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Examination of the Causality Relationship between Psychological Distress and Social Participation in Elderly People: A Pilot Study

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Few studies have considered the causal relationship between psychological distress and social participation in elderly people. Here we investigated this relationship based on an initial survey and a follow-up survey. In 2016, a survey was distributed to 86 participants. A follow-up survey of 80 of those participants was performed in 2017. We adopted the following variables: psychological distress and social participation as represented by the Kessler psychological distress scale and social participation scores, respectively. By using cross-lagged and synchronous effects models, we found that the 2016 Kessler psychological distress scale had a significant influence on the 2017 social participation scores (standardization factor = −0.221, $p = 0.020$) and the 2017 Kessler psychological distress scale significantly influenced the 2017 social participation scores (standardization factor = −0.345, $p = 0.039$). The results suggest that psychological distress may affect social participation one year later.

Key words: causal relationship, elderly people, psychological distress, social participation, structural equation modeling (SEM)

The increasing aging of the population is becoming a global issue and is a particular concern in Japan. According to the Cabinet Office of the Government of Japan, the aging rate (the proportion of the total population that is aged 65 or older) in Japan was 27.3% in 2016 (http://www8.cao.go.jp/kourei/whitepaper/w-2017/html/gaiyou/s1_1.html [in Japanese] accessed 16 May, 2019). Therefore, maintaining the health of the elderly is important, and maintaining the health of the elderly would be beneficial to other countries. The World Health Organization stated that "health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (http://www.who.int/about/mission/en/ [in Japanese] accessed 16 May, 2019). It is well known that there is a high cor-relation between mental health and social participation (SP). As previously described [1,2], we conducted a study in the 2 phase. We carried out this study using data from a secondary analysis in our previous report [1,2].

A number of studies have shown a relationship between mental health (psychological distress, PD) and SP in elderly people. Some studies, including one of ours [1], reported that active SP reduced the likelihood of depression [3-6]; however, others did not support this observation [7,8]. However, few studies have clarified the causal relationship between PD and SP in elderly people. In the present study, we define this relationship as a "Granger" [9] causal relationship. The "Granger causality test" is used to determine causal relationships by controlling the prior values of each

variable and examining the cross-lagged effects between them. If the cross-lagged effects of X → Y and Y → X are both significant, there is a bi-directional causal relationship. It is assumed that there is no causal relation between the variables when only one cross-lagged effect is significant, only one causal relationship exists, or both cross-lagged effects are not significant.

In this study, we used "Granger causality" to investigate the causal relationship between PD (mental factor) and SP in elderly people with a 1-year follow-up.

Methods

Study design. We applied structural equation modeling (SEM) using both the cross-lagged and synchronous effects models. In addition, we adopted the following as proxy variables: PD and SP as represented by the Kessler PD (K6) [10,11] and SP scores, respectively. We assumed the following hypothesis: improvement in PD causes an increase in SP scores. The survey methods were assessed using a self-administered questionnaire. The initial survey included 96 elderly people who participated at a health club at college A in Utazu, Japan. We carried out the study from July 20 to September 10, 2016 [1]. We excluded the data from the following participants from our analysis: 3 out of 96 people who canceled their enrollment in this study, and 7 people who had missing data. Therefore, the results from 86 respondents were used for the analysis. A similar follow-up survey was conducted from July 20 to September 15, 2017 in the second phase. Of the initial survey respondents, the data from 80 participants (excluding those who could not be surveyed) were analyzed. Therefore, we analyzed data from 80 (71.9 ± 5.5 years; K6 score: 2.4 ± 3.1; presence of exercise limitation: 9.1%) of the 86 subjects from our previous report [2]. Due to the small number of subjects (n = 80), we conducted this research as a pilot study.

We received approval from the Shikoku Medical College Ethic Screening Committee (approval number: H27-7), and written informed consent was obtained from each subject.

Clinical parameters and measurements. As shown in our previous report, anthropometric and body composition parameters were evaluated based on the following as confounding factors: age (years), height (cm), body weight (kg), and body mass index (BMI, kg/m^2) in 2016 and 2017 [1,2].

Psychological distress. Data for the K6 scores are cited from our previous papers [1,2]. "The K6 is a self-completed questionnaire developed by R.C. Kessler as a screening test for psychological distress that can effectively discriminate psychological distress: it is valid and reliable. The K6 data used in this study were taken six K6 questions on a 5-point Likert scale, and the response to each item was transformed into scores ranging from 0 to 4 points" [1].

Social participation. We evaluated SP as established by Haeuchi *et al.* [12]. We asked the respondents whether they had participated in any of the following 8 types of social activities within the past year: (1) local events and festivals, (2) resident and neighborhood associations, (3) circle activities; *i.e.*, a group activity based on a hobby or an interest such as history, (4) golden age club, (5) volunteer activities, (6) religious activities, (7) paid work, or (8) learning in a social environment. For each of the 8 activities, subjects were asked to indicate whether they had participated in at least once (scored as 2), more than once (scored as 1), or not at all (scored as 0). Thus the total scores were in the range from 0 to 16.

Statistical analyses. We applied SEM to clarify the causal relationship between PD and SP. First, to measure the reliability of the SP questionnaire, we determined the Cronbach's α value for the questionnaire; a value of 0.7 to 0.8 was considered to indicate that the questionnaire was sufficiently reliable [13].

Second, to measure the fitness of these models, we used χ^2 (values of $p > 0.05$ indicated that the model conformed to the data), adjusted goodness of fit index (AGFI) (from 0 to 1; the AGFI corresponds to the adjusted determination coefficient in regression analysis, preferably 0.95 or greater), comparative fit index (CFI) (from 0 to 1; the CFI corrects for the influence of the number of data, preferably 0.95 or greater), and root mean square error of approximation (RMSEA) (the RMSEA expresses the deviation between the distribution of the model and the true distribution as an amount per one degree of freedom, preferably less than 0.05). The appropriate sample size of the cross-lagged and synchronous effects models has not yet been clarified. Thus, we also verified SEM by using the bootstrap method (2,000 samples).

Third, to determine whether the variables of the initial survey could adequately predict the variables of the second survey, the PD and SP in 2016 were com-

pared with those in 2017, respectively.

Finally, to clarify whether there was a relationship between PD and SP, we adopted cross-lagged and synchronous effects models.

All calculations were performed using SPSS version 24 and AMOS version 24 (IBM).

Results

Data obtained in this study were calculated and expressed as means ± standard deviations (SDs) in Table 1, and the Cronbach's α value was 0.752.

To measure the fitness of these models (excluding insignificant paths), the following fitness indices of the models were obtained, and all showed high degrees of fitness: $\chi^2 = 0.729$ ($p = 0.393$); AGFI = 0.954; CFI = 1.000; and RMSEA = 0.000 for the cross-lagged effects model, and $\chi^2 = 3.332$ ($p = 0.189$); AGFI = 0.980; CFI = 0.987; and RMSEA = 0.092 for the synchronous effects model.

As shown in Fig. 1, the K6 scores (PD) in 2016 were significantly correlated with those in 2017 (standardization factor; SF = 0.833), while the SP scores were moderately correlated (SF = 0.424) between 2016 and 2017.

In the cross-lagged effects model, the effect of K6 in 2016 on SP in 2017 was significant (SF: −0.221, $p < 0.05$) (Fig. 1); however, the reverse, from 2016 SP to 2017 K6 scores (SF: 0.143, $p = 0.065$), was not. Therefore, it may be possible that the K6 scores in 2016 exerted a causal effect (−0.221) on SP in 2017. In the synchronous effects model, the effect of K6 in 2016 on SP was significant (SF: −0.345, $p < 0.05$); however, the reverse was not (SF: 0.069, $p = 0.518$) (Fig. 2). Therefore, it is possible that the K6 scores in 2017 exerted a causal effect (−0.345) on SP in 2017. After bootstrapping was performed (2,000 samples), 0 was not included in the 95% confidence interval (0.012, 0.109).

Discussion

The results of this study indicate that PD may affect SP one year later. Since Cronbach's α was 0.75, the reliability of the SP questionnaire was satisfactory. Our previous study [1] was a cross-sectional analysis. Therefore, although we found a correlation between PD and SP in that study, no causal relationship could be established. This study is a longitudinal study (second

Table 1   Clinical characteristics of the enrolled subjects

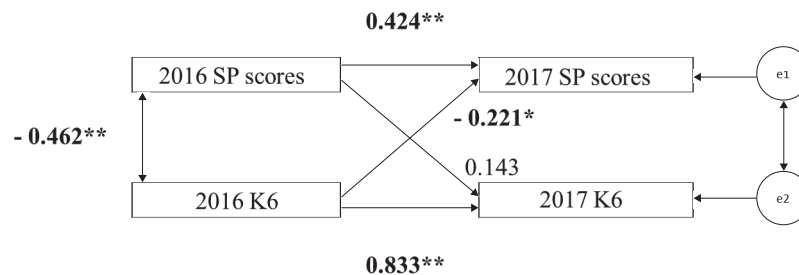|	2016			2017		
	Mean ± SD	Minimum	Maximum	Mean ± SD	Minimum	Maximum
Number of subjects	80			80		
Age (year)	71.9 ± 5.5	65	85			
Height (cm)	157.2 ± 9.2	138.3	178.4	157.1 ± 9.2	138.3	178.4
Body weight (kg)	56.1 ± 9.8	40.3	86.2	56.0 ± 9.7	40.3	83.1
BMI (kg/m²)	22.6 ± 2.8	14.9	29.1	22.6 ± 2.6	14.9	29.1
Social participation score	6.5 ± 4.8	0	12	7.0 ± 5.1	0	13
K6 score	2.4 ± 3.0	0	14	2.4 ± 3.1	0	14

Fig. 1   Cross-Lagged Effects Model. SP scores, social participation scores; K6, K6 scores; and e_1 and e_2, error. The values are standardization coefficients. **$p < 0.01$, *$p < 0.05$.
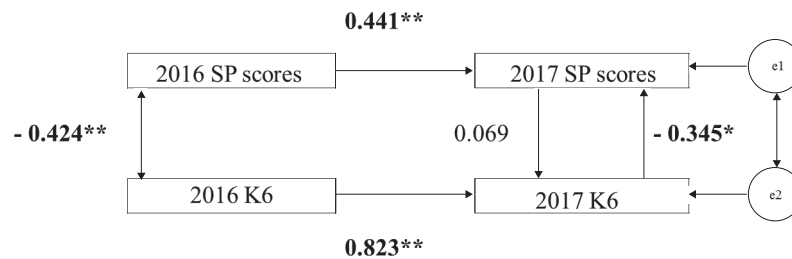
Fig. 2   Synchronous Effects Model. SP scores, social participation scores; K6, K6 scores; and e_1 and e_2, error. The values are standardization coefficients. **p < 0.01, *p < 0.05.

term). Thus, PD may be the cause and SP may be the result in the sense of "Granger causality."

In SEM, it is required that a non-logical value does not initially arise in the measurement model. The fitness degree of our model was good prior to assessing the resulting data, and the fitness of our model was satisfactory.

Since one year had passed between the initial survey and the follow-up survey, the measurement interval may have been too long in this study. Therefore, the study had a limitation in that the cross-lagged effects model alone (Fig. 1) could not exclude the indirect influence through a third variable other than between PD and SP. We introduced a synchronous effects model (Fig. 2) to overcome this limitation. By applying both the cross-lagged effects and synchronous effects models, it was possible to consider the Granger causality.

PD in 2016 was significantly correlated with PD in 2017. The SP scores between 2016 and 2017 were moderately correlated. Although these results did not affect the analysis of the causal relationship between PD and SP, changes in SP from 2016 to 2017 were influenced by aging and by the time of measurement. Therefore, it was necessary to verify which variable was affected in at least 2 cohorts.

Finally, based on the analysis using the cross-lagged effects model, the effect of K6 in 2016 on SP in 2017 continued to be significant despite the influence of SP in 2016. However, the effect of K6 in 2016 on SP in 2017 was not significant. Based on the analysis using the synchronous effects model, the effect of K6 in 2016 on SP in 2017 continued to be significant despite the influence of SP in 2016. However, the effect of K6 in 2016 on SP in 2017 was not significant. These results show that K6 in 2016 may have had an impact on SP in 2017 [14]. Improvements in PD may increase SP one year later when assessed using the cross-lagged and synchro-

nous effects models. This finding is in contrast with the conclusions of many other studies in which increased SP scores reduced the likelihood of depression [3,4,6,15-17]. This discrepancy may be due to the effect of physical activity on mental health level in cross-sectional studies. The relationship between cause and effect has not been sufficiently clarified in healthy elderly people (K6 score = 2.4) in long-term studies.

Our study has several limitations. First, since the sample size was less than 100, maximum-likelihood estimation and a simple model were used [18]. Second, regression of the problem to the average may occur [19]. Therefore, when conducting a longitudinal investigation in 2 phases, a high score in the first investigation tends to be higher than the true score of the investigational target, and a low score tends to be lower than the true score of the investigational target. As a result, in the second investigation, the high scores from the first investigation were reduced, but the low scores from the first investigation were higher. In order to resolve this issue, the observation of three or more phases is necessary. Regression to the average can be resolved in this way since the observation scores randomly fluctuate near the true score when the change is measured in more than 3 phases. Finally, in our previous study [1], K6 scores were not related to age, BMI (kg/m^2), working hours (h/day), exercise (Mets · h/week), number of steps (steps/day), walking time (min/day), ≤1.5 Mets (%/day), 1.6-2.9 Mets (%/day), 3-5.9 Mets (%/day), sleep time (h/day), spouse (presence or none), exercise limitation (presence or none), pain in limbs (presence or none), smoking habits (smoker or none), or drinking habits (drinker or none). In this study, no other third variable could be added to the model. Even if a causal relationship from x to y is shown, there is a possibility that the causal relation could be more appropriately described using an

unknown third variable. Therefore, the possibility of the influence of an unknown variable should be removed by searching for a third variable z that may affect the estimation of the causal relationship between x and y, and it should be incorporated into the model.

In conclusion, the results suggest that improving PD may affect the SP of elderly people one year later.

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