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Rotating savings and credit association, its members' diversity, and higher-level functional capacity: A 3-year prospective study from the Japan Gerontological Evaluation Study

Koryu Sato,[1] Naoki Kondo[1,2] and Katsunori Kondo[3,4]

[1]Department of Health Education and Health Sociology, The University of Tokyo, Tokyo, Japan
[2]Department of Health and Social Behavior, School of Public Health, The University of Tokyo, Tokyo, Japan
[3]Department of Social Preventive Medical Sciences, Center for Preventive Medical Sciences, Chiba University, Chiba, Japan
[4]Department of Gerontological Evaluation, Center for Gerontology and Social Science, National Center for Geriatrics and Gerontology, Aichi, Japan

Correspondence
Mr Koryu Sato MPH, Department of Health Education and Health Sociology, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo, Japan.
Email: kos639@mail.harvard.edu

Aim: A rotating savings and credit association – an informal local microfinance group – provides community-dwelling older adults with cohesive social capital. This study examined whether participation in *mujin*, a traditional Japanese rotating savings and credit association, affected the maintenance of higher-level functional capacity in older adults.

Methods: We studied 10 991 older adults living in 24 municipalities in Japan who were aged ≥65 years, and physically and cognitively independent. We carried out a baseline survey in 2013 and a follow-up survey in 2016. Higher-level functional capacity, consisting of instrumental activities of daily living, intellectual activity and social role, was assessed using the Tokyo Metropolitan Institute of Gerontology Index of Competence. To address potential reverse causation, we used stabilized inverse probability weights to balance characteristics at baseline between *mujin* participants and non-participants.

Results: In our analytic sample, 406 out of 10 991 older adults (3.7%) participated in *mujin* at the baseline. Our weighted logistic regression showed that *mujin* participants were more likely to maintain higher-level functional capacity (i.e. full marks in the Tokyo Metropolitan Institute of Gerontology Index of Competence) 3 years later compared with non-participants (odds ratio 1.75, 95% confidence interval 1.29–2.39). Furthermore, independent social role functioning and intellectual activity were associated with participation in *mujin* for an equal number of both sexes, as well as people of high social standing.

Conclusions: The present study suggests that rotating savings and credit associations can help older adults maintain their independence in a higher-level functional capacity. Furthermore, the members' diversity might add to these beneficial effects. **Geriatr Gerontol Int 2019; 19: 1268–1274**.

Keywords: *mujin*, social capital, social cohesion, social participation, stabilized inverse probability weights.

Introduction

Social capital is recognized as an important social determinant of functional capacity in later life.[1,2] Putnam defines social capital as "features of social organization, such as trust, norms and networks, that can improve the efficiency of society by facilitating coordinated actions."[3] In his book, Putnam exemplifies social capital by referring to rotating savings and credit associations (ROSCA), which are informal local microfinance groups that exist globally.[3] In a ROSCA, members regularly participate in meetings and need to deposit a fixed amount of money; an assigned member then receives the aggregate deposit. The same process continues until all members take an aggregate deposit, and those who

have received money cannot drop out of the group at this time. Therefore, members must trust each other, facilitating the building of cohesive social capital. Some studies examining ROSCA in developing countries suggested beneficial associations of participation in ROSCA with health outcomes.[4–6]

Japanese ROSCA are called *mujin* (also known as *tanomoshi-ko*, *yui* or *moai*). Although *mujin* have largely disappeared as formal banking systems developed after World War II, they remain active in some regions. Currently, the purpose of *mujin* is to promote friendship rather than mutual financial aid.[7] For example, *mujin* are still actively organized in Yamanashi Prefecture. In 2013, its residents were reported to enjoy the longest healthy life expectancy (defined as "expectation of life free of limitations for activities of daily living")

among Japan's 47 prefectures.[8] Given the cohesive social capital they build, *mujin* activity might be the secret to their healthy longevity.

A few studies examined the associations between *mujin* and health in older populations. Kondo *et al.* found that older adults with a higher level of engagement (i.e. participation history, maximum number of memberships and duration of membership) in *mujin* had greater social role performance than non-participants.[9] In their later work, they used cohort data, and suggested that those who enjoyed *mujin* and participated frequently less likely experienced the onset of functional disability during an 8-year study period.[10] However, these previous studies did not address reverse causation: *mujin* participants could have already been healthier than non-participants. Those who had lost their higher-level functional capacity would have had difficulties participating in *mujin*. Given that the loss of higher-level functional capacity is a precursor to disability, a longitudinal study that addresses reverse causation is required to confirm the effect of *mujin* on prolonging healthy life expectancy.[11,12]

The present study develops those of Kondo *et al.*[9,10] using stabilized inverse probability weights (IPW) to address potential reverse causation.[13] After balancing covariates, including various health conditions between the groups of *mujin* participants and non-participants at baseline, we compared higher-level functional capacity in *mujin* participants with controls over a period of 3 years. Furthermore, it is unclear whether the effect differs by the structural characteristics of *mujin* (i.e. sex ratio, area of residence, age composition and members' social standing). We examined variations in effectiveness across different structural characteristics of *mujin*.

Methods

Study participants

We obtained panel data from the Japan Gerontological Evaluation Study (JAGES), an ongoing cohort study of physically and cognitively independent Japanese people aged ≥65 years.[14] From October to December 2013, self-reported questionnaires were mailed to eligible residents in 24 municipalities in 10 (out of 47) prefectures, including two municipalities in Yamanashi Prefecture. Random sampling methods were used in 12 large municipalities, whereas a census of all eligible residents was carried out in 12 smaller municipalities. Of the 31 150 people invited to participate, 22 121 returned the questionnaires, corresponding to a response rate of 71.0%. A total of 1373 individuals, whose sex and age could not be confirmed, were excluded. From October to November 2016, a follow-up survey was carried out. We could follow up with 12 271 individuals, corresponding to a follow-up rate of 59.1%. From the analysis, we excluded those who did not respond to the question of whether he or she participated in *mujin* at baseline (*n* = 1280). Thus, our analytic sample comprised 10 991 participants. The study protocol was reviewed and approved by the ethics committees at the University of Tokyo, Nihon Fukushi University, National Center for Geriatrics and Gerontology, and Chiba University.

Outcome variable

We used the Tokyo Metropolitan Institute of Gerontology Index of Competence (TMIG-IC) to measure higher-level functional capacity. The TMIG-IC is a multidimensional 13-item index developed on the basis of Lawton's model of competence of older adults.[11] Validity and reliability of the index have been confirmed,[15] and it has been widely used.[9,12,16] The TMIG-IC

comprises three subscales: (i) instrumental self-maintenance, or instrumental activities of daily living (IADL); (ii) intellectual activity (IA); and (iii) social role (SR; see Table S1 for the 13-item list of the TMIG-IC). The score of each subscale was calculated by summing answers (yes = 1, no = 0). Full marks of IADL, IA and SR are 5, 4 and 4 points, respectively. Those who reported full marks were considered to be independent, and we constructed binary variables to indicate independent (1) or dependent (0) for the total score of TMIG-IC and each of the subscales.

Explanatory variable

Our primary explanatory variable was participation in *mujin* at baseline, measured by a question asking, "Do you take part in *mujin* activities?" In addition, we asked participants about the following characteristics of the *mujin* in which they participated (if one participated in multiple groups, they were asked to answer according to the group they found most important): (i) sex ratio (men or women only/more men than women/more women than men/roughly an equal proportion of men to women); (ii) area of residence (only people from the same municipality/some people from other municipalities); (iii) age composition (mostly people of the same generation/mixture of different generations [age difference of at least 20 years]); and (iv) social standing (there is a person or people of high social standing [e.g. residents' association official, politician, city council member, company or trade association executive, doctor, lawyer etc.]/there are no people of high social standing). We also examined whether participants in *mujin* with specific characteristics achieved better outcomes compared with non-participants.

Covariates

We adjusted for potential confounders measured at baseline, namely sex, age, marital status (married and spouse is alive or other [divorced, widowed and never married]), educational attainment (≤9 years, 10–12 years and ≥13 years), annual equivalized household income (≤¥1.9 million, ¥2.0–3.9 million and ≥¥4.0 million), occupational status (working or not working), depressive symptoms assessed with the short version of the Geriatric Depression Scale[17] (non-depressed [<5] or depressed [≥5]), self-rated health (very good/good *vs* poor/very poor), self-reported medical condition (no illness or having illness), social participation other than *mujin* (measured by the number of the following groups attended in a month: volunteer groups, sports groups, hobby activities, study or cultural groups and activities for teaching skills[18]), alcohol consumption (drinker or non-drinker), smoking status (smoker or non-smoker) and functional independence at baseline assessed with the TMIG-IC (IADL, IA and SR).

Statistical analysis

We addressed potential reverse causation between exposure (i.e. participation in *mujin*) and outcome using stabilized IPW. We calculated propensity scores of participation in *mujin* using a logistic regression model with the aforementioned covariates. After checking whether calculated weights balanced covariates measured at baseline between the groups, we incorporated them into multivariable logistic regressions with the same covariates on functional independence in the follow up. To address potential bias caused by missing values, we used multiple imputation under the missing at random assumption (i.e. a missing mechanism is related to the other variables measured in the same survey for that participant). Incomplete variables were imputed by a multivariate

normal model using all the variables as explanatory variables. We created 20 imputed datasets, and the estimates were combined. All analyses were carried out using Stata, version 14.2 (StataCorp, College Station, TX, USA).

Results

Table 1 delineates the characteristics of the participants. The proportion of those who reported independence in IADL at the follow up increased compared with baseline, whereas 4.8% of participants experienced a decline of the subscore of IADL. The proportion of those who reported independence in the total score of TMIG-IC, IA and SR declined, and 29.9%, 15.2% and 25.3% of participants experienced a decline of the total score of TMIG-IC and the subscore of IA and SR, respectively. In our analytic sample, 406 individuals participated in *mujin* at baseline. Participation rates of *mujin* were 33.6% in Yamanashi Prefecture and 2.4% in other prefectures.

Table 2 shows the characteristics of *mujin* and its participants. In our sample, one-third of *mujin* participants resided in Yamanashi Prefecture, whereas people residing within the prefecture were composed of 2.8% of non-participants. *Mujin* consisting of only men or only women were the fewest compared with other categories of gender makeup. Most *mujin* were organized by people from the same municipality. Approximately half of *mujin* were composed of people of the same generation, whereas the other half involved different generations with more than 20-year age differences. One-third of *mujin* included a person or people of high social standing.

We compared covariates measured at baseline between *mujin* participants and non-participants before and after weighting in Table 3 (see Table S2 for the logistic model calculating propensity scores). Before weighting, *mujin* participants were more likely to be men, younger, married, educated, working, independent in IA and SR, smokers, and to partake in social activities than non-participants. They were also less likely to be depressed and report poor self-rated health. After weighting, absolute values of the standardized difference between the groups were <0.1; thus, the two groups were well-balanced at baseline.

Our logistic regression with stabilized IPW showed that participation in *mujin* at baseline had a positive effect on the maintenance of independence in the total score of TMIG-IC (odds ratio [OR] 1.75, 95% confidence interval [CI] 1.29–2.39) and the subscale of SR (OR 1.71, 95% CI 1.24–2.37) in 3 years (Table 4). The point estimates of the effects of *mujin* also showed a positive effect on independence in IADL and IA, though they did not reach significant levels. We also tested a dummy variable, in the regression model, indicating residence in Yamanashi Prefecture to consider the special characteristics of this prefecture, given the concentration of *mujin* participants there. However, the dummy variable did not show any associations.

In Figure 1, we further examined effect variation on functional independence across different characteristics of *mujin*. As shown in Figure 1a, *mujin* that comprised of an equal number of both sexes showed beneficial effects, not only in SR (OR 2.06, 95% CI 1.20–3.54), but also in IA (OR 2.49, 95% CI 1.01–6.15). In contrast, *mujin* composed of single-sex and more women than men did not show any salutary effects of significant levels (Fig. 1a). In addition, *mujin* involving people of high social standing showed beneficial effects, not only in SR (OR 1.94, 95% CI 1.10–3.43), but also in IA (OR 2.04, 95% CI 1.001–4.15; Fig. 1d).

Table 1 Participants' characteristics

	n	%	Mean (SD)
Male	5076	46.5	
Age (years)	10 911	100.0	72.91 (5.58)
Marital status			
Married and spouse is alive	8107	74.3	
Other	2665	24.4	
Missing	139	1.3	
Education (years)			
Low (≤9)	4082	37.4	
Middle (10–12)	4281	39.2	
High (≥13)	2403	22.0	
Missing and other	145	1.3	
Annual equivalized household income (million JPY)			
Low (≤1.9)	4436	40.7	
Middle (2.0–3.9)	3826	35.1	
High (≥4.0)	1065	9.8	
Missing	1584	14.5	
Occupational status			
Working	2574	23.6	
Not working	7730	70.8	
Missing	607	5.6	
Depressive symptoms (GDS)			
Not depressed (<5)	7317	67.1	
Depressed (≥5)	2128	19.5	
Missing	1466	13.4	
Self-rated health			
Very good or good	9198	84.3	
Very poor or poor	1464	13.4	
Missing	249	2.3	
Self-reported medical condition			
No illness	1788	16.4	
Having illness	8503	77.9	
Missing	620	5.7	
Social participation	8987	82.4	0.85 (1.03)
Missing	1924	17.6	
Alcohol consumption			
Drinker	3974	36.4	
Non-drinker	6830	62.6	
Missing	107	1.0	
Smoking			
Smoker	1048	9.6	
Non-smoker	9733	89.2	
Missing	130	1.2	
TMIG-IC score (2013)			
Total			
Independent (13)	4697	43.0	
Dependent (≤12)	5696	52.2	
Missing	518	4.7	
IADL			
Independent (5)	9106	83.5	
Dependent (≤4)	1599	14.7	
Missing	206	1.9	
IA			
Independent (4)	7862	72.1	
Dependent (≤3)	2805	25.7	

(Continues)

Table 1 Continued

	n	%	Mean (SD)
Missing	244	2.2	
SR			
Independent (4)	6278	57.5	
Dependent (≤3)	4359	40.0	
Missing	274	2.5	
TMIG-IC score (2016)			
Total			
Independent (13)	4056	37.2	
Dependent (≤12)	5888	54.0	
Missing	967	8.9	
IADL			
Independent (5)	9539	87.4	
Dependent (≤4)	1073	9.8	
Missing	299	2.7	
IA			
Independent (4)	7240	66.4	
Dependent (≤3)	3209	29.4	
Missing	462	4.2	
SR			
Independent (4)	5444	49.9	
Dependent (≤3)	4940	45.3	
Missing	527	4.8	
Mujin participant	406	3.7	
Participation rate of *mujin*			
Yamanashi		33.6	
Other prefectures		2.4	

Total *n* = 10 911. GDS, Geriatric Depression Scale; IA, intellectual activity; IADL, instrumental activities of daily living; JPY, Japanese yen; SD, standard deviation; SR, social role; TMIG-IC, Tokyo Metropolitan Institute of Gerontology Index of Competence.

Discussion

In the present study, we found that ROSCA can delay the deterioration of SR functioning, especially given that SR is the most complex function among the higher-level functional capacities,[11] and SR functioning is most likely to be lost with advancing age, followed by IA and IADL.[12]

We believe that the beneficial effects of *mujin* derive from its role as social participation. Social participation has been shown to promote the maintenance of functional capacity in older adults.[19–22] One challenge faced by interventions involving social participation is the gender gap in participation rates; older men are less likely to participate in social activities than older women.[23,24] In contrast to this tendency, we found that men were more likely to participate in *mujin* than women (Tables 3,S2 S3). This can be explained by the historical and cultural context of Japan; until recently, the man has been the householder responsible for the family budget, and therefore has participated in *mujin* more actively, given that *mujin* is originally a financial activity.[9]

Furthermore, we showed that participation in *mujin* was independently associated with the maintenance of functional capacity after adjusting for engagement in paid work and other social activities (i.e. volunteer groups, sports groups, hobby activities, study or cultural groups and activities for teaching skills). This suggests that *mujin* is distinct from such social activities. For example, the financial investment component of *mujin* can motivate consistent commitment to participate in the activity, leading to habit formation.[25] In fact, a previous study showed that approximately 80% of participants stayed members of *mujin* for ≥10 years.[9] In addition,

Table 2 Characteristics of *mujin* and its participants

	n	%
Residence		
Yamanashi	150	36.9
Other prefectures	256	63.1
Sex ratio		
Men or women only	67	17.8
More men than women	114	30.2
More women than men	77	20.4
Roughly and equal proportion of men to women	119	31.6
Area of residence		
Only people from the same municipality	327	83.9
Some people from other municipalities	63	16.2
Age composition		
Mostly people of the same generation	184	47.3
Mixture of different generations (age difference of at least 20 years)	205	52.7
Social standing		
There is a person or people of high social standing[†]	121	32.4
There are no people of high social standing	253	67.7

[†]For example, residents' association official, politician, city council member, company or trade association executive, doctor, lawyer and so on.

mujin has higher proportions of participants who have low household income, depressive symptoms, poor self-rated health, and some illness than paid work and other social activities (Table S3). Such broad-based characteristics of *mujin* might differentiate it from other activities.

Furthermore, we found that some types of *mujin*, namely those consisting of an equal number of both sexes and involving people of high social standing, have a further beneficial effect on the maintenance of independence in IA. This might be explained by the characteristics of social capital. Social capital is often characterized as "bonding," "bridging" and "linking" types.[26] Bonding social capital refers to resources that are shared within networks where members share similar backgrounds, such as social class or race/ethnicity. This type of social capital provides members with cohesive relationships, and *mujin* can be categorized as essentially bonding social capital. In contrast, bridging social capital refers to resources that are accessed across networks that bridge individuals from different backgrounds. *Mujin* consisting of both sexes, people from other municipalities and different generations play a role in bridging different networks. This type of social capital enables individuals to access resources outside their networks, and might provide them with opportunities for better health.[27,28] In accordance with the present findings, a previous study found that older adults who participated in social groups with diverse membership were more likely to report better self-rated health than those who participated in less diverse groups; furthermore, gender was the key dimension of diversity.[29] While bridging social capital is characterized by horizontal relationships, linking social capital is characterized by vertical relationships across different social classes. *Mujin* that include people of high social standing provides members with linking social capital. Connecting with authorities (e.g. doctors, lawyers etc.) might provide individuals with information, advice and instrumental assistance that can help them solve problems. The present findings suggest that *mujin* that combine roles of bridging or linking can be more effective at slowing decline in functional capacity in older adults than *mujin* that work by only bonding homogeneous members.

Table 3 Comparison of the baseline characteristics between *mujin* participants and non-participants before/after stabilized inverse probability weighting

	Before weighting			After weighting		
	Mujin participant	Non-participant	Standardized difference	*Mujin* participant	Non-participant	Standardized difference
Male	0.57	0.46	0.23	0.45	0.47	−0.02
Age (years)	72.15†	72.94†	−0.15	72.92†	72.91†	0.002
Married	0.82	0.75	0.17	0.77	0.75	0.05
Education						
Low	0.34	0.38	−0.10	0.37	0.38	−0.03
Middle	0.45	0.40	0.10	0.38	0.40	−0.04
Household income						
Low	0.46	0.47	−0.01	0.49	0.47	0.05
Middle	0.40	0.41	−0.03	0.40	0.41	−0.02
Working	0.37	0.25	0.26	0.24	0.25	−0.02
TMIG-IC independence						
IADL	0.84	0.85	−0.01	0.84	0.85	−0.03
IA	0.78	0.73	0.12	0.72	0.73	−0.02
SR	0.78	0.58	0.43	0.58	0.59	−0.01
Depressed	0.19	0.25	−0.14	0.24	0.24	0.01
Poor self-rated health	0.11	0.14	−0.10	0.16	0.14	0.06
Having illness	0.15	0.18	−0.08	0.16	0.18	−0.04
Social participation	1.54‡	1.21‡	0.26	1.27‡	1.23‡	0.04
Drinker	0.41	0.37	0.09	0.37	0.37	0.01
Smoker	0.13	0.10	0.11	0.10	0.10	0.01

The proportions of those who apply to each item are presented except for the following items: † average years of chronological age; ‡ the average number of the following groups engaged in a month: volunteer groups, sports groups, hobby activities, study or cultural groups, and activities for teaching skills. IA, intellectual activity; IADL, instrumental activities of daily living; SR, social role; TMIG-IC, Tokyo Metropolitan Institute of Gerontology Index of Competence.

Table 4 Logistic regressions of participation in *mujin* on higher-level functional capacity with stabilized inverse probability weighting

	Total			IADL			IA			SR		
	OR	95% CI		OR	95% CI		OR	95% CI		OR	95% CI	
Mujin	1.75***	1.29	2.39	1.37	0.82	2.30	1.30	0.91	1.84	1.71**	1.24	2.37
Male	0.60***	0.53	0.67	0.51***	0.42	0.61	0.87*	0.77	0.99	0.59***	0.53	0.66
Age	0.99**	0.98	0.99	0.95***	0.94	0.96	1.00	0.99	1.01	0.98***	0.97	0.99
Married	1.17*	1.04	1.31	0.84	0.70	1.02	1.21**	1.06	1.37	1.19**	1.06	1.34
Education												
Low	0.88	0.77	1.01	0.70**	0.56	0.87	0.54***	0.47	0.63	1.18*	1.03	1.36
Middle	1.00	0.88	1.13	0.76*	0.61	0.94	0.86*	0.74	0.99	1.05	0.93	1.20
Household income												
Low	0.86	0.73	1.02	1.17	0.89	1.54	0.79*	0.64	0.97	0.94	0.79	1.11
Middle	0.95	0.80	1.12	1.07	0.82	1.40	0.90	0.73	1.10	1.03	0.88	1.22
Working	1.02	0.90	1.15	0.91	0.75	1.10	0.91	0.80	1.03	1.21**	1.07	1.37
TMIG-IC independence												
IADL	1.90***	1.59	2.26	10.41***	8.89	12.19	1.29**	1.11	1.49	1.26**	1.09	1.46
IA	4.84***	4.21	5.57	1.50***	1.27	1.77	10.39***	9.31	11.60	1.43***	1.27	1.61
SR	6.19***	5.53	6.92	1.23*	1.05	1.45	1.44***	1.29	1.60	8.89***	8.05	9.81
Depressed	0.86*	0.74	0.99	0.87	0.72	1.04	0.87*	0.76	0.99	0.77***	0.67	0.88
Poor self-rated health	0.80**	0.68	0.94	0.67***	0.55	0.82	0.83*	0.71	0.96	0.85*	0.73	0.99
Having illness	1.22**	1.07	1.38	1.24	0.98	1.56	1.13	0.97	1.30	1.15*	1.01	1.31
Social participation	1.15***	1.10	1.19	1.09**	1.02	1.16	1.05*	1.01	1.10	1.16***	1.11	1.20
Drinker	1.11	0.99	1.25	1.01	0.85	1.19	1.19**	1.05	1.34	1.06	0.95	1.18
Smoker	0.94	0.79	1.12	0.98	0.77	1.24	0.82*	0.69	0.97	0.96	0.82	1.14
Constant	0.10*	0.04	0.21	92.94***	29.39	293.93	0.51	0.23	1.15	0.55	0.26	1.19

***P < 0.001. **P < 0.01. *P < 0.05. CI, confidence interval; IA, intellectual activity; IADL, instrumental activities of daily living; OR, odds ratio; SR, social role; TMIG-IC, Tokyo Metropolitan Institute of Gerontology Index of Competence.
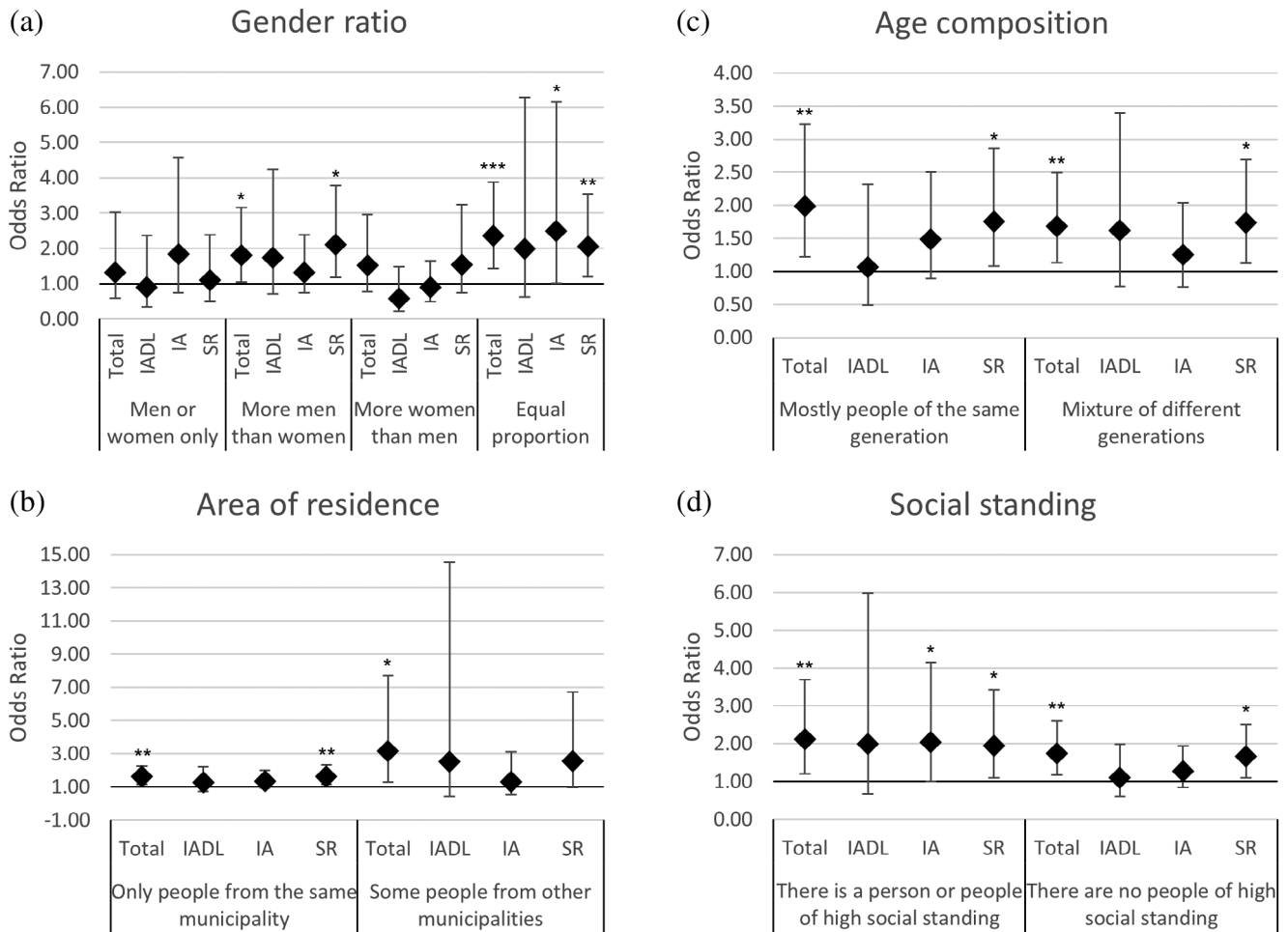
Figure 1 Participation in *mujin* and higher-level functional capacity by characteristics of *mujin*. The estimates were obtained from logistic regressions with stabilized inverse probability weights adjusted for sex, age, marital status, educational attainment, annual equivalized household income, occupational status, depressive symptoms, self-rated health, self-reported medical condition, social participation other than *mujin*, alcohol consumption, smoking status and functional independence at baseline. the reference is non-participants. *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$. IA, intellectual activity; IADL, instrumental activities of daily living; SR, social role.

The present study had several limitations. First, although we used an IPW method to address potential reverse causation between exposure and outcome (i.e. healthier people are more likely to participate in *mujin*) and successfully balanced both groups at baseline, this method cannot treat unobserved factors. Second, previous studies suggested that the extent and intensity of participation in *mujin* (i.e. maximum number of memberships, duration of membership, frequency of meeting and feelings of pleasure) matter, but we did not collect such detailed information on individual participation.[9,10] However, we were able to obtain valuable information on the structural characteristics of *mujin* (i.e. sex ratio, area of residence, age composition and members' social standing) and show variation in the impact on higher-level functional capacity based on the three types of social capital, which the previous studies have not examined. Third, higher-level functional capacity was self-reported, and thus misclassification is possible. Fourth, we examined various characteristics of *mujin*, which might induce the type I error as a result of multiple testing. One should carefully interpret the results based on point estimates and confidence intervals.

In summary, the present study suggests that participation in *mujin*, a traditional Japanese ROSCA, can help older adults maintain their independence in higher-level functional capacity, especially SR functioning. In addition, *mujin* characterized not only by "bonding," but also by "bridging" or "linking" social capital (i.e. the involvement of both sexes equally and of people of high social standing), showed a further impact on independence in IA. As social capital is developed in the historical and cultural context of each community, it is important for social epidemiology research to understand, not only the characteristics of social capital, but also how it can be adapted for interventions that promote healthy aging.

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Disclosure statement

The authors declare no conflict of interest.

References

1 Kim D, Subramanian SV, Kawachi I. Social capital and physical health: a systematic review of the literature. In: Kawachi I, Subramanian SV, Kim D, eds. *Social Capital and Health*. New York, NY: Springer New York, 2008; 139–190. https://doi.org/10.1007/978-0-387-71311-3_8.

2 Coll-Planas L, Nyqvist F, Puig T, Urrútia G, Solà I, Monteserín R. Social capital interventions targeting older people and their impact on health: a systematic review. *J Epidemiol Community Health* 2017; **71**: 663–672. https://doi.org/10.1136/jech-2016-208131.

3 Putnam RD, Leonardi R, Nanetti RY. *Making Democracy Work: Civic Traditions in Modern Italy*. Princeton, NJ: Princeton University Press, 1993.

4 Mohindra KS, Haddad S. Women's interlaced freedoms: a framework linking microcredit participation and health. *J Human Dev* 2005; **6**: 353–374. https://doi.org/10.1080/14649880500287662.

5 Leatherman S, Dunford C. Linking health to microfinance to reduce poverty. *Bull World Health Organ* 2010; **88**: 470–471. https://doi.org/10.2471/BLT.09.071464.

6 Hamad R, Fernald LCH. Microcredit participation and nutrition outcomes among women in Peru. *J Epidemiol Community Health* 2012; **66**: e1. https://doi.org/10.1136/jech.2010.108399.

7 Dekle R, Hamada K. On the development of rotating credit associations in Japan. *Econ Dev Cult Change* 2000; **49**: 77–90. https://doi.org/10.1086/452491.

8 Hashimoto S. Study on calculation and evaluation of national trend of health life expectancy - Trends in nationwide and prefectures. In: Tsuji I, ed. *Study on Factor Analysis of Healthy Life Span and Regional Disparity and Validation of Health Promotion Measures*. Tokyo, Japan: Ministry of Health, Labour and Welfare, 2017. http://toukei.umin.jp/kenkoujyumyou/houkoku/H29.pdf.

9 Kondo N, Minai J, Imai H, Yamagata Z. Engagement in a cohesive group and higher-level functional capacity in older adults in Japan: a case of the Mujin. *Soc Sci Med* 2007; **64**: 2311–2323. https://doi.org/10.1016/j.socscimed.2007.02.009.

10 Kondo N, Suzuki K, Minai J, Yamagata Z. Positive and negative effects of finance-based social capital on incident functional disability and mortality: an 8-year prospective study of elderly Japanese. *J Epidemiol* 2012; **22**: 543–550. https://doi.org/10.2188/jea.JE20120025.

11 Lawton MP. Assessing the competence of older people. In: Kent DP, Kastenbaum R, Sherwood S, eds. *Research, Planning, and Action for the Elderly : the Power and Potential of Social Science*. Boston, MA: Behavioral Publications, 1972.

12 Fujiwara Y, Shinkai S, Kumagai S et al. Longitudinal changes in higher-level functional capacity of an older population living in a Japanese urban community. *Arch Gerontol Geriatr* 2003; **36**: 141–153.

13 Hernán MA, Robins JM. Estimating causal effects from epidemiological data. *J Epidemiol Community Health* 2006; **60**: 578–586. https://doi.org/10.1136/jech.2004.029496.

14 Kondo K, Rosenberg M. *Advancing Universal Health Coverage through Knowledge Translation for Healthy Ageing: Lessons Learnt from the Japan Gerontological Evaluation Study*. Geneva, Switzerland: World Health Organization, 2018. [Cited 18 April 2019.] Available from URL: https://apps.who.int/iris/handle/10665/279010.

15 Koyano W, Shibata H, Nakazato K, Haga H, Suyama Y. Measurement of competence: reliability and validity of the TMIG index of competence. *Arch Gerontol Geriatr* 1991; **13**: 103–116. https://doi.org/10.1016/0167-4943(91)90053-S.

16 Fujiwara Y, Shinkai S, Kobayashi E et al. Engagement in paid work as a protective predictor of basic activities of daily living disability in Japanese urban and rural community-dwelling elderly residents: an 8-year prospective study. *Geriatr Gerontol Int* 2016; **16**: 126–134. https://doi.org/10.1111/ggi.12441.

17 Burke WJ, Roccaforte WH, Wengel SP. The short form of the geriatric depression scale: a comparison with the 30-item form. *J Geriatr Psychiatry Neurol* 1991; **4**: 173–178. https://doi.org/10.1177/089198879100400310.

18 Saito M, Kondo N, Aida J et al. Development of an instrument for community-level health related social capital among Japanese older people: the JAGES project. *J Epidemiol* 2016; **27**: 221–227. https://doi.org/10.1016/j.je.2016.06.005.

19 Tomioka K, Kurumatani N, Hosoi H. Association between social participation and 3-year change in instrumental activities of daily living in community-dwelling elderly adults. *J Am Geriatr Soc* 2017; **65**: 107–113. https://doi.org/10.1111/jgs.14447.

20 Tomioka K, Kurumatani N, Social Participation HH. Cognitive decline among community-dwelling older adults: a community-based longitudinal study. *J Gerontol B Psychol Sci Soc Sci* 2018; **73**: 799–806. https://doi.org/10.1093/geronb/gbw059.

21 James BD, Boyle PA, Buchman AS, Bennett DA. Relation of late-life Social activity with incident disability among community-dwelling older adults. *J Gerontol A Biol Sci Med Sci* 2011; **66A**: 467–473. https://doi.org/10.1093/gerona/glq231.

22 Kanamori S, Kai Y, Aida J et al. Social participation and the prevention of functional disability in older Japanese: the JAGES cohort study. *PLoS ONE*. 2014; **9**: e99638. https://doi.org/10.1371/journal.pone.0099638.

23 Katagiri K, Kim J-H. Factors determining the social participation of older adults: a comparison between Japan and Korea using EASS 2012. *PLoS ONE* 2018; **13**: e0194703. https://doi.org/10.1371/journal.pone.0194703.

24 Hikichi H, Kondo K, Takeda T, Kawachi I. Social interaction and cognitive decline: results of a 7-year community intervention. *Alzheimer's & Dementia* 2017; **3**: 23–32. https://doi.org/10.1016/j.trci.2016.11.003.

25 Eyal N. In: Hoover R, ed. *Hooked: How to Build Habit-Forming Products*. New York: Portfolio/Penguin, 2014.

26 Szreter S, Woolcock M. Health by association? Social capital, social theory, and the political economy of public health. *Int J Epidemiol* 2004; **33**: 650–667. https://doi.org/10.1093/ije/dyh013.

27 Moore S, Bockenholt U, Daniel M, Frohlich K, Kestens Y, Richard L. Social capital and core network ties: a validation study of individual-level social capital measures and their association with extra- and intra-neighborhood ties, and self-rated health. *Health Place* 2011; **17**: 536–544. https://doi.org/10.1016/j.healthplace.2010.12.010.

28 Legh-Jones H, Moore S. Network social capital, social participation, and physical inactivity in an urban adult population. *Soc Sci Med* 2012; **74**: 1362–1367. https://doi.org/10.1016/j.socscimed.2012.01.005.

29 Zaitsu M, Kawachi I, Ashida T, Kondo K, Kondo N. Participation in community group activities among older adults: is diversity of group membership associated with better self-rated health? *J Epidemiol* 2018; **28**: 452–457. https://doi.org/10.2188/jea.JE20170152.

Supporting information

Additional supporting information may be found in the online version of this article at the publisher's website:

Table S1 Tokyo Metropolitan Institute of Gerontology Index of Competence
Table S2 Logistic regression for propensity score of participation in *mujin*
Table S3 Comparisons of characteristics of participants between *mujin* and other social activities

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