scores for each of the 15 questions, ranging from 0 to 15. A higher score indicated the severity of depressive symptoms, and a score  $\geq 6$  was regarded as having depressive symptoms (Schreiner et al., 2003).

### *2.3 Assessment of social activities*

Social activities involved social-related, learning, and personal activities, which were equally assessed at both baseline and follow-up. Social-related activities included six questions, learning activities four questions, and personal activities ten questions (see Supplementary Table S1) (Aoki et al., 1996). For each question, scores of 3, 2, and 1 corresponded to “regularly doing,” “occasionally doing,” and “not doing” these activities, respectively. For each participant, we calculated the total score for each part as the sum of scores for the number of questions, ranging from 6 to 18 for social-related, 4 to 12 for the learning, and 10 to 30 for personal activities. We then assigned all participants to different frequency groups based on the first quartile of participants without depressive symptoms at baseline. Participants with scores lower than the first quartile (social-related activities: 7, learning activities: 4, personal activities: 17) were assigned to the “low frequency” group. In contrast, the others were assigned to the “regular frequency” group. At follow-up, participants were similarly categorized using the same cut-off points. Overall, these questions exhibited an acceptable level of internal consistency, with the Cronbach’s  $\alpha$  for all the three parts being larger than 0.61 at both baseline and follow-up.

We classified the combination of multiple social activities into four groups based on the frequency of each activity. Group A included participants with a low frequency of engagement in all three activities. Group B included participants with a low frequency of engagement in two activities but a regular frequency of attention on one activity. Group C included participants with a low frequency of engagement in one activity but a regular frequency in two activities. Finally, Group D included participants with a regular frequency of engagement in all three activities.

#### *2.4 Changes in depressive symptoms and changes in social activities*

We examined four patterns of changes in depressive symptoms over time: two for participants who did not have depressive symptoms at baseline, namely “continued absence of depressive symptoms” and “occurrence of depressive symptoms;” and two for participants who had depressive symptoms at baseline, namely “improvement of depressive symptoms” and “persistence of depressive symptoms.”

We then classified the changes in social activities between baseline and follow-up into four categories: continued low frequency (CLF), increased frequency (IF), decreased frequency (DF), and continued regular frequency (CRF). Regarding the changes in combination of multiple social activities between baseline and follow-up, we identified 16 variations, shown in Supplementary Table S2.

#### *2.5 Covariates*

Data on covariates were collected using self-administered questionnaires and a comprehensive health check-up performed at baseline. Sociodemographic variables included sex, year of participation (1996–2005), marital status (married, other), educational background (junior high school or lower, high school, college or higher), and residential status (living alone, other). Health-related variables included smoking (never, former, current), drinking (never, current), body mass index (BMI, calculated as the self-reported body weight divided by the square of the self-reported body

height) (<18.5; 18.5–25.0; >25.0), history of chronic diseases, and competence of daily living (low, high). History of chronic disease was collected by asking participants if they had a history of any cancer, hypertension, diabetes, arthritis, or cardiovascular disease. Competence of daily living was evaluated by the Tokyo Metropolitan Institute of Gerontology Index of Competence questionnaire, which contains 13 close-ended questions and has been validated in the Japanese population (Koyano et al., 1991). The total score was calculated as the sum of scores for responses to each of the 13 questions; a higher total score indicates a higher competence in daily living. The value of 11 and over indicate higher competence of the elderly (Okabayashi et al., 2019).

## 2.6 Statistical analysis

We compared the baseline demographic characteristics among participants who showed a transition of depressive symptoms using a chi-squared test for categorical data. Due to the higher prevalence rate of our outcome (the occurrence (12.6%) and persistence (49.8%) of depressive symptoms), a modified Poisson regression model for binary outcome data, with a log link function and robust error variance, was constructed to estimate the risk ratios (RRs) and 95% confidence intervals (95% CIs). We used the RRs and CIs to determine the association between changes in social activities, changes in combination of multiple social activities, and occurrence/persistence of depressive symptoms while adjusting for potential confounders. Statistical analyses were performed using SAS software package version 9.4 for Microsoft Windows (SAS Institute Inc., Cary, NC, USA). Statistical significance was set as  $P < 0.05$ .

## 3. Results

### 3.1 Baseline characteristics

Among participants who had changes in social-related activities, participants with CRF in engagement were more likely to be never smoker, have higher education backgrounds and competence of daily living, and be free of depressive symptoms. Most participants engaged in learning activities at CRF were women; they were less likely to be current smokers and drinkers. They had higher education backgrounds and competence of daily living and a lower proportion of having depressive symptoms. Among participants who demonstrated changes in personal activities, a higher proportion of those in the CRF classification were female and never smoker or never drinkers. They also had higher educational backgrounds and competence of daily living and were less likely to have depressive symptoms (Table 1).

### 3.2 Association between changes in social activities and the occurrence of depressive symptoms among participants with no depressive symptoms at baseline

A total of 246 (12.6%) developed depressive symptoms after six-year follow-up period. Compared with participants who partook in activities at CLF, those who participated in social-related, learning activities, and personal activities at IF or CRF were less likely to develop depressive symptoms. Those who had DF of social-related activities also showed significant association with the occurrence of depressive

1 symptoms (Table 2).

2 On the association between changes in combination of multiple social activities and  
 3 the occurrence of depressive symptoms, compared with participants who remained in  
 4 Group A, those who remained in Group B, Group C, and Group D were less likely to  
 5 develop depressive symptoms. Similarly, those who increased the number of regular  
 6 frequency activities to two (Group A and Group B to Group C) or three (Group A,  
 7 Group B and Group C to Group D) after the six-year follow-up period were less likely  
 8 to experience depressive symptoms. Meanwhile, participants who had a decrease in  
 9 the number of regular frequency activities (from Group D to Group A) were more  
 10 likely to report the occurrence of depressive symptoms. However, this was not the  
 11 case for participants from Group D to Group C (Table 3).

### 12 *3.3 Association between changes in social activities and the persistence of depressive* 13 *symptoms among those with depressive symptoms at baseline*

14 A total 260 (49.8%) participants reported persistent depressive symptoms after the  
 15 six-year follow-up period. Compared with participants who engaged in activities at  
 16 CLF, those who reported IF or CRF for personal activities were less likely to have  
 17 persistent depressive symptoms after controlling for all the confounding factors. The  
 18 DF group for learning activities had a higher likelihood for having persistent  
 19 depressive symptoms (Table 4).

20 On the association between changes in combination of multiple social activities and  
 21 the persistence of depressive symptoms, compared with participants who remained in  
 22 Group A, those who remained in Group D, those who increased the number of regular  
 23 frequency activities from Group A to Group C, from Group C to Group D, and those  
 24 who decreased the number of regular frequency activities from Group D to Group A  
 25 showed significant association with the persistence of depressive symptoms (Table 3).

## 26 **4. Discussions**

27 We explored the association between changes in social activities and the occurrence  
 28 and persistence of depressive symptoms. Regarding the changes in each social activity,  
 29 we found that older adults without depressive symptoms, who participated in these  
 30 social activities at CRF or IF had a significant association with the occurrence of  
 31 depressive symptoms. However, for older adults with depressive symptoms at  
 32 baseline, only the CRF and IF of personal activities and DF of learning activities  
 33 showed an association with the persistence of depressive symptoms. Regarding the  
 34 changes in the combination of multiple social activities, we found that participants  
 35 were less likely to develop depressive symptoms if they maintained the same level of  
 36 participation or increased the number of regular frequency social activities to two or  
 37 three. However, for those who had depressive symptoms, they had either maintain all  
 38 three kinds of activities at a regular frequency or increase the number of social  
 39 activities at regular frequency to have an association with the persistence of  
 40 depressive symptoms.

41 A prospective study on Koreans aged 45 years or older found that continued or new  
 42 participation in social activities is negatively associated with the occurrence of

depressive symptoms (Choi et al., 2015). They found that the strength of the negative association varies across types of social activities, with stronger negative effects of leisure, culture or sports club, and family or school reunion activities compared with volunteer or political activities (Choi et al., 2015). Our results also confirmed that the effect size of the negative relation between CRF or IF of social activities and depressive symptoms varied across different types of social activities. Personal activities had the strongest effect, followed by socially relevant activities and then by learning activities. Cross-sectional and prospective studies have demonstrated that a higher level of perceived emotional support could protect people from depressive symptoms, whereas a lower level is associated with the presence or development of depressive symptoms (Santini et al., 2015). Another longitudinal study on adults aged 60 years and over also found that decreased participation in social activities is associated with higher score on the Center for Epidemiological Studies-Depression scale (higher scores indicate severe depressive symptoms) (Chao, 2016). Our results similarly demonstrated that decreased social-related activities was associated with the occurrence of depressive symptoms and decreased learning activities was associated with the persistence of depressive symptoms. This longitudinal study also found the cumulative and compensatory effects of different types of leisure activities on depressive symptoms, which means a gain in certain activities may compensate for losses in other activities (Chao, 2016). Our results on changes in the accumulation of social activities and the occurrence of depressive symptoms also suggested that even with a low frequency of one or two activities, maintaining the same combination status during follow-up showed significant association with the development depressive symptoms, which may suggest a compensatory effect among different frequency groups of social activities.

Early research has revealed that the strength and direction of the association of social activities with persistent depressive symptoms also related to the type of activity (Croezen et al., 2015; Min et al., 2016; Ryu et al., 2021). Increased participation in sports, social clubs, and other club activities is associated with a contemporary decline in depressive symptoms but does not predict changes in depressive symptoms after multi-year follow-up period. A possible explanation is that the short-term benefits of social engagement on depressive symptoms diminish over time; another is that depressive symptoms affect engagement in social activities (Croezen et al., 2015). In our study, we found an association of CFR and IF of personal activities with the persistence of depressive symptoms after controlling for all the confounding factors. The measurement of changes in social activities and persistence of depressive symptoms in our study were at the same wave; the association also seemed contemporaneous. More longitudinal studies are needed to explain the association between changes in social activities and the improvement of depressive symptoms.

The age-specific participants allowed us to eliminate the confounding factor of age. In addition, we used a set of questions rather than a single question to assess social activities from multiple perspectives, which makes our results more generalizable. Several limitations also should be considered. First, the self-reported questions on social activity assessment may lead to recalled biases. Second, social activities and



depressive symptoms may interact with each other over time, the exposure and outcome in our study were measured at the same time; as much, we could not consider causality. Future studies should carefully consider the statistical methods or use prospective or intervention studies to explore this interaction between social activity and depressive symptoms over time, especially for participants with depressive symptoms at baseline. Third, cognitive function was not included as a confounding factor because relatively few participants completed the assessments.

## **5. Conclusions**

We found that Japanese community-dwelling older adults participating in personal activities had a greater impact on depressive symptoms than social-related and learning activities. A combination of more types of social activities at regular frequency and an increase in the number of social activities at regular frequency was significantly associated with the occurrence of depressive symptoms in older people. For participants who had depressive symptoms, only a greater number of regular frequency activities both at baseline and follow-up was associated with the persistence of depressive symptoms.

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## **CRedit authorship contribution statement**

Shigekazu Ukawa, Hideki Ohira, Takashi Kawamura, Kenji Wakai, Masahiko Ando, and Akiko Tamakoshi: project administration, data collection. Yifan Shan, Wenjing Zhao, and Akiko Tamakoshi: study design. Yifan Shan, Wenjing Zhao, Wen Hao and Takashi Kimura: data analysis and manuscript preparation. Yifan Shan, Wenjing Zhao, Wen Hao, Takashi Kimura, Shigekazu Ukawa, Hideki Ohira, Takashi Kawamura, Kenji Wakai, Masahiko Ando, and Akiko Tamakoshi: review and editing.

Yifan Shan, Wenjing Zhao, and Akiko Tamakoshi: Conceptualization; Shigekazu Ukawa, Hideki Ohira, Takashi Kawamura, Kenji Wakai, Masahiko Ando, and Akiko Tamakoshi: Data curation; Yifan Shan, Wen Hao Takashi Kimura: Formal analysis; Shigekazu Ukawa, Hideki Ohira, Takashi Kawamura, Kenji Wakai, Masahiko Ando, and Akiko Tamakoshi: Funding acquisition; Shigekazu Ukawa, Hideki Ohira, Takashi Kawamura, Kenji Wakai, Masahiko Ando, and Akiko Tamakoshi: Investigation; Yifan Shan, Wenjing Zhao, Akiko Tamakoshi: Methodology; Shigekazu Ukawa, Hideki Ohira, Takashi Kawamura, Kenji Wakai, Masahiko Ando, and Akiko Tamakoshi: Project administration; Shigekazu Ukawa, Hideki Ohira, Takashi Kawamura, Kenji Wakai, Masahiko Ando, and Akiko Tamakoshi: Resources; Yifan Shan, Wenjing Zhao,

Wen Hao, Takashi Kimura: Software; Akiko Tamakoshi: Supervision; Takashi Kimura: Validation; Yifan Shan, Akiko Tamakoshi: Visualization; Yifan Shan: Writing - original draft; Yifan Shan, Wenjing Zhao, Wen Hao, Takashi Kimura, Shigekazu Ukawa, Hideki Ohira, Takashi Kawamura, Kenji Wakai, Masahiko Ando, and Akiko Tamakoshi: Writing - review & editing.

## Declaration of Competing Interest

There are no conflicts of interest to declare.

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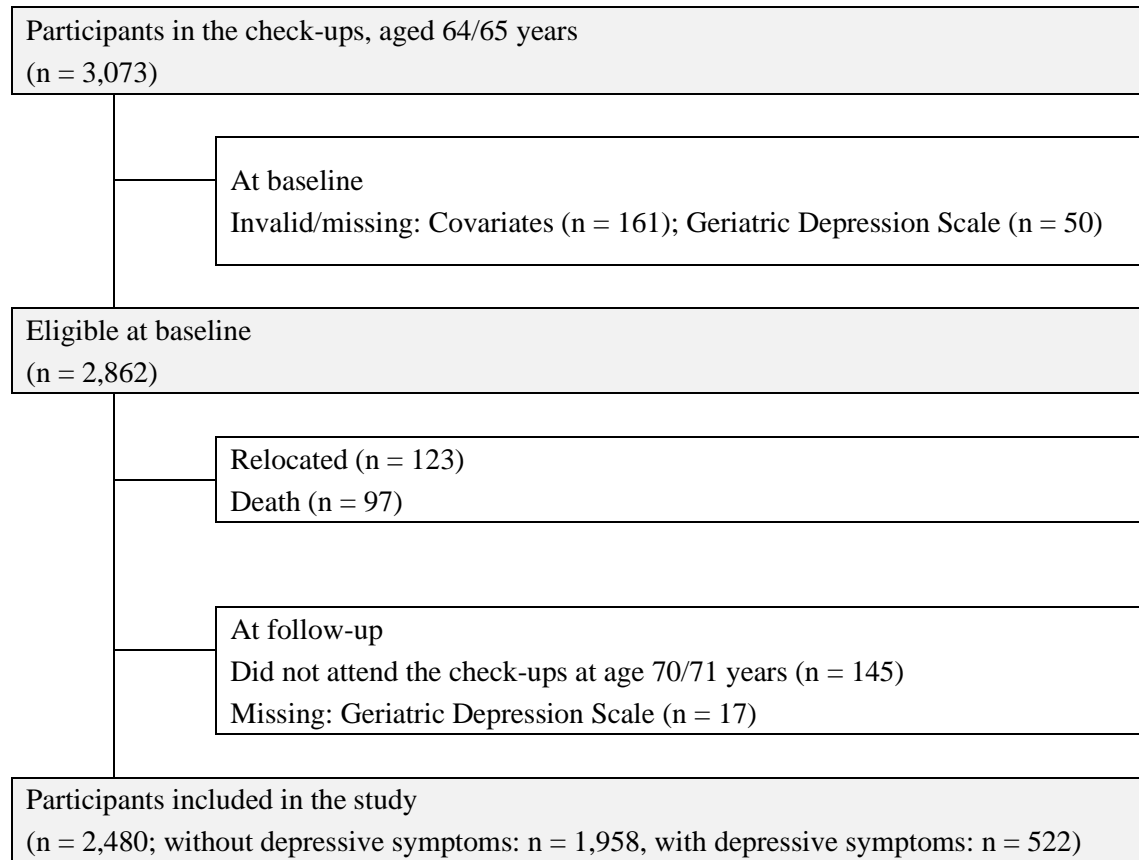


Fig. 1. Flowchart of participant recruitment

**Table 1** Baseline characteristic of participants who had changes in social activities

Items	Total	Changes in social-related activity				<i>P</i>	Changes in learning activity				<i>P</i>
		CLF	IF	DF	CRF		CLF	IF	DF	CRF	
<b>Number of participants</b>	2480	449	569	169	1293		915	510	240	815	
<b>Sex (female)</b>	1239 (50.0)	205 (45.7)	272 (47.8)	88 (52.1)	674 (52.1)	0.068	405 (44.3)	225 (44.1)	134 (55.8)	475 (58.3)	<b>&lt;.0001</b>
<b>Participation year</b>											
1996	169 (6.8)	33 (7.3)	43 (7.6)	10 (5.9)	83 (6.4)	0.109	67 (7.3)	42 (8.2)	12 (5.0)	48 (5.9)	0.268
1997	201 (8.1)	46 (10.2)	48 (8.4)	11 (6.5)	96 (7.4)		69 (7.5)	50 (9.8)	15 (6.3)	67 (8.2)	
1998	224 (9.0)	29 (6.5)	61 (10.7)	16 (9.5)	118 (9.1)		73 (8.0)	46 (9.0)	25 (10.4)	80 (9.8)	
1999	270 (10.9)	52 (11.6)	53 (9.3)	26 (15.4)	139 (10.8)		97 (10.6)	56 (11.0)	27 (11.3)	90 (11.0)	
2000	263 (10.6)	61 (13.6)	60 (10.5)	19 (11.2)	123 (9.5)		103 (11.3)	56 (11.0)	28 (11.7)	76 (9.3)	
2001	296 (11.9)	60 (13.4)	65 (11.4)	24 (14.2)	147 (11.4)		122 (13.3)	61 (12.0)	24 (10.0)	89 (10.9)	
2002	284 (11.5)	55 (12.2)	66 (11.6)	17 (10.1)	146 (11.3)		96 (10.5)	54 (10.6)	35 (14.6)	99 (12.1)	
2003	283 (11.4)	39 (8.7)	63 (11.1)	16 (9.5)	165 (12.8)		94 (10.3)	55 (10.8)	35 (14.6)	99 (12.1)	
2004	240 (9.7)	43 (9.6)	48 (8.4)	16 (9.5)	133 (10.3)		101 (11.0)	34 (6.7)	18 (7.5)	87 (10.7)	
2005	250 (10.1)	31 (6.9)	62 (10.9)	14 (8.3)	143 (11.1)		93 (10.2)	56 (11.0)	21 (8.8)	80 (9.8)	
<b>BMI</b>											
<18.5	116 (4.7)	32 (7.1)	25 (4.4)	8 (4.7)	51 (3.9)	0.209	46 (5.0)	19 (3.7)	11 (4.6)	40 (4.9)	0.710
18.5-25.0	1819 (73.3)	327 (72.8)	417 (73.3)	125 (74.0)	950 (73.5)		661 (72.2)	374 (73.3)	173 (72.1)	611 (75.0)	
>25.0	545 (22.0)	90 (20.0)	127 (22.3)	36 (21.3)	292 (22.6)		208 (22.7)	117 (22.9)	56 (23.3)	164 (20.1)	
<b>Smoking</b>											
Never	1384 (55.8)	219 (48.8)	308 (54.1)	94 (55.6)	763 (59.0)	<b>0.003</b>	462 (50.5)	266 (52.2)	138 (57.5)	518 (63.6)	<b>&lt;.0001</b>
Former	678 (27.3)	134 (29.8)	166 (29.2)	40 (23.7)	338 (26.1)		244 (26.7)	151 (29.6)	63 (26.3)	220 (27.0)	
Current	418 (16.9)	96 (21.4)	95 (16.7)	35 (20.7)	192 (14.8)		209 (22.8)	93 (18.2)	39 (16.3)	77 (9.4)	

<b>Drinking (current drinker)</b>	1116 (45.0)	189 (42.1)	264 (46.4)	63 (37.3)	600 (46.4)	0.069	406 (44.4)	267 (52.4)	102 (42.5)	341 (41.8)	<b>0.002</b>
<b>Marital status (married)</b>	2228 (89.8)	390 (86.9)	512 (90.0)	150 (88.8)	1176 (91.0)	0.096	817 (89.3)	460 (90.2)	217 (90.4)	734 (90.1)	0.918
<b>Education background</b>											
Junior high school or lower	765 (30.8)	170 (37.9)	178 (31.3)	59 (34.9)	358 (27.7)	<b>0.001</b>	387 (42.3)	150 (29.4)	72 (30.0)	156 (19.1)	<b>&lt;.0001</b>
High school	1106 (44.6)	181 (40.3)	262 (46.0)	80 (47.3)	583 (45.1)		367 (40.1)	232 (45.5)	105 (43.8)	402 (49.3)	
College or higher	609 (24.6)	98 (21.8)	129 (22.7)	30 (17.8)	352 (27.2)		161 (17.6)	128 (25.1)	63 (26.3)	257 (31.5)	
<b>Living alone</b>	94 (3.8)	23 (5.1)	22 (3.9)	7 (4.1)	42 (3.2)	0.349	31 (3.4)	17 (3.3)	8 (3.3)	38 (4.7)	0.469
<b>History of chronic disease</b>	718 (29.0)	121 (26.9)	178 (31.3)	47 (27.8)	372 (28.8)	0.474	264 (28.9)	145 (28.4)	62 (25.8)	247 (30.3)	0.586
<b>Competence of daily living</b>											
low	258 (10.4)	102 (22.72)	69 (12.13)	16 (9.47)	71 (5.49)	<b>&lt;.0001</b>	145 (15.85)	58 (11.37)	16 (6.67)	39 (4.79)	<b>&lt;.0001</b>
high	2222 (89.6)	347 (77.28)	500 (87.87)	153 (90.53)	1222 (94.51)		770 (84.15)	452 (88.63)	224 (93.33)	776 (95.21)	
<b>Depressive symptoms</b>											
not have	1958 (79.0)	288 (64.1)	434 (76.3)	132 (78.1)	1104 (85.4)	<b>&lt;.0001</b>	656 (71.7)	401 (78.6)	189 (78.8)	712 (87.4)	<b>&lt;.0001</b>
have	522 (21.0)	161 (35.9)	135 (23.7)	37 (21.9)	189 (14.6)		259 (28.3)	109 (21.4)	51 (21.3)	103 (12.6)	

Difference among different changes in social activities tested by chi-square test. CLF: continued low frequency, IF: increased frequency, DF: decreased frequency, CRF: continued regular frequency

**continued Table 1** Baseline characteristic of participants who had changes in social activities

Items	Changes in personal activity				<i>P</i>
	CLF	IF	DF	CRF	
<b>Number of participants</b>	335	403	208	1534	
<b>Sex (female)</b>	128 (38.2)	158 (39.2)	110 (52.9)	843 (55.0)	<b>&lt;.0001</b>
<b>Participation year</b>					
1996	26 (7.8)	30 (7.4)	23 (11.1)	90 (5.9)	
1997	35 (10.4)	36 (8.9)	9 (4.3)	121 (7.9)	
1998	32 (9.6)	43 (10.7)	17 (8.2)	132 (8.6)	
1999	42 (12.5)	34 (8.4)	31 (14.9)	163 (10.6)	
2000	40 (11.9)	33 (8.2)	25 (12.0)	165 (10.8)	<b>0.025</b>
2001	40 (11.9)	48 (11.9)	31 (14.9)	177 (11.5)	
2002	27 (8.1)	46 (11.4)	19 (9.1)	192 (12.5)	
2003	37 (11.0)	46 (11.4)	17 (8.2)	183 (11.9)	
2004	27 (8.1)	40 (9.9)	24 (11.5)	149 (9.7)	
2005	29 (8.7)	47 (11.7)	12 (5.8)	162 (10.6)	
<b>BMI</b>					
<18.5	22 (6.6)	25 (6.2)	10 (4.8)	59 (3.8)	
18.5-25.0	249 (74.3)	281 (69.7)	151 (72.6)	1138 (74.2)	0.131
>25.0	64 (19.1)	97 (24.1)	47 (22.6)	337 (22.0)	
<b>Smoking</b>					
Never	156 (46.6)	179 (44.4)	116 (55.8)	933 (60.8)	
Former	85 (25.4)	145 (36.0)	47 (22.6)	401 (26.1)	<b>&lt;.0001</b>
Current	94 (28.1)	79 (19.6)	45 (21.6)	200 (13.0)	
<b>Drinking (current drinker)</b>	158 (47.2)	203 (50.4)	78 (37.5)	677 (44.1)	<b>0.020</b>
<b>Marital status (married)</b>	298 (89.0)	357 (88.6)	186 (89.4)	1387 (90.4)	0.664

<b>Education background</b>					
Junior high school or lower	126 (37.6)	121 (30.0)	88 (42.3)	430 (28.0)	
High school	126 (37.6)	176 (43.7)	76 (36.5)	728 (47.5)	<b>&lt;.0001</b>
College or higher	83 (24.8)	106 (26.3)	44 (21.2)	376 (24.5)	
<b>Living alone (Yes)</b>	15 (4.5)	11 (2.7)	9 (4.3)	59 (3.8)	0.603
<b>Chronic disease (have)</b>	102 (30.4)	111 (27.5)	66 (31.7)	439 (28.6)	0.656
<b>Competence of daily living</b>					
low	112 (33.43)	69 (17.12)	21 (10.1)	56 (3.65)	
high	223 (66.57)	334 (82.88)	187 (89.9)	1478 (96.35)	<b>&lt;.0001</b>
<b>Depressive symptoms</b>					
not have	207 (61.8)	290 (72.0)	159 (76.4)	1302 (84.9)	
have	128 (38.2)	113 (28.0)	49 (23.6)	232 (15.1)	<b>&lt;.0001</b>

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Difference among different changes in social activities tested by chi-square test. CLF: continued low frequency, IF: increased frequency, DF: decreased frequency, CRF: continued regular frequency



**Table 2** Association between changes in social activities and the occurrence of depressive symptoms among participants who did not have depressive symptoms at baseline

Changes in social activities	Participants without depressive symptoms at baseline (n =1958)	Occurrence of depressive symptoms (n = 246)	Model 1	Model 2	Model 3
			RR (95% CI)	RR (95% CI)	RR (95% CI)
<b>Social-related activity</b>					
CLF	232	56 (19.4)	1.00 (ref)	1.00 (ref)	1.00 (ref)
IF	388	46 (10.6)	0.54 (0.37, 0.77) **	0.55 (0.39, 0.80) **	0.56 (0.39, 0.80) **
DF	94	38 (28.8)	1.45 (1.02, 2.07) *	1.45 (1.02, 2.08) *	1.56 (1.09, 2.23) *
CRF	998	106 (9.6)	0.48 (0.36, 0.65) ***	0.51 (0.37, 0.69) ***	0.55 (0.41, 0.74) ***
<b>Learning activity</b>					
CLF	548	108 (16.5)	1.00 (ref)	1.00 (ref)	1.00 (ref)
IF	363	38 (9.5)	0.58 (0.41, 0.82) **	0.60 (0.43, 0.85) **	0.63 (0.45, 0.89) **
DF	153	36 (19.1)	1.14 (0.81, 1.60)	1.19 (0.85, 1.68)	1.24 (0.88, 1.75)
CRF	648	64 (9)	0.53 (0.40, 0.71) ***	0.58 (0.42, 0.78) **	0.62 (0.46, 0.84) **
<b>Personal activity</b>					
CLF	153	54 (26.1)	1.00 (ref)	1.00 (ref)	1.00 (ref)
IF	265	25 (8.6)	0.33 (0.21, 0.51) ***	0.34 (0.22, 0.53) ***	0.37 (0.24, 0.58) ***
DF	109	50 (31.5)	1.17 (0.84, 1.62)	1.20 (0.86, 1.66)	1.32 (0.94, 1.86)
CRF	1185	117 (9)	0.33 (0.25, 0.44) ***	0.35 (0.26, 0.47) ***	0.41 (0.30, 0.57) ***

CLF: continued low frequency, IF: increased frequency, DF: decreased frequency, CRF: continued regular frequency; RR = relative ratio, CI = confidence interval; Model 1 adjusted for sex and year of participation; Model 2 adjusted for sex, year of participation, smoking, drinking, marital status, education background and living alone; Model 3 adjusted for sex, year of participation, smoking, drinking, marital status, education background, living alone, BMI, history of chronic disease and competence of daily living; \*P<0.05, \*\*P<0.01, \*\*\*P<0.001

**Table 3** Association between changes in combination of multiple social activities and the occurrence/persistence of depressive symptoms

Changes in combination of multiple social activities	Participants without depressive symptoms at baseline (n=1958)	Occurrence of depressive symptoms (n = 246)	adjusted model RR (95% CI)	Participants with depressive symptoms at baseline (n = 522)	Persistence of depressive symptoms (n=260)	adjusted model RR (95% CI)
remained in Group A	66	23 (34.8)	1.00 (ref)	56	38 (67.9)	1.00 (ref)
Group B → Group A	117	17 (14.5)	1.10 (0.66, 1.83)	54	30 (55.6)	0.91 (0.61, 1.34)
Group C → Group A	220	20 (9.1)	1.48 (0.82, 2.68)	42	26 (61.9)	0.61 (0.27, 1.40)
Group D → Group A	494	39 (7.9)	3.02 (1.70, 5.38) **	51	16 (31.4)	1.71 (1.21, 2.42) **
Group A → Group B	75	16 (21.3)	0.74 (0.42, 1.30)	44	21 (47.7)	0.72 (0.49, 1.05)
remained in Group B	72	4 (5.6)	0.49 (0.28, 0.85) *	34	12 (35.3)	0.94 (0.68, 1.28)
Group C → Group B	39	2 (5.1)	0.63 (0.35, 1.13)	11	4 (36.4)	0.93 (0.62, 1.40)
Group D → Group B	174	15 (8.6)	0.80 (0.35, 1.81)	52	26 (50.0)	1.16 (0.71, 1.9)
Group A → Group C	116	10 (8.6)	0.18 (0.06, 0.48) **	43	25 (58.1)	0.60 (0.37, 0.98) *
Group B → Group C	282	28 (9.9)	0.29 (0.16, 0.54) ***	47	14 (29.8)	0.85 (0.60, 1.19)
remained in Group C	52	18 (34.6)	0.32 (0.19, 0.56) ***	26	15 (57.7)	1.01 (0.73, 1.39)
Group D → Group C	22	10 (45.5)	0.46 (0.25, 0.83) *	8	3 (37.5)	0.78 (0.44, 1.40)
Group A → Group D	78	14 (17.9)	0.17 (0.04, 0.69) *	23	13 (56.5)	0.65 (0.32, 1.34)
Group B → Group D	14	10 (71.4)	0.31 (0.16, 0.62) **	3	3 (100.0)	0.97 (0.69, 1.37)
Group C → Group D	26	6 (23.1)	0.38 (0.23, 0.63) **	8	6 (75.0)	0.51 (0.31, 0.82) **
remained in Group D	111	14 (12.6)	0.30 (0.18, 0.49) ***	20	8 (40.0)	0.60 (0.37, 0.96) *

RR = relative ratio, CI = confidence interval; Adjusted for sex, year of participation, smoking, drinking, marital status, education background, living alone, BMI, history of chronic disease and competence of daily living; \*P<0.05, \*\*P<0.01, \*\*\*P<0.001

**Table 4** Association between changes in social activities and the persistence of depressive symptoms among participants who have depressive symptoms at baseline

Changes in social activities	Participants with depressive symptoms at baseline (n = 522)	Persistence of depressive symptoms (n=260)	Model 1	Model 2	Model 3
			RR (95% CI)	RR (95% CI)	RR (95% CI)
<b>Social-related activity</b>					
CLF	161	89 (55.3)	1.00 (ref)	1.00 (ref)	1.00 (ref)
IF	135	72 (53.3)	0.98 (0.80, 1.21)	0.99 (0.80, 1.23)	1.05 (0.84, 1.30)
DF	37	20 (54.1)	1.00 (0.72, 1.38)	0.99 (0.72, 1.38)	1.05 (0.76, 1.45)
CRF	189	79 (41.8)	0.78 (0.62, 0.97) *	0.78 (0.63, 0.97) *	0.84 (0.67, 1.05)
<b>Learning activity</b>					
CLF	259	140 (54.1)	1.00 (ref)	1.00 (ref)	1.00 (ref)
IF	109	45 (41.3)	0.78 (0.61, 1.00) *	0.82 (0.64, 1.05)	0.83 (0.65, 1.07)
DF	51	31 (60.8)	1.20 (0.93, 1.53)	1.27 (0.99, 1.62)	1.33 (1.04, 1.70) *
CRF	103	44 (42.7)	0.81 (0.63, 1.03)	0.88 (0.68, 1.13)	0.91 (0.71, 1.17)
<b>Personal activity</b>					
CLF	128	81 (63.3)	1.00 (ref)	1.00 (ref)	1.00 (ref)
IF	113	46 (40.7)	0.61 (0.47, 0.80) **	0.64 (0.49, 0.83) **	0.66 (0.50, 0.86) **
DF	49	28 (57.1)	0.85 (0.65, 1.12)	0.83 (0.63, 1.09)	0.88 (0.67, 1.16)
CRF	232	105 (45.3)	0.72 (0.59, 0.87) **	0.73 (0.60, 0.89) **	0.80 (0.64, 0.99) *

CLF: continued low frequency, IF: increased frequency, DF: decreased frequency, CRF: continued regular frequency; RR = relative ratio, CI = confidence interval; Model 1 adjusted for sex and year of participation; Model 2 adjusted for sex, year of participation, smoking, drinking, marital status, education background and living alone; Model 3 adjusted for sex, year of participation, smoking, drinking, marital status, education background, living alone, BMI, history of chronic disease and competence of daily living; \*P<0.05, \*\*P<0.01, \*\*\*P<0.001