OPEN ACCESS Freely available online

PLOS ONE

Participation in Sports Organizations and the Prevention of Functional Disability in Older Japanese: The AGES Cohort Study

Satoru Kanamori[1]*, Yuko Kai[2], Katsunori Kondo[3], Hiroshi Hirai[4], Yukinobu Ichida[3], Kayo Suzuki[3], Ichiro Kawachi[5]

1 Faculty of Health and Care and Nursing, Juntendo University, Tokyo, Japan, 2 Physical Fitness Research Institute Meiji Yasuda Foundation of Health and Welfare, Hachioji, Japan, 3 Center for Well-being and Society, Nihon Fukushi University, Nagoya, Japan, 4 Faculty of Engineering, Department of Civil and Environmental Engineering, Iwate University, Morioka, Japan, 5 Department of Society, Human Development, and Health, Harvard School of Public Health, Boston, Massachusetts, United States of America

Abstract

Background: We sought to examine prospectively the difference in the association between incident functional disability and exercise with or without sports organization participation.

Methods: The study was based on the Aichi Gerontological Evaluation Study (AGES) Cohort Study data. In October 2003, self-reported questionnaires were mailed to 29,374 non-disabled Japanese individuals aged 65 years or older. Of these, 13,310 individuals were introduced to the Study, and they were followed for 4 years. Analysis was carried out on 11,581 subjects who provided all necessary information for the analysis.

Results: Analysis was carried out on incident functional disability by 4 groups of different combinations of performance of exercise and participation in a sports organization Active Participant (AP), Exercise Alone (EA), Passive Participant (PP) and Sedentary (S). Compared to the AP group, the EA group had a hazard ratio (HR) of 1.29 (1.02–1.64) for incident functional disability. No significant difference was seen with the PP group, with an HR of 1.16 (0.76–1.77). When a measure of social networks was added to the covariates, the HR of the EA group dropped to 1.27 (1.00–1.61), and significant differences disappeared. In contrast, it showed hardly any change when social support was added.

Conclusion: The results suggested that, even with a regular exercise habit, incident functional disability may be better prevented when a person participates in a sports organization than when he/she does not. In addition, participation in a sports organization correlates positively with social networks, which may lead to a small decrease in incident functional disability.

Citation: Kanamori S, Kai Y, Kondo K, Hirai H, Ichida Y, et al. (2012) Participation in Sports Organizations and the Prevention of Functional Disability in Older Japanese: The AGES Cohort Study. PLoS ONE 7(11): e51061. doi:10.1371/journal.pone.0051061

Editor: Alejandro Lucia, Universidad Europea de Madrid, Spain

Received July 24, 2012; Accepted October 29, 2012; Published November 30, 2012

Funding: This study was supported in part by MEXT-Supported Program for the Strategic Research Foundation at Private Universities, 2009-2013 and Grant-in-Aid for Scientific Research (23243070). The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing Interests: The authors have declared that no competing interests exist.

* Email: skanamo@juntendo.ac.jp

Introduction

Over 1 in 5 people are 60 years or older in more developed regions today, and aging is predicted to advance in developing nations as well in the future, [1]. At 31.1% of the country's population, Japan has the largest proportion of people who are 60 years and older in the world, and the number of older people with incident functional disability is increasing as society continues to age, [2]. Reducing this number is an urgent task throughout the world.

Exercise is an effective way to prevent incident functional disability. Training programs that include special exercises have been reported to influence numerous factors related to functional disability, such as maintenance of physical functioning, [3], prevention of falls, [4] and improvement of cognitive functioning, [5]. Such special exercise training programs may not even be necessary; as links have also been shown between walking and physical activity that includes exercise, and a decrease in functional disability, [6–11].

While people may exercise alone, they may also join a group or organization to get exercise. Mechanisms for the effect of participation in organized sports on health may include not only physiological mechanisms through the increase in physical activity, but also mechanisms whereby social networks and social support are more easily obtained through the joining of a group or organization, [12]. Links have been shown between poor social relationships and a decline in functional status, [7] as well as death, [13,14]. This means that, in addition to physiological effects of exercise, getting exercise by participating in a sports organization may have additional effects from social

relationships which are not achieved in exercise without participation in an organization. To the best of our knowledge, the effect of the latter has not been tested in any studies to date. If participation in a sports organization is indeed more strongly linked to incident functional disability prevention than private exercise, approaches for incident functional disability prevention should involve increasing participation in a sports organization in addition to recommending private exercise.

This prospective cohort study of older Japanese people aimed to test the relationship between incident functional disability and differences in whether or not subjects exercised and/or participated in a sports organization.

Methods

Study Sample

The present study is based on the Aichi Gerontological Evaluation Study (AGES) Cohort Study data, [15,16]. This study involves investigating factors associated with incident functional disability among non-institutionalized elderly individuals aged 65 years or older. The region studied covered 6 municipalities in the Chita-hanto Peninsula of Aichi Prefecture, Japan (Handa city, Tokoname city, Agui town, Taketoyo town, Minamichita town and Mihama town). In October 2003, self-reported questionnaires were mailed to 29,374 community-dwelling individuals aged 65 years or older who were not eligible to receive benefits from public long-term care insurance (LTCI) services. The survey was conducted using a random sampling method in the 2 larger municipalities (Handa city and Tokoname city) and a complete census (complete enumeration) of the 4 smaller municipalities (Agui town, Mihama town, Minami-Chita town, and Taketoyo town) by municipal officers of the public LTCI system. The official residential registries were maintained by the municipal administrations, and the Japanese registries included information such as age. Questionnaires were sent to 5,000 people each from Handa city and Tokoname city and to all eligible people in the other municipalities. Of those, 13,310 individuals (6,508 males; 6,802 females) were introduced to the AGES Cohort. They were followed for a 4-year period starting in November 2003 (observation period: November 2003 to October 2007). Analysis was carried out on 11,581 subjects, excluding 319 people whose information on age or sex was missing, and 1,410 people who did not respond to questions on frequency of exercise and participation in a sports organization. Subjects were 5,700 males (49.2%) and 5,881 females (50.8%), and the mean age was 72.66 6.1 years. Baseline characteristics of the participants have been reported elsewhere, [15,16].

Ethical approval for the study was obtained from the Nihon Fukushi University Ethics Committee.

Incident Functional Disability

We defined the state of becoming eligible for certification of needed long-term care within the procedure prescribed in the LTCI system that has been in place in Japan since 2000 as "incident functional disability." Certification of needed long-term care is based on evaluation of the need for long-term care according to uniform criteria for all of Japan and based on both a home-visit interview and a written opinion from the primary physician, [17]. We obtained information on certification of needed long-term care, death, and moving out of the study area from the LTCI database maintained by the municipalities. The day certification of needed long-term care was issued was the application date for certification of needed long-term care.

Performing Exercise and Participation in a Sports Organization

To define exercise, subjects were asked "Do you engage in any leisure activities at the moment?" Those who answered "Yes" were then asked about the frequency of performing a sports activity such as ground golf, gateball [Japanese croquet], walking, jogging or any other physical exercises ("frequency of exercise"). Subjects who responded with "almost every day," "twice or three times a week," or "once a week" were labeled "Exercisers," and those who responded with "once or twice a month," "several times a year" or "I don't engage in any sports activities" were labeled as "Inactive." Those who responded with "No" to the first question were considered the same as those who responded with "I don't engage in any sports activities." To determine participation in a sports organization, subjects were asked if they are a member of a "sports group or club." Those who answered "Yes" were labeled "Participants" and those who answered "No" were labeled "Non-participants."

Covariates

Based on previous studies, [8–11,18], age, sex, annual equivalent income, educational attainment, marital status, occupational status, self-reported medical conditions, depression (Geriatric Depression Scale: GDS), [19], smoking and alcohol consumption were used as covariates that may correlate with participation in a sports organization, performance of exercise and incident functional disability. Social networks and social support were used to test which aspect of participation in a sports organization accounts for the prevention of incident functional disability, since previous studies indicate that social relations are important mediating factors in the mechanisms for the effect of participation in organized sports on health, [12]. Frequency of meeting friends was used as a measure of social networks, and social support was measured with four types: "receiving" and "providing" emotional and instrumental support.

Statistical Analysis

As shown in Table 1, subjects were first split into 4 groups based on whether or not they performed exercise and participated in a sports organization. Table 2 shows baseline characteristics and the incident rate of functional disability over 4 years for each group related to performance of exercise and participation in a sports organization. To test for group differences, one-way analysis of variance (ANOVA) was performed on age, and x2 tests were performed on sex, frequency of exercise, social networks and social support. Next, Cox's proportional hazards model was used to calculate the hazard ratio (HR) of incident functional disability over 4 years. Respondents who were lost to follow-up by moving or death without incident functional disability, were included as censored data in the models. Regression analysis was performed with simultaneous forced entry of age, sex, annual equivalent

Table 1. Combination of frequency of exercise and participation in a sport organization.

		Sport organization	
		Participation	Non-participation
Exercise	Once a month or more	Active Participant (AP)	Exercise Alone (EA)
	Less than once a month	Passive Participant (PP)	Sedentary (S)

doi:10.1371/journal.pone.0051061.t001

Table 2. Baseline characteristics.

		Active Participant (AP)	Exercise Alone (EA)	Passive Participant (PP)	Sedentary (S)	p
N		1,888	2,548	447	6,698	–
Age (years)	Mean6 SD	70.76 4.9	71.86 5.5	70.76 5.0	73.56 6.6	, .001
		%				
Sex (%)	Males	52.2	57.1	55.7	45.0	, .001
Frequency of exercise (%)	Almost everyday	28.1	57.1	0.0	0.0	, .001
	Twice or three times a week	44.5	28.4	0.0	0.0	
	Once a week	27.3	14.6	0.0	0.0	
	Once or twice a month	0.0	0.0	31.3	2.6	
	Several times a year	0.0	0.0	3.8	1.1	
	Never	0.0	0.0	64.9	96.3	
Frequency of meeting friends (%)	Once a month or more	93.3	75.5	87.0	65.7	, .001
	Less than once a month	5.7	23.0	10.5	30.4	
	Missing	1.0	1.5	2.5	4.0	
Receiving emotional support (%)	Yes	90.3	86.8	86.8	82.9	, .001
	No	6.5	8.9	9.8	10.7	
	Missing	3.2	4.3	3.4	6.4	
Providing emotional support (%)	Yes	86.3	81.6	83.4	73.8	, .001
	No	9.7	13.6	12.3	18.3	
	Missing	4.0	4.8	4.3	7.9	
Receiving instrumental support (%)	Yes	94.0	91.1	92.6	88.9	, .001
	No	3.8	5.4	4.5	5.8	
	Missing	2.2	3.5	2.9	5.3	
Providing instrumental support (%)	Yes	92.5	90.0	92.2	83.5	, .001
	No	3.8	5.7	4.3	9.1	
	Missing	3.7	4.2	3.6	7.3	

*P-value was calculated using one-way analysis of variance (ANOVA) for age.
*P-values were calculated using x^2 test for sex, frequency of frequency of exercise of meeting friends, receiving emotional support, providing emotional support, receiving instrumental support, and providing instrumental support.
doi:10.1371/journal.pone.0051061.t002

income, educational attainment, marital status, occupational status, self-reported medical conditions, depression, smoking and alcohol consumption as covariates (Model 1).

To test which aspect of participation in a sports organization accounts for the prevention of incident functional disability, we added one social network/support measure to each model from Model 2 to Model 6 and inspected the change in the HR estimate associated with sports participation. Thus, in Model 2 for example, we added the variable "frequency of meeting friends" (as a measure of social network) above and beyond the variables in Model 1. In a similar manner, we added the following additional variables in subsequent models: receiving emotional support in Model 3, providing emotional support in Model 4, receiving instrumental support in Model 5, and providing instrumental support in Model 6.

All variables except for age were set as dummy variables. A "missing" category was used in analysis to account for missing values in response to questions regarding the covariates. SPSS 18.0J was used for statistical analysis with a significance level of 5%.

Results

Table 2 shows baseline characteristics. A total of 4,436 subjects exercised once or more a week (38.3%) and 2,335 subjects (20.2%) participated in a sports organization.

There were 1,888 subjects (16.3%) in the Active Participant (AP) group, 2,548 subjects (22.0%) in the Exercise Alone (EA) group, 447 subjects (3.9%) in the Passive Participant (PP) group and 6,698 subjects (57.8%) in the Sedentary (S) group. Mean age was lowest in the AP group and highest in the S group,

with a difference of 2.8 years. The proportion of males was below 50% only in the S group. Regarding frequency of exercise, nearly twice the people in the EA group exercised "almost every day" compared to the AP group. Also, more than ten times more people in the PP group exercised "once or twice a month" compared to the S group. The ratio of subjects who met friends once a month or more decreased in order of AP, PP, EA and S, showing a trend for greater frequency of meeting friends by those who participated in a sports organization. Social support showed the same pattern as frequency of meeting friends, with the ratio of subjects who said they have social support decreasing in order of AP, PP, EA and S for all aspects of support except for receiving emotional support. However, the difference between groups was smaller than that for frequency of meeting friends.

Among the 11,581 subjects analyzed, 909 people died (331 people developed an incident functional disability before they died), 1,380 people developed an incident functional disability and 128 people moved out of the research area during the 4 year follow-up period. The incident rate of functional disability was calculated by dividing the person-years of observation from the number of people who developed an incident functional disability (Table 3). Incident rate was lowest in the AP group, followed by the PP group, the EA group and the S group, in increasing order. The same trend was seen when the data was stratified by age.

Table 4 shows the results of analyzing incident functional disability by performance of exercise and participation in a sports organization using Cox's proportional hazards model. Setting the "Exerciser" group as the reference, the HR for the "Inactive" group was significantly high at 1.26 (95% confidence intervals: 1.10–1.45). Setting the "Participant" group as the reference, the HR for the "Non-participant" group was also significantly high at 1.33 (1.09–1.62).

Table 5 shows the results of analyzing incident functional disability by the 4 groups of different combinations of performance of exercise and participation in a sports organization using Cox's proportional hazards model. Setting the AP group as the reference, the HR for the EA group was significantly high at 1.29 (1.02–1.64) and was even higher for the S group at 1.65 (1.33–2.04). No significant difference was seen in the PP group, with an HR of only 1.16 (0.76–1.77). As it is likely that subjects who responded that they participated in a sports organization but that they "Never" exercised also hardly ever participated in their sports organization, we then conducted sub-analysis with these subjects in the "S" group. The number of subjects in the PP group dropped from 447 people to 157 people, but the HR only changed from 1.16 (0.76–1.77) to 1.15 (0.56–2.37) and the lack of a difference between the PP group and the AP group was therefore maintained.

Next, social networks and social support were used to test which aspect of participation in a sports organization accounts for the prevention of incident functional disability (Table 6). As mentioned above, frequency of meeting friends was then added to the covariates in Model 1 as a measure of social networks. The HR for the EA group dropped slightly from 1.29 (1.02–1.64) to 1.27 (1.00–1.61), and significance disappeared. The HR for the S group was also somewhat attenuated from 1.65(1.33–2.04) to 1.60(1.29–1.98), but the 95% confidence intervals overlapped, and we cannot say that these estimates are statistically different. Addition of either measure of social support resulted in almost no change in the HR for the EA group and the S group.

Table 4. Adjusted hazard ratios (95% confidence intervals) for incident functional disability by exercise and participation in a sport organization.

	N	Crude HR (95% CI)	Adjusted HR (95% CI)
Exerciser	4,436	1.00	1.00[a)]
Inactive	7,145	2.13(1.88–2.42)	1.26(1.10–1.45)
Participant	2,335	1.00	1.00[b)]
Non-participant	9,246	2.64(2.20–3.17)	1.33(1.09–1.62)

[a)]Adjusted for age, sex, annual equivalent income, educational attainment, marital status, occupation status, self-reported medical conditions, depression, smoking, alcohol consumption, and participation in a sport organization.
[b)]Adjusted for age, sex, annual equivalent income, educational attainment, marital status, occupation status, self-reported medical conditions, depression, smoking, alcohol consumption, and exercise.
doi:10.1371/journal.pone.0051061.t004

Discussion

In the present study, we tested incident functional disability by performance of exercise and participation in a sports organization.

Table 3. Incident rate of functional disability for 4 years.

		Active Participant (AP)	Exercise Alone (EA)	Passive Participant (PP)	Sedentary (S)
	Age(years)				
N (%)	65–74	1,503(79.6)	1,815(71.2)	340(76.1)	3,681(55.0)
	75+	385(20.4)	733(28.8)	107(23.9)	3,017(45.0)
	total	1,888(100.0)	2,548(100.0)	447(100.0)	6,698(100.0)
Incident /Person year	65–74	39/6423	77/7850	10/1491	201/16776
	75+	61/845	148/1661	18/228	826/7145
	total	100/7268	225/9511	28/1719	1027/23921
Incident rate	65–74	0.006	0.010	0.007	0.012
	75+	0.072	0.089	0.079	0.116
	total	0.014	0.024	0.016	0.047

doi:10.1371/journal.pone.0051061.t003

Table 5. Adjusted hazard ratios (95% confidence intervals) for incident functional disability by combination of exercise and participation in a sport organization.

	N	Crude HR (95% CI)	Adjusted HR (95% CI) Model 1[a)]
Active Participant (AP)	1,888	1.00	1.00
Exercise Alone (EA)	2,548	1.72(1.36–2.18)	1.29(1.02–1.64)
Passive Participant (PP)	447	1.18(0.78–1.80)	1.16(0.76–1.77)
Sedentary (S)	6,698	3.14(2.56–3.85)	1.65(1.33–2.04)

[a)]Model 1 is adjusted for age, sex, annual equivalent income, educational attainment, marital status, occupation status, self-reported medical conditions, depression, smoking, and alcohol consumption.
doi:10.1371/journal.pone.0051061.t005

The HR of incident functional disability was significantly higher for the "Inactive" groups than the "Exerciser" groups. Regarding participation in a sports organization, the risk of incident functional disability was significantly higher in the "Non-participant" groups compared to the "Participant" groups. Furthermore, the HR was significantly higher for the EA group than the AP group. It was reported that participation in social activities leads to a decrease in the risk of functional decline, [7] and incident disability, [18]. These past studies suggest that one such social activity, participation in a sports organization, may lead to incident functional disability prevention. The results of the present study agreed with this hypothesis. Moreover, the results suggest that the health protection effects of participation in a sports organization include not only the physiological effect of exercise, but other effects aside from the exercise itself. Greater amount of exercise has been shown to lead to decreasing risk of functional disability, [6]. There were about twice as many people in the EA group who exercised every day than in the AP group. As a result, there may have been more positive results from exercise in the EA group. It is possible that this effect led to an apparent decrease in the difference in whether or not subjects participated in a sports organization, causing level of participation to be underestimated. This supports the hypothesis that, even when exercise is performed regularly, incident functional disability may be better prevented if they participate in a sports organization than if they do not. When subjects who participated in a sports organization but responded that they "never" exercised were included in the "S" group for analysis, there was no significant difference between the AP group and the PP group. This suggests that participation in a sports organization may help prevent incident functional disability, regardless of frequency of exercise. It remains unclear, however, why there is a difference in incident functional disability with frequency of exercise in those who participate in a sports organization. Future studies are needed to clarify this point.

Next, we tested to see how far health protection effects from participation in a sports organization aside from the effects of exercise could be explained by social relations. When a measure of social networks was added to the covariates in the model, the HR of the EA group dropped, and significant differences disappeared. Using a method for calculating the rate of change from earlier literature "$(OR_1\text{-}OR_2)/(OR_1\text{-}1)*100$", [20], the decrease in HR by social networks was 6.9%. A decrease by 7.7% was also seen for the S group. Only a small fraction of the change was attributable to social networks, but its involvement was nonetheless indicated. An association has also been shown between social networks and decrease in disability, [11,21]. It is thus conceivable that participation in a sports organization relates more strongly with social networks than private exercise does, and leads to a decrease in incident functional disability. However, the change in HR was minor. In addition, it is possible that social network was not sufficiently evaluated, as frequency of meeting friends was the only measure used.

On the other hand, while social support may also be obtained through participation in a sports organization, adding social support to the covariates had hardly any effect on the HR of the EA group and S group. Group differences in ratio of people with social support were smaller compared to frequency of meeting friends. This suggests that social support has a weaker connection to participation in a sports organization than social networks do. Moreover, in congruence with previous studies, no relationship was seen between incident functional disability and receiving emotional support, [21,22] or providing social support, [11].

Table 6. Adjusted hazard ratios (95% CI) for incident functional disability by social relations.

	Model 1[a)]	Model 2[b)]	Model 3[c)]	Model 4[d)]	Model 5[e)]	Model 6[f)]
Active Participant (AP)	1.00	1.00	1.00	1.00	1.00	1.00
Exercise Alone (EA)	1.29(1.02–1.64)	1.27(1.00–1.61)	1.29(1.02–1.64)	1.29(1.02–1.63)	1.28(1.01–1.63)	1.30(1.03–1.65)
Passive Participant (PP)	1.16(0.76–1.77)	1.15(0.76–1.76)	1.15(0.75–1.75)	1.15(0.76–1.75)	1.14(0.75–1.74)	1.18(0.77–1.79)
Sedentary (S)	1.65(1.33–2.04)	1.60(1.29–1.98)	1.64(1.33–2.03)	1.63(1.32–2.02)	1.63(1.32–2.02)	1.64(1.33–2.03)

[a)]Model 1 is adjusted for age, sex, annual equivalent income, educational attainment, marital status, occupation status, self-reported medical conditions, depression, smoking, and alcohol consumption.
[b)]Model 2 is adjusted for the covariates in Model 1 plus frequency of meeting friends.
[c)]Model 3 is adjusted for the covariates in Model 1 plus receiving emotional support.
[d)]Model 4 is adjusted for the covariates in Model 1 plus providing emotional support.
[e)]Model 5 is adjusted for the covariates in Model 1 plus receiving instrumental support.
[f)]Model 6 is adjusted for the covariates in Model 1 plus providing instrumental support.
doi:10.1371/journal.pone.0051061.t006

These findings suggest that social support does not explain why participation in a sports organization leads to a decrease in incident functional disability.

The present study has four limitations. The first is that, for people participating in a sports organization, there is no distinction between exercise carried out in the sports organization and private exercise, nor is there any clear distinction among the types of exercise. We acknowledge that people in the "Exercise Alone" category are not necessarily exercising in solitude. Instead, we have used this label to contrast it with people who exercise as part of an organized activity. In future studies, a question should be added to the questionnaires that will enable such distinction. The second limitation is that final analysis was only carried out on about 40% of subjects due to lack of response to the questionnaires and missing variables- therefore it is possible that the results of the present study do not give a complete picture of the region studied. The third limitation is that the sample size in the present study was too small to allow for more detailed analysis of frequency of exercise. Future studies are required to further elucidate the reason why incident functional disability prevention efficacy was greater in the AP group than the EA group and clarify the most preferable frequency of exercise. The fourth limitation is that the only measure used was frequency of meeting friends, though social networks were used to test which aspect of participation in a sports organization serves to prevent incident functional disability. Future studies should consider more aspects of social networks.

In conclusion, tests of the relationship between incident functional disability and 4 groups made up of different combinations of performance of exercise and participation in a sports organization showed a significantly higher HR in the EA group compared to the AP group. This suggests that, even when exercise is performed once a week or more, incident functional disability may be better prevented if the person participates in a sports organization than if they do not. Moreover, when various aspects of social relations were added to the covariates, only inclusion of social networks brought a small reduction in the HR of the EA group and S group. Compared to private exercise, participation in a sports organization correlates more with social networks, which may lead to a small decrease in incident functional disability.

Acknowledgments

This study used data from the Aichi Gerontological Evaluation Study (AGES), conducted by the Nihon Fukushi University Center for Well-being and Society as one of their research projects. We would like to express our deepest gratitude to everyone who participated in the surveys. In addition, we are also sincerely grateful for the advice we received about this study from everyone involved in the Japanese Association of Exercise Epidemiology, and, in particular, Dr. Yoshikazu Nakamura of Jichi Medical University, Dr. Susumu Sawada of the National Institute of Health and Nutrition, and Dr. Chiyoe Murata, Dr. Masashige Saito and Dr. Naoki Kondo who are members of the AGES Project.

Author Contributions

Conceived and designed the experiments: SK YK KK IK. Analyzed the data: SK YK KK YI. Wrote the paper: SK YK KK IK. Reviewing of manuscript: SK YK KK HH YI KS IK. Acquisition of data: KK HH KS.

References

1. United Nations, Department of Economic and Social Affairs, Population Division (2011) World Population Prospects: The 2010 Revision, Highlights and Advance Tables. Working Paper No. ESA/ P/ WP.220. Available: http:/ / esa.un.org/ unpd/ wpp/ Documentation/ pdf/ WPP2010_Highlights.pdf. Accessed 2012 Jul 18.
2. Ministry of health, labor and welfare. Preventive long-term care (in Japanese). Available: http:/ / www.mhlw.go.jp/ topics/ kaigo/ yobou/ dl/ yobou.pdf. Accessed 2012 Jul 18.
3. Wolff I, van Croonenborg JJ, Kemper HC, Kostense PJ, Twisk JW (1999) The effect of exercise training programs on bone mass: a meta-analysis of published controlled trials in pre- and postmenopausal women. Osteoporos 9: 1–12.
4. Gillespie LD, Gillespie WJ, Cumming R, Lamb SE, Rowe BH (2001) Interventions for preventing falls in elderly people (Cochrane Review). Cochrane Library; 4. Available: http:/ / onlinelibrary.wiley.com/ doi/ 10.1002/ 14651858.CD000340/ abstract;jsessionid = 0391D2C79723FB9C03A77A45E5723764.d01t02. Accessed 2012 Jul 18.
5. Colcombe S, Kramer AF (2003) Fitness effects on the cognitive function of older adults: a meta-analytic study. Psychological science 14: 125–130.
6. Paterson DH, Warburton DE (2010) Physical activity and functional limitations in older adults: a systematic review related to Canada's Physical Activity Guidelines. The international journal of behavioral nutrition and physical activity 7: 38–59.
7. Stuck AE, Walthert JM, Nikolaus T, Bula CJ, Hohmann C, et al. (1999) Risk factors for functional status decline in community-living elderly people. Social science & medicine 48: 445–469.
8. Liao WC, Li CR, Lin YC, Wang CC, Chen YJ, et al. (2011) Healthy behaviors and onset of functional disability in older adults: results of a national longitudinal study. Journal of the American geriatrics society 59: 200–206.
9. Boyle PA, Buchman AS, Wilson RS, Bienias JL, Bennett DA (2007) Physical activity is associated with incident disability in community-based older persons. Journal of the American geriatrics society 55: 195–201.
10. Takeda T, Kondo K, Hirai H (2010) Psychosocial risk factors involved in progressive dementia-associated senility among the elderly residing at home AGES-Three year cohort longitudinal study. Japanese journal of public health 57: 1054–1065 (in Japanese).
11. Hirai H, Kondo K, Ojima T, Murata C (2009) Examination of risk factors for onset of certification of long-term care insurance in community-dwelling older people: AGES project 3-year follow-up study. Japanese journal of public health 56: 501–512 (in Japanese).
12. Street G, James R, Cutt H (2007) The relationship between organised physical recreation and mental health. Health promotion Journal of Australia 18: 236–239.
13. Julianne HL, Timothy BS, J. Bradley L (2010) Social relationships and mortality risk: a meta-analytic review. Plos medicine 7: e1000316. Available: http:/ / www.plosmedicine.org/ article/ info%3Adoi%2F10.1371%2Fjournal.pmed.1000316. Accessed 2012 Jul 18.
14. House JS, Landis KR, Umberson D (1988) Social relationships and health. Science 214: 540–5.
15. Kondo K (2010) Health Inequalities in Japan: An Empirical Study of Older People. Melbourne: Trans Pacific Press. 291P.
16. Nishi A, Kondo K, Hirai H, Kawachi I (2011) Cohort Profile: The AGES 2003 cohort study in Aichi, Japan. Journal of epidemiology 21: 151–157.
17. Tsutsui T, Muramatsu N (2005) Care-needs certification in the long-term care insurance system of Japan. Journal of the American geriatrics society 53: 522–527.
18. James BD, Boyle PA, Buchman AS, Bennett DA (2011) Relation of late-life social activity with incident disability among community-dwelling older adults. The journals of gerontology. Series A, Biological sciences and medical sciences 66: 467–473.
19. Sheikh JI, Yesavage JA (1986) Clinical gerontology: a guide to assessment and intervention. London: Routledge. 532p.
20. Schempf AH, Kaufman JS (2011) On the percent of excess risk explained. Journal of epidemiology and community health 65: 190.
21. Mendes de Leon CF, Glass TA, Beckett LA, Seeman TE, Evans DA, et al. (1999) Social networks and disability transitions across eight intervals of yearly data in the New Haven EPESE. The journals of gerontology. Series B, Psychological sciences and medical sciences 54(3): S162–172.
22. Mendes de Leon CF, Gold DT, Glass TA, Kaplan L, George LK (2001) Disability as a function of social networks and support in elderly African Americans and Whites: the Duke EPESE 1986–1992. The journals of gerontology. Series B, Psychological sciences and medical sciences 56(3): S179–190.

BMJ open accessible medical research

Dental status and incident falls among older Japanese: a prospective cohort study

Tatsuo Yamamoto,[1] Katsunori Kondo,[2] Jimpei Misawa,[2] Hiroshi Hirai,[3] Miyo Nakade,[4] Jun Aida,[5] Naoki Kondo,[6] Ichiro Kawachi,[7] Yukio Hirata[1]

To cite: Yamamoto T, Kondo K, Misawa J, et al. Dental status and incident falls among older Japanese: a prospective cohort study. BMJ Open 2012;2:e001262. doi:10.1136/bmjopen-2012-001262

< Prepublication history for this paper is available online. To view this file please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2012-001262).

Received 4 April 2012
Accepted 5 July 2012

For numbered affiliations see end of article.

Correspondence to
Dr Yukio Hirata;
hiratay@kdcnet.ac.jp

ABSTRACT

Objective: To examine if self-reported number of teeth, denture use and chewing ability are associated with incident falls.

Design: Longitudinal cohort study (the Aichi Gerontological Evaluation Study).

Setting: 5 Japanese municipalities.

Participants: 1763 community-dwelling individuals aged 65 years and older without experience of falls within the previous year at baseline.

Main outcome measures: Self-reported history of multiple falls during the past year at the follow-up survey about 3 years later. Baseline data on the number of teeth present and/or denture use and chewing ability were collected using self-administered questionnaires. Logistic regression analyses controlled for sex, age, functional disability during follow-up period, depression, self-rated health and educational attainment.

Results: 86 (4.9%) subjects reported falls at the follow-up survey. Logistic regression models fully adjusted for all covariates showed that subjects having 19 or fewer teeth but not using dentures had a significantly increased risk for incident falls (OR 2.50, 95% CI 1.21 to 5.17, p=0.013) compared with those having 20 or more teeth. Among subjects with 19 or fewer teeth, their risk of falls was not significantly elevated so long as they wore dentures (OR 1.36, 95% CI 0.76 to 2.45, p=0.299). No significant association was observed between chewing ability and incident falls in the fully adjusted model.

Conclusions: Having 19 or fewer teeth but not using dentures was associated with higher risk for the incident falls in older Japanese even after adjustment for multiple covariates. Dental care to prevent tooth loss and denture treatment for older people might prevent falls, although the authors cannot exclude the possibility that the association is due to residual confounding.

ARTICLE SUMMARY

Article focus

- An association has been reported between dental occlusion and physical function including lower extremity dynamic strength and balance.
- Whether number of teeth, denture use and chewing ability predict subsequent incidence of falls is unknown.
- The aim of this study was to examine if self-reported number of teeth, denture use and chewing ability are associated with incident falls.

Key messages

- Having 19 or fewer teeth but not using dentures was a strong independent predictor of incident falls in a community-dwelling older population.
- In addition to preventing tooth loss, denture treatment for older people might prevent falls.

Strengths and limitations of this study

- Strengths of this study include large sample size, population-based sampling and control for many potential confounding factors.
- The following limitations should be considered: the information on dental status and falls was self-reported and misclassification of cases is possible. Moreover, we cannot exclude the possibility that the association is due to residual confounding.

INTRODUCTION

Falls occur frequently in older people and adversely affect their quality of life. More than one-third of persons aged 60 years and older fall each year in Japan,[1] England[2] and the USA,[3] and in half of cases, falls are recurrent.[3] The consequences of falls are severe: 6% of falls lead to a fracture and 24% lead to other serious injuries.[2] Thus, falls impose a burden on the sustainability of health and long-term care in Japan and many other countries, where population is rapidly ageing.[4] In Japan, the annual health and long-term care costs attributable to falls are about 730 thousand million Japanese yen in 2002, which amounts to roughly 5% of the entire health and long-term care costs.[5]

A number of studies[6] including those using Japanese data[7] have identified risk factors for falls, including female sex, older age, having a history of falls, arthritis, cerebrovascular

disease, depression and the impairment of muscle strength and/or balance. Although exercise programmes including balance training are effective,[8] multifactorial fall prevention programmes to address these risk factors have not been successful in reducing falls.[9] A recent systematic review concluded that there is limited evidence to suggest that multifactorial fall prevention programmes in primary care, community or emergency care settings are effective in reducing the number of falls.[10] Therefore, identification of additional modifiable risk factors may be helpful to establish more effective programmes for fall prevention.

Unhealthy dental status is a candidate risk factor for falls.[11 12] A longitudinal study showed that partial or complete loss of dental occlusion was associated with a decline in lower extremity dynamic strength and balance function.[13] One 1-year prospective longitudinal study using 146 demented older people reported the association between dental occlusion and subsequent physical health.[14] Researchers have argued that these potential links between dental health and physical health may be because jaw position affects body posture.[11] Proprioceptive receptors of the masticatory muscular system and dentoalveolar ligaments provide sensory afferent input,[15] and hence poor dental occlusion may decrease that proprioception, thereby interfering with the stability of head posture (and increasing the risk of falling). However, whether or not dental occlusion and chewing ability actually predict the subsequent incidence of falls is largely unknown.

Therefore, this prospective study aimed to determine the association between dental health in terms of the number of teeth present, denture use and chewing ability and the incidence of falls in a large cohort of older Japanese people.

METHODS

Study population

Our analyses were based on data from the Aichi Gerontological Evaluation Study (AGES) Project, an ongoing Japanese prospective cohort study.[16 17] The detailed protocol of the AGES and baseline characteristics of the study participants have been published elsewhere.[16 18] In brief, the AGES aims to investigate the factors related to the loss of healthy years, such as functional decline, cognitive impairment or death among non-institutionalised older people. The sample was restricted to those who did not already have a physical or cognitive disability at baseline, defined by not receiving public long-term care insurance benefits and self-reported dependence in walking, toileting and bathing.

The sampling frame for the AGES cohort was selected as follows. In 2003, the residential registers of five municipalities in Aichi prefecture were obtained with the cooperation of city officials. From these comprehensive registers, we selected a random sample of one in three citizens aged 65 years or older in four towns (1281, 1537, 1766 and 1873) and a random sample of 1666 in a city. They (N=8123) were then mailed the baseline questionnaire, inviting them to participate in the AGES cohort study. Responses were obtained from 3998 subjects (49.2%), and 3981 subjects were identified using ID. We mailed a follow-up survey between March 2006 and March 2007 to the 3471 subjects after excluding 510 subjects who died or started receiving insurance benefits due to certified disability (N=472) or could not be traced (N=38). Two thousand six hundred and forty subjects responded to the follow-up survey (76.1%) and formed the analytic sample for our study. After excluding 166 and 545 subjects who experienced multiple and single falls, respectively, as well as 106 subjects without information of falls at baseline, we were left with 1823 subjects who did not report experiencing falls at baseline. After excluding 56 subjects without information on falls at follow-up and four subjects without information on age, a total of 1763 subjects formed the final analytic population of this study. The AGES protocol was reviewed and approved by the Ethics Committee on Research of Human Subjects at Nihon Fukushi University.

Outcome variables

History of falls was ascertained by asking, "Have you had any falls over the past year?" with possible answers of "multiple times," "once" or "none." Multiple falls was used as an outcome and the last two categories were combined because previous studies have found that single fallers are more similar to non-fallers than to recurrent fallers on a range of medical, physical and psychological risk factors.[3 19 20]

Dental health variables

Dental status and chewing ability were assessed using a self-administered questionnaire. Respondents were asked to classify their dental status as having 20 or more teeth, having 19 or fewer teeth with dentures, having 19 or fewer teeth without dentures, having few teeth with dentures or having few teeth without dentures. Data from having 19 or fewer teeth with dentures and those from having few teeth with dentures were combined. Data from having 19 or fewer teeth without dentures and those from having few teeth without dentures were also combined.

Chewing ability was ascertained by asking, "How is your ability to chew?" with possible answers being "I can chew anything I want," "I can chew most foods with some exceptions," "I can eat limited foods as I cannot chew very well," "I can hardly chew anything" and "I have liquid foods as I cannot chew at all." Data from the last three categories were combined due to the small number of respondents.

Covariates

Studies suggest that falls are associated with sex,[7 21] age,[2 7] stroke,[7] severe foot problems,[2] impaired vision and impaired hearing,[2] activities of daily living (ADL),[3 6 21]

body mass index (BMI),[21] use of sedatives,[2] depression,[2] self-rated health,[21] exercise,[2] mobility[2] and socioeconomic status.[22] Therefore, associations of incident fall with sex, age, present illness related to falls, ADL, BMI, use of sedatives, depression, self-rated health, exercise (how much they walked in minutes per day), frequency of outings, educational attainment and equivalised household income were analysed. Self-reported current medical treatment of stroke, osteoporosis, joint disease/ neuralgia, injury/ fracture, impaired vision and/ or impaired hearing was used as a variable for present illness related to falls. To evaluate functional status, the survey asked whether the respondents had difficulty or needed someone's assistance in performing any of the following ADL: basing, walking and using the toilet.[23] Subjects without difficulty for all three ADL items were categorised into ADL without limitation and those with at least one ADL item with difficulty into ADL with limitation. BMI was categorised into three groups (<18.5, 18.5e 24.9 and 25.0 or more).[24] Depression was assessed with the short version of the Geriatric Depression Scale-15 developed for self-administration in the community using a simple yes/ no format[25] and was categorised into three groups: 0e 4 (no), 5e 9 (mild) and 10e 15 (moderate to severe). To adjust household income for household size, equivalised income was calculated by dividing the household income by the square root of the number of household members and grouped into one of the seven categories. In addition to these covariates, data on functional disability during follow-up period were collected from the public long-term care insurance database maintained by each participating municipality and used as a covariate. Incidence of functional disability was determined based on when a person newly qualified for the insurance benefit, new registrations to the public long-term care insurance database.[26] The distribution of each covariate at baseline for the overall AGES 2003 cohort (n=32 891) has been reported elsewhere.[16]

Statistical analysis

Categorical variables that included missing data were recorded by reassigning missing values to separate "missing" categories in order to maximise the number of subjects included in the statistical analysis and thereby maximise statistical power. Logistic regression models were used to calculate the ORs and 95% CIs for the incident falls at the follow-up. First, univariate ORs were calculated for each dental health variable and each covariate. Variables that were marginally significant ($p<0.10$) in the univariate analyses were selected as covariates for subsequent multivariate analysis. Then, logistic regression analysis was performed for each dental variable after including sex, age, functional disability during follow-up period, depression, self-rated health and educational attainment as covariates. All statistical analyses were conducted using IBM SPSS Statistics V.19 (IBM Co.).

RESULTS

A total of 86 (4.9%) of the 1763 respondents reported the incidence of multiple falls at the follow-up survey. Table 1 shows the rates of fallers and non-adjusted ORs for reporting multiple falls at the follow-up survey according to dental health variables and covariates. Univariate models showed that poor dental status, chewing ability, male sex, older age, lower functional disability during follow-up period, depression, poor self-rated health and low educational attainment were each associated with incident falls.

In the fully adjusted model, subjects with 19 or fewer teeth without dentures had a 2.50 (95% CI 1.21 to 5.17)-fold increased risk for incident falls compared with those having 20 or more teeth(Table 2). No significant association was observed between incident falls and chewing ability after adding all covariates in the logistic regression model. When the two dental health variables were entered simultaneously into the same model with full adjustment for all covariates, there was no change in the ORs for any of the dental status variables.

DISCUSSION

Results of the present study showed that subjects with 19 or fewer teeth without dentures had a significantly higher risk for incident falls than those with 20 or more teeth, even after adjusting for multiple potential confounding factors including demographics, physical and mental health status, and socioeconomic status. These findings are consistent with those of a 1-year longitudinal study using 146 older patients with severe dementia, showing that patients with functionally inadequate dental status had significantly more frequent falls than those with functionally adequate occlusion composed of natural teeth, dentures or both.[14] Interestingly, among subjects with 19 or fewer teeth, their risk of falls was not significantly elevated so long as they wore dentures. These results suggest that the poor dental occlusion due to not using dentures after losing teeth is a strong risk factor for falls among subjects with 19 or fewer teeth.

There are several possible pathways between not using dentures after losing teeth and incident falls. One possibility is that the loss of occlusion due to not using dentures may result in a decrease in functional balance and these functional declines lead to falls. A cross-sectional study suggests that dental occlusal condition is associated with balance function.[12] An 8-year longitudinal study showed that partial or complete loss of occlusion was associated with a decrease in balance function.[13] Because balance deficit is a well-known risk factor for falls,[6] it is plausible that poor balance may explain the increased risk of falls among subjects with poor dental occlusion.

A clinical study showed that dental occlusion affects postural and gaze stabilisation because proprioceptive receptors of the masticatory muscular system and dentoalveolar ligaments provide sensory afferent input,

Table 1 Univariate associations of dental health variables and covariates with incident falls

	Total n	Fallers n (%)	OR (95% CI)	p Value
Dental status				
$ 20 teeth	586	17 (2.9)	1.00	
# 19 teeth with dentures	958	49 (5.1)	1.80 (1.03 to 3.16)	0.039
# 19 teeth without dentures	198	17 (8.6)	3.14 (1.57 to 6.28)	0.001
Missing	21	3 (14.3)	5.58 (1.50 to 20.76)	0.010
Chewing ability				
Can chew anything	719	30 (4.2)	1.00	
Can chew most foods	935	47 (5.0)	1.22 (0.76 to 1.94)	0.414
Cannot chew very well	97	9 (9.3)	2.35 (1.08 to 5.11)	0.031
Missing	12	0 (0.0)	0.00 (0.00)	0.999
Sex				
Female	853	32 (3.8)	1.00	
Male	910	54 (5.9)	1.62 (1.03 to 2.53)	0.035
Age (years)				
65e 69	707	23 (3.3)	1.00	
70e 74	569	27 (4.7)	1.48 (0.84 to 2.61)	0.175
75e 79	325	18 (5.5)	1.74 (0.93 to 3.28)	0.084
80e 84	120	12 (10.0)	3.30 (1.60 to 6.84)	0.001
$ 85	42	6 (14.3)	4.96 (1.90 to 12.93)	0.001
Present illness related to falls*				
No	1224	58 (4.7)	1.00	
Yes	539	28 (5.2)	1.10 (0.69 to 1.75)	0.682
Activities of daily living				
Without limitation	1669	81 (4.9)	1.00	
With limitation or missing	94	5 (5.3)	1.10 (0.44 to 2.79)	0.838
Functional disability during follow-up period				
No	1734	81 (4.7)	1.00	
Yes	29	5 (17.2)	4.25 (1.58 to 11.43)	0.004
Body mass index				
<18.5	113	8 (7.1)	1.68 (0.78 to 3.62)	0.189
18.5e 24.9	1196	52 (4.3)	1.00	
$ 25.0	380	21 (5.5)	1.29 (0.77 to 2.17)	0.342
Missing	74	5 (6.8)	1.59 (0.62 to 4.12)	0.336
Use of sedatives				
No	1602	80 (5.0)	1.00	
Yes	161	6 (3.7)	0.74 (0.32 to 1.72)	0.478
Depression				
No	1143	39 (3.4)	1.00	
Mild	311	21 (6.8)	2.05 (1.19 to 3.54)	0.010
Moderate to severe	77	8 (10.4)	3.28 (1.48 to 7.29)	0.004
Missing	232	18 (7.8)	2.38 (1.34 to 4.24)	0.003
Self-rated health				
Excellent	162	6 (3.7)	1.00	
Good	1192	50 (4.2)	1.14 (0.48 to 2.70)	0.769
Fair	321	21 (6.5)	1.82 (0.72 to 4.60)	0.206
Poor	59	9 (15.3)	4.68 (1.59 to 13.80)	0.005
Missing	29	0 (0.0)	0.00 (0.00)	0.998
Exercise (walk in minute/day)				
$ 60	430	20 (4.7)	1.00	
30e 59	569	16 (2.8)	0.59 (0.30 to 1.16)	0.126
<30	564	38 (6.7)	1.48 (0.85 to 2.58)	0.167
Missing	200	12 (6.0)	1.31 (0.63 to 2.73)	0.474
Frequency of outings				
Almost everyday	843	37 (4.4)	1.00	
2e 3 times a week	532	27 (5.1)	1.17 (0.70 to 1.94)	0.557
Once a week or less	335	20 (6.0)	1.38 (0.79 to 2.42)	0.256
Missing	53	2 (3.8)	0.85 (0.20 to 3.65)	0.831

Continued

Table 1 Continued

	Total n	Fallers n (%)	OR (95% CI)	p Value
Educational attainment (years)				
$ 13	184	4 (2.2)	1.00	
10e 12	506	23 (4.5)	2.14 (0.73 to 6.28)	0.165
6e 9	953	49 (5.1)	2.44 (0.87 to 6.84)	0.090
<6	53	4 (7.5)	3.67 (0.89 to 15.22)	0.073
Missing	67	6 (9.0)	4.43 (1.21 to 16.21)	0.025
Equivalised household income (yen)				
<500 000	53	0 (0.0)	0.00 (0.00)	0.997
500 000e 999 999	108	7 (6.5)	1.00	
1 000 000e 1 499 999	139	7 (5.0)	0.77 (0.26 to 2.25)	0.627
1500 000e 1 999 999	262	15 (5.7)	0.88 (0.35 to 2.21)	0.780
2000 000e 2 999 999	429	16 (3.7)	0.56 (0.22 to 1.39)	0.213
3000 000e 3 999 999	263	15 (5.7)	0.87 (0.35 to 2.20)	0.773
$ 4000 000	164	5 (3.0)	0.45 (0.14 to 1.47)	0.187
Missing	345	21 (6.1)	0.94 (0.39 to 2.26)	0.882

*Stroke, osteoporosis, joint disease/neuralgia, injury/fracture, impaired vision and/or impaired hearing.

and hence poor dental occlusion may decrease that proprioception and interfere with the stability of head posture.[15] Another clinical study showed that denture use improves postural swaying.[27] Because using dentures reduced the OR for incident falls in the present study, proprioceptive receptors of the masticatory muscular system might be more strongly associated with balance function and falls than those of dentoalveolar ligaments.

Some subjects with 20 or more teeth may have had dentures in the present study; however, the information was not obtained. Subjects with 20 or more teeth without dentures may be more appropriate than those with 20 or more teeth with/ without dentures as a reference, and lack of the information might underestimate the association between dental status and incident falls. However, studies show that people having at least 20 teeth usually can eat anything even they do not ware dentures.[28 29] Therefore, the lack of the information of with/ without dentures in subjects having 20 or more teeth may be negligible.

We excluded individuals with history of falls because we wanted to examine prospectively the risk of incident falls. In addition, there is a theoretical possibility that history of falls might confound the association between number of teeth and risk of future falls, that is, history of falls in the past can be a prior common cause of (1) number of teeth (because some people may break teeth when they fall) and (2) past falls predict future falls. For these reasons, we felt that it was justified to exclude those with fall history at baseline.

In the present study, self-reported chewing ability was not associated with the incident falls. This result disagreed with those from a cross-sectional study showing a significant association between chewing ability judged from number of foods chewable and one-leg standing time.[30] Because self-reported mastication can be modified by cooking (eg, cooking soft meal helps chewing ability) and is more subjective than self-reported number of teeth present and denture use, this might dilute the association between self-reported chewing ability and the incident falls. A study using 5643 subjects aged 40e 89 years showed that number of functional teeth which differentiate subjects with and without subjective dysphagia, defined as suffering any kind of subjective impairment to eating function, including biting difficulty, declined with age.[31] Additional studies using objective measures for chewing ability are required to clarify the relationship between chewing ability and the incident falls.

Using dentures does not always recover chewing ability. For example, a cross-sectional study showed that biting forces among removable partial and complete denture wearers were 35% and 11%, respectively, when expressed as a percentage of the subjects with natural dentition.[32] These results may explain the different associations of dental status and chewing ability with incident falls in the present study. When both dental status and chewing ability were simultaneously entered in the fully adjusted logistic regression model in the present study, only dental status was still significantly associated with incident falls.

Men were at increased risk of falls in the present study, which disagrees with a meta-analysis[7] based on people aged 60 years or older showing that female sex was a risk factor. On the other hand, our study result is also similar to another large study of 12 684 individuals aged 85 years or older.[21] We feel that the association between sex and risk of falls might vary according to the study population. Indeed, current clinical guidelines for the prevention of falls do not include sex as a risk factor,[6 33] and thus it may not be a settled question.

Strengths and limitations

We note some strength of the present study including large sample size, population-based sampling and

Table 2 Multivariate adjusted OR and 95% CI for the association of dental status and chewing ability with incident falls

	OR (95% CI)	p Value	OR (95% CI)	p Value
Dental status				
$ 20 teeth	1.00			
# 19 teeth with dentures	1.36 (0.76 to 2.45)	0.299		
# 19 teeth without dentures	2.50 (1.21 to 5.17)	0.013		
Missing	5.75 (1.23 to 26.78)	0.026		
Chewing ability				
Can chew anything			1.00	
Can chew most foods			0.97 (0.59 to 1.59)	0.910
Cannot chew very well			1.47 (0.64 to 3.37)	0.361
Missing			0.00 (0.00)	0.999
Sex				
Female	1.00		1.00	
Male	1.86 (1.16 to 2.96)	0.010	1.86 (1.16 to 2.96)	0.009
Age (years)				
65e 69	1.00		1.00	
70e 74	1.31 (0.73 to 2.34)	0.366	1.36 (0.76 to 2.42)	0.302
75e 79	1.42 (0.74 to 2.74)	0.290	1.57 (0.82 to 3.02)	0.178
80e 84	2.51 (1.17 to 5.39)	0.018	2.84 (1.34 to 6.04)	0.007
$ 85	3.78 (1.27 to 11.19)	0.017	4.63 (1.59 to 13.49)	0.005
Functional disability during follow-up period				
No	1.00		1.00	
Yes	2.30 (0.75 to 7.06)	0.144	2.11 (0.70 to 6.37)	0.184
Depression				
No	1.00		1.00	
Mild	1.82 (1.01 to 3.26)	0.046	1.82 (1.01 to 3.26)	0.045
Moderate to severe	2.47 (1.02 to 5.97)	0.045	2.49 (1.03 to 6.02)	0.042
Missing	2.14 (1.09 to 4.17)	0.026	2.07 (1.06 to 4.04)	0.032
Self-rated health				
Excellent	1.00		1.00	
Good	1.14 (0.47 to 2.77)	0.767	1.07 (0.44 to 2.59)	0.877
Fair	1.43 (0.54 to 3.78)	0.474	1.33 (0.50 to 3.54)	0.568
Poor	2.71 (0.83 to 8.77)	0.097	2.60 (0.81 to 8.34)	0.109
Missing	0.00 (0.00)	0.998	0.00 (0.00)	0.998
Educational attainment (years)				
$ 13	1.00		1.00	
10e 12	2.49 (0.83 to 7.45)	0.102	2.59 (0.87 to 7.72)	0.089
6e 9	2.21 (0.77 to 6.33)	0.140	2.50 (0.87 to 7.12)	0.087
<6	1.77 (0.37 to 8.56)	0.476	2.24 (0.49 to 10.27)	0.299
Missing	2.78 (0.68 to 11.38)	0.156	3.17 (0.77 to 13.01)	0.110

control for many potential confounding factors. However, the present study has a number of limitations. First, measurement of dental status was based on self-report, not based on clinical examination. However, the validity and reliability of self-reported number of teeth has been established by multiple studies and widely used in epidemiological surveys.[34] For example, validation studies in the USA and Japan have reported a high agreement between self-reported and examined number of teeth (Pearson's correlation coefficient: r=0.97 and 0.93, respectively) in 50 community-dwelling individuals aged 70 years or older and 2496 subjects with a mean age of 59.[35 36] Second, self-report of falls may not be perfectly accurate.[37] However, the associations with demographic factors and other covariates are in the generally expected direction, suggesting that there may be sufficient value in this outcome.

CONCLUSIONS

The primary implication of this study is the importance of maintaining the dental occlusion, especially with natural teeth, in order to prevent falls among older adults. The loss of teeth might be an independent risk factor for incident falls, but it could be prevented by using dentures. Promoting dental care including proper use of denture might be an additional option for the prevention of falls in addition to current interventions targeting conventional risk factors, which warrants further interventional studies testing the effects of dental care and denture use on the prevention of falls.

Author affiliations
[1]Division of Sociological Approach in Dentistry, Department of Dental Sociology, Kanagawa Dental College, Yokosuka-shi, Kanagawa, Japan
[2]Center for Well-being and Society, Nihon Fukushi University, Nagoya-shi, Aichi, Japan

[3]Department of Civil and Environmental Engineering, Faculty of Engineering, Iwate University, Morioka-shi, Iwate, Japan
[4]Department of Nutrition, Faculty of Health and Nutrition, Tokaigakuen University, Nagoya-shi, Aichi, Japan
[5]Department of International and Community Oral Health, Tohoku University Graduate School of Dentistry, Sendai-shi, Miyagi, Japan
[6]Department of Health Sciences, Interdisciplinary Graduate School of Medicine and Engineering, University of Yamanashi, Chuo-shi, Yamanashi, Japan
[7]Department of Society, Human Development and Health, Harvard School of Public Health, Boston, Massachusetts, USA

Contributors TY and YH had the idea for the study, participated in its design, performed the statistical analysis and drafted the manuscript, and YH is the guarantor. KK is coordinator of Aichi Gerontological Evaluation Study Project, helped develop the idea of the study, participated in acquiring the data and with design and edited the manuscript. JM participated in design of study and edited the manuscript. HH and MN participated in acquiring the data and with design and critically revised the manuscript. JA, NK and IK participated in the design of the study, deciding on statistical methods used, helped in interpreting the results and revising the manuscript.

Funding This study was supported in part by a grant of the Strategic Research Foundation Grant-aided Project for Private Universities from Ministry of Education, Culture, Sport, Science and Technology, Japan (MEXT), 2009e 2013, and Health Labour Sciences Research Grant, Comprehensive Research on Aging and Health (H22-Choju-Shitei-008) from the Japanese Ministry of Health, Labour and Welfare.

Competing interests None.

Ethical approval The Aichi Gerontological Evaluation Study protocol including the present study was reviewed and approved by the Ethics Committee on Research of Human Subjects at Nihon Fukushi University.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data available.

REFERENCES

1. Matsuda R. Life-style choices and falls. In: Kondo K, ed, Health Inequalities in Japan: An Empirical Study of Older People. Melbourne, Australia: Trans Pacific Press, 2010.
2. Tinetti ME, Speechley M, Ginter SF. Risk factors for falls among elderly persons living in the community. N Engl J Med 1988;319:1701e 7.
3. Nevitt MC, Cummings SR, Kidd S, et al. Risk factors for recurrent nonsyncopal falls: a prospective study. JAMA 1989;261:2663e 8.
4. Department of Economic and Social Affairs, United Nations. World Population Ageing: 1950-2050. http://www.un.org/esa/population/publications/worldageing19502050/
5. Hayashi Y. [Prevention of the falls in the elderly] (In Japanese). Nihon Ronen Igakkai Zasshi 2007;44:591e 4.
6. Anon. Guideline for the prevention of falls in older persons. American Geriatrics Society, British Geriatrics Society, and American Academy of Orthopaedic Surgeons Panel on Falls Prevention. J Am Geriatr Soc 2001;49:664e 72.
7. Ueno M, Kawai S, Mino T, et al. [Systematic review of fall-related factors among the house-dwelling elderly in Japan] (In Japanese). Nihon Ronen Igakkai Zasshi 2006;43:92e 101.
8. Sherrington C, Whitney JC, Lord SR, et al. Effective exercise for the prevention of falls: a systematic review and meta-analysis. J Am Geriatr Soc 2008;56:2234e 43.
9. Shaw FE, Bond J, Richardson DA, et al. Multifactorial intervention after a fall in older people with cognitive impairment and dementia presenting to the accident and emergency department: randomised controlled trial. BMJ 2003;326:73e 5.
10. Gates S, Fisher JD, Cooke MW, et al. Multifactorial assessment and targeted intervention for preventing falls and injuries among older people in community and emergency care settings: systematic review and meta-analysis. BMJ 2008;336:130e 3.
11. Bracco P, Deregibus A, Piscetta R. Effects of different jaw relations on postural stability in human subjects. Neurosci Lett 2004;356:228e 30.
12. Yamaga T, Yoshihara A, Ando Y, et al. Relationship between dental occlusion and physical fitness in an elderly population. J Gerontol A Biol Sci Med Sci 2002;57:M616e 20.
13. Okuyama N, Yamaga T, Yoshihara A, et al. Influence of dental occlusion on physical fitness decline in a healthy Japanese elderly population. Arch Gerontol Geriatr 2011;52:172e 6.
14. Yoshida M, Morikawa H, Kanehisa Y, et al. Functional dental occlusion may prevent falls in elderly individuals with dementia. J Am Geriatr Soc 2005;53:1631e 2.
15. Gangloff P, Louis JP, Perrin PP. Dental occlusion modifies gaze and posture stabilization in human subjects. Neurosci Lett 2000;293:203e 6.
16. Kondo K. Introducing a survey on health of older people in Japan: AGES (Aichi Gerontological Evaluation Study) project. In: Kondo K, ed, Health Inequalities in Japan: An Empirical Study of Older People. Melbourne, Australia: Trans Pacific Press, 2010.
17. Nishi A, Kondo K, Hirai H, et al. Cohort profile: the AGES 2003 cohort study in Aichi, Japan. J Epidemiol 2011;21:151e 7.
18. Aida J, Hanibuchi T, Nakade M, et al. The different effects of vertical social capital and horizontal social capital on dental status: a multilevel analysis. Soc Sci Med 2009;69:512e 18.
19. Lord SR, Clark RD, Webster IW. Physiological factors associated with falls in an elderly population. J Am Geriatr Soc 1991;39:1194e 200.
20. Ivers RQ, Cumming RG, Mitchell P, et al. Visual impairment and falls in older adults: the Blue Mountains Eye Study. J Am Geriatr Soc 1998;46:58e 64.
21. Grundstrom AC, Guse CE, Layde PM. Risk factors for falls and fall-related injuries in adults 85 years of age and older. Arch Gerontol Geriatr 2012;54:421e 8.
22. Marshall SW, Runyan CW, Yang J, et al. Prevalence of selected risk and protective factors for falls in the home. Am J Prev Med 2005;28:95e 101.
23. Murata C, Kondo T, Tamakoshi K, et al. Factors associated with life space among community-living rural elders in Japan. Public Health Nurs 2006;23:324e 31.
24. WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet 2004;363:157e 63.
25. 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;4:173e 8.
26. Aida J, Kondo K, Hirai H, et al. Association of dental status and incident disability among an older Japanese population. J Am Geriatr Soc 2012;60:338e 43.
27. Maruya M, Shimizu K, Ohnuma T, et al. [The effect of wearing denture and changes of occlusal position on body sway in edentulous patient] (In Japanese). J Jpn Prosthodont Soc 2000;44:781e 5.
28. Käyser AF. Shortened dental arches and oral function. J Oral Rehabil 1981;8:457e 62.
29. Yoshihara A, Watanabe R, Nishimuta M, et al. The relationship between dietary intake and the number of teeth in elderly Japanese subjects. Gerodontology 2005;22:211e 18.
30. Takata Y, Ansai T, Awano S, et al. Relationship of physical fitness to chewing in an 80-year-old population. Oral Dis 2004;10:44e 9.
31. Fukai K, Takiguchi T, Ando Y, et al. Critical tooth number without subjective dysphagia. Geriatr Gerontol Int 2011;11:482e 7.
32. Miyaura K, Morita M, Matsuka Y, et al. Rehabilitation of biting abilities in patients with different types of dental prostheses. J Oral Rehabil 2000;27:1073e 6.
33. Moreland J, Richardson J, Chan DH, et al. Evidence-based guidelines for the secondary prevention of falls in older adults. Gerontology 2003;49:93e 116.
34. Pitiphat W, Garcia RI, Douglass CW, et al. Validation of self reported oral health measures. J Public Health Dent 2002;62:122e 8.
35. Douglass CW, Berlin J, Tennstedt S. The validity of self-reported oral health status in the elderly. J Public Health Dent 1991;51:220e 2.
36. Ando Y, Ikeda S, Yoshihara A. [The reliability of self-assessment of number of remaining teeth using questionnaires] (In Japanese). J Dent Health 1997;47:657e 62.
37. Cummings SR, Nevitt MC, Kidd S. Forgetting falls. The limited accuracy of recall of falls in the elderly. J Am Geriatr Soc 1988;36:613e 16.

Dental status and incident falls among older Japanese: a prospective cohort study

Tatsuo Yamamoto, Katsunori Kondo, Jimpei Misawa, et al.

BMJ Open 2012 2:
doi: 10.1136/bmjopen-2012-001262

神奈川歯科大学
Kanagawa Dental College

プレスリリース　2012年8月1日

報道関係各位

（お問い合わせ先）
神奈川歯科大学
社会歯科学講座歯科医療社会学分野
准教授　山本龍生
電話：
Eメール：

歯を失って義歯を使わなければ転倒のリスクが2.5倍に

～厚労省研究班が健康な高齢者1763名を追跡して明らかに～

歯の状態とその後の転倒とが関連していることが，65歳以上の健常者1763名を対象にした3年間の追跡調査で判明しました。郵送調査の3年後に過去1年間に転倒したか否かを再調査しました。その結果，性，年齢，期間中の要介護認定の有無，うつの有無などに関わらず，**歯が19本以下で義歯を使用していない人は，転倒のリスクが高くなる**ことが示されました。さらに，歯が19本以下でも義歯を入れることで，転倒のリスクを約半分に抑制できる可能性も示されました。

＜背景＞

高齢者の約3分の1が1年間に転倒を経験し，転倒した者の約6%が骨折すると言われている。骨折の中でも大腿骨頸部骨折は，高齢者の寝たきり原因となる。また，1度転倒すると，転倒の恐怖から高齢者の引きこもりが起こることも示唆されている。

高齢者の転倒のリスク因子として，リウマチ等の疾患，うつ，脚力やバランス機能の低下などが知られている。しかし，それらのリスク因子への介入が，必ずしも転倒予防には結びついておらず，さらなるリスク因子の特定が望まれている。

一方，臼歯の咬合の喪失が，その後の脚力やバランス機能の低下につながることが報告されている。歯や咀嚼筋から中枢に向かう神経が，体のバランス機能と関連することが示唆されている。しかし，歯の状態がその後の転倒に影響するのかどうかについては，海外も含め報告がほとんどなく，わかっていなかった。

そこで歯の状態とその後の転倒との関係を明らかにすることを目的として追跡調査を行った。

＜方法＞

AGES（Aichi Gerontological Evaluation Study，愛知老年学的評価研究）プロジェクトの一環として，2003年に愛知県に居住する65歳以上の健常者を対象としてアンケート調査を行った。そして，最初の調査時点で過去1年間に転倒の経験がない者のうち，3年間追跡できた1763名の3年後における過去1年間の転倒経験と，歯数および義歯使用の有無との関係を検討した。

＜結果＞

追跡調査で過去1年間に2回以上の転倒を経験した人は86名（4.9%）であった。転倒経験者の割合は，歯数が少ない人ほど高くなった。

転倒との関連がみられた性，年齢，追跡期間中の要介護認定の有無，うつ，主観的健康観，教育歴を考慮し，リスクの度合いを計算すると，**20歯以上の人に対して19歯以下で義歯未使用の人の転倒リスクは2.50倍**であった（図）。なお，19歯以下で義歯を使用している人の転倒リスクは1.36倍であり，20歯以上の人との間に明らかな（統計学的に有意な）違いは見られなかった。

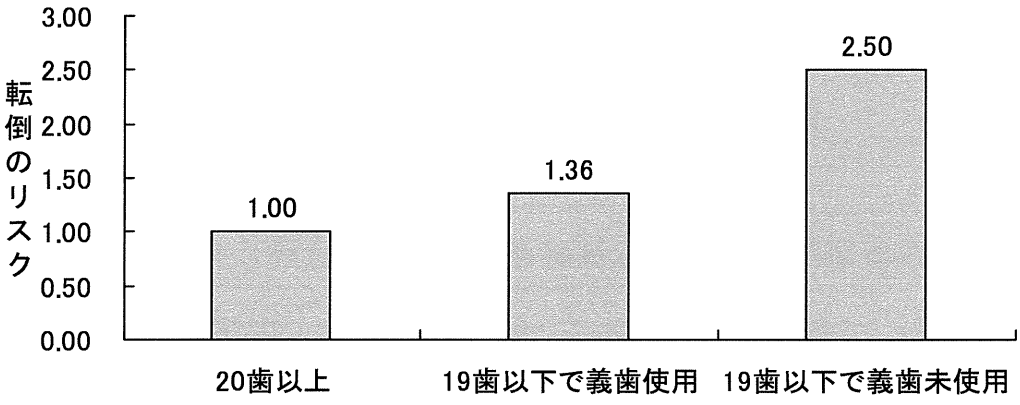


図　歯数・義歯と転倒との関係
（性，年齢，追跡期間中の要介護認定の有無，うつ，主観的健康観，教育歴を調整済み）

＜研究の意義＞

歯を失っても義歯を使用しないことによって，その後に転倒するリスクが高まることが示された。歯を失っても義歯を使用しなければ，下顎の位置が不安定になり，頭部を含めた体の重心が不安定となり，それらの結果としてバランス低下を招き，転倒する可能性が示唆される。また，歯が少なくても義歯を入れることで転倒リスクを抑制できる可能性も明らかになった。

この研究は，厚生労働科学研究班（主任研究者　近藤克則　日本福祉大学教授）の山本龍生　神奈川歯科大学　准教授が分析し，雑誌BMJ Openに掲載された。厚生労働科学研究（長寿科学総合研究事業）の一つとして行われている「介護保険の総合的政策評価ベンチマークシステムの開発（平成２２年～平成２４年）」における研究成果である。

論文発表

Yamamoto T, Kondo K, Misawa J, Hirai H, Nakade M, Aida J, Kondo N, Kawachi I, Hirata Y. Dental status and incident falls among older Japanese: a prospective cohort study. BMJ Open 2012;2:e001262 doi:10.1136/bmjopen-2012-001262.

社会保障制度改革国民会議 提出資料

2013年3月27日

日本歯科医師会
会長　大久保 満男

国民の健康を守るために
日本歯科医師会の基本方針

健康で安心な生活を営むための国家と国民の責務
- ➢ 健康増進活動の充実・・・地域住民の主体的な参加
- ➢ 医療提供体制の充実 ＝ 国民皆保険の充実・・・（公助・共助・自助の連携）

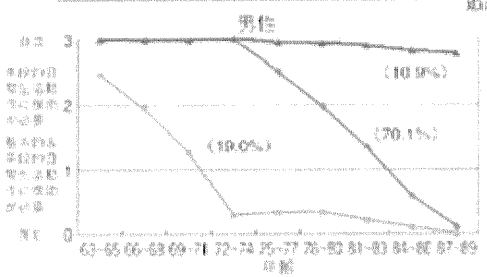
1. 健康寿命の延伸
   - 地域保健活動と公的医療保険との連携
   - 特に超高齢社会におけるハイリスク者への医療提供体制をいかに構築するか
2. 要介護者のQOLの維持と改善
   - 公的医療保険と公的介護保険との連携の在り方
   - 在宅医療・歯科医療の提供体制の充実
3. 看取りの医療のあり方
   - 死生観、人生の価値とは

医療・歯科医療が人々の日々の営みとしての生活をどのように支えるか
「治す医療」から「治し支える医療」へのパラダイムシフト

1

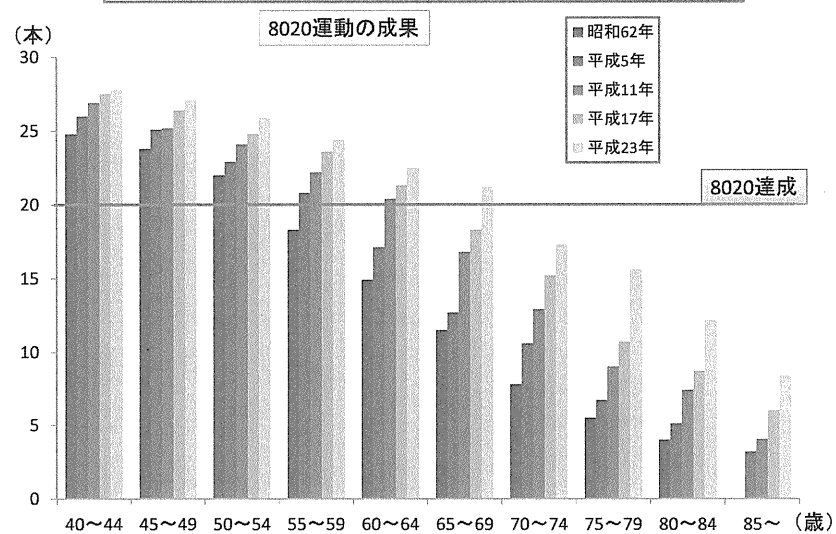
加齢に伴う自立度の変化

＊全国高齢者20年の追跡調査（N＝5715）



2

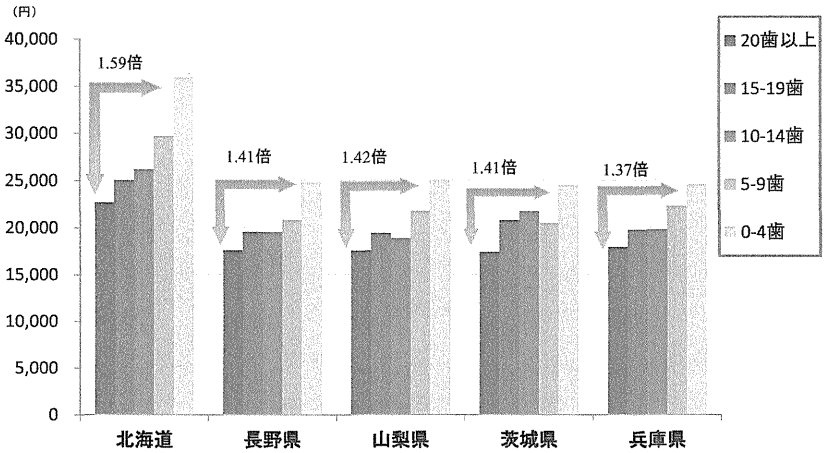
年齢別平均現在歯数の経年推移（歯科疾患実態調査結果より）



3

仮説 … 歯が多いほど 健康であれば医療費は少ない

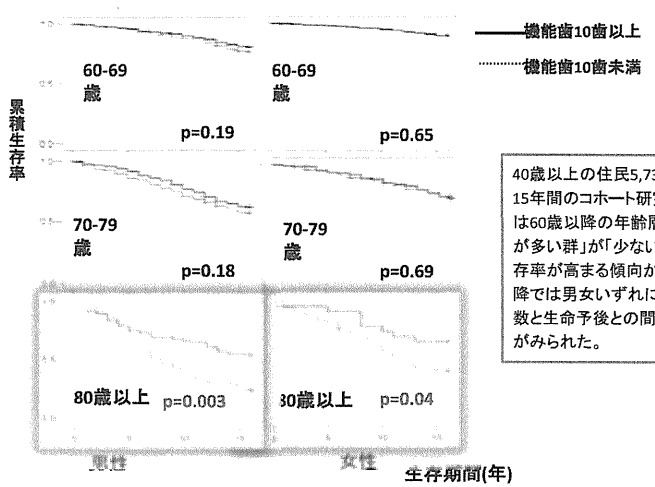
都道府県に関わらず、歯が多く残っている人ほど医科医療費が少ない傾向を示す



歯の数と健康度との関係(国保連合会・歯科医師会協力)

歯の本数が多いほど生存年数が長い

機能歯数(10歯未満/10歯以上)と生存曲線

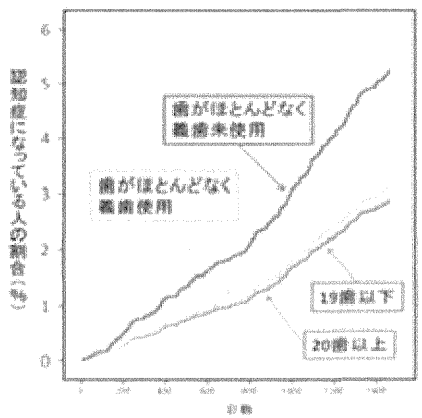


40歳以上の住民5,730名を対象とした15年間のコホート研究の結果、男性では60歳以降の年齢層で、「機能歯数が多い群」が「少ない群」に比べて生存率が高まる傾向がみられ、80歳以降では男女いずれにおいても、機能歯数と生命予後との間には有意な関連がみられた。

Fukai K et al., Geriatr Gerontol Int 7: 341-347, 2007

歯数が多いほど、また義歯による機能回復をするほど認知症発症が少ない。

歯数・義歯使用と認知症発症との関係
(年齢、所得、BMI、治療中疾患、飲酒等の有無を調整済み)



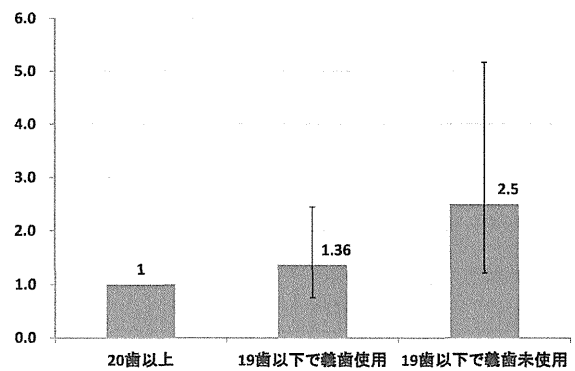
認知症の認定を受けていない65歳以上の住民4,425名を対象とした4年間のコホート研究の結果、年齢、治療疾患の有無や生活習慣などに関わらず、歯がほとんどなく義歯を使用していない人は、認知症発症のリスクが高くなることが示された。
特に、歯がほとんどないのに義歯を使用していない人は、20本以上歯が残っている人の1.9倍、認知症発症のリスクが高いことがわかった。
さらに、歯がほとんどなくても義歯を入れることで、認知症の発症リスクを4割抑制できる可能性も示された。

Yamamoto et al., Psychosomatic Medicine, 2012

歯を失い、義歯を使用していないと転倒のリスクが高まる

歯数・義歯使用有無と転倒リスク
(性、年齢、追跡期間中の要介護認定、教育歴等を調整済み)

20歯以上の者を1とした場合のオッズ比

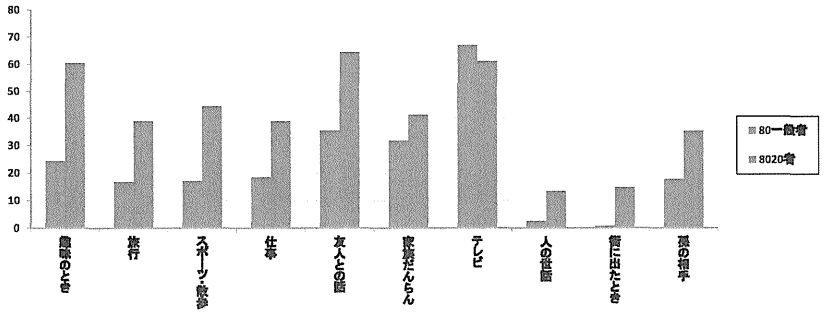


過去1年間に転倒経験のない65歳以上の住民1,763名を対象とした4年間のコホート研究の結果、性、年齢、期間中の要介護認定の有無、うつの有無などに関わらず、歯が19本以下で義歯を使用していない人は、転倒のリスクが高くなることが示された。
さらに、歯が19本以下でも義歯を入れることで、転倒のリスクを約半分に抑制できる可能性も示された。

Yamamoto et al., BMJ Open,2: e001262, 2012

いい歯のお年寄り8020コンクール・アンケート（集計結果）

楽しいときは？

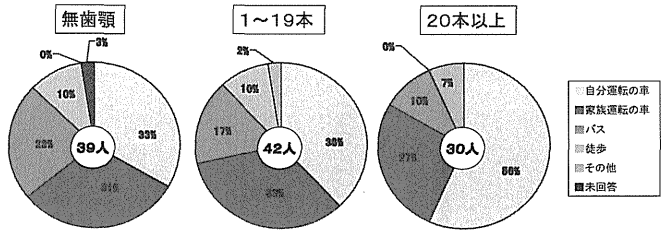


	趣味のとき	旅行	スポーツ・散歩	仕事	友人との話	家族だんらん	テレビ	人の世話	街に出たとき	孫の相手
80一般者	24.4	16.9	17.1	18.5	35.4	31.7	66.9	2.5	0.7	17.8
8020者	60.5	38.9	44.4	38.9	64.4	41.2	61.1	13.4	14.7	35.3

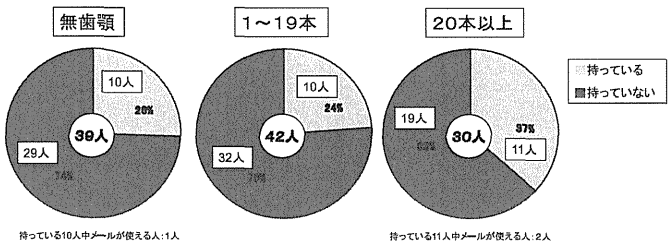
8

兵庫県香美町村岡区　80歳口腔保健実態調査

残存歯数別　交通手段



残存歯数別　携帯電話所有状況



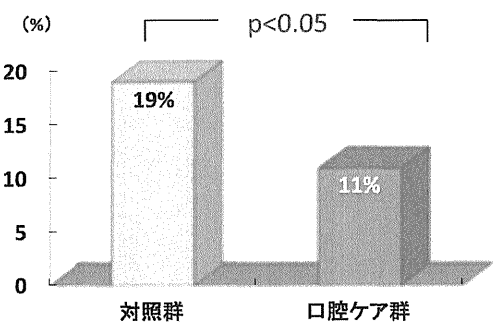
持っている10人中メールが使える人：1人

持っている11人中メールが使える人：2人

9

口腔ケアと誤嚥性肺炎との関係

専門的口腔管理・ケアと口腔清掃により、誤嚥性肺炎の発症が約6割以下に減少　（2年間の肺炎発症率の比較）



全国11カ所の特別養護老人ホーム：入所者366名を対象

専門的口腔管理群
週に1度、歯科医師・歯科衛生士による専門的な口腔管理を実施し、介護者又は看護師による毎食後の歯磨きおよび1%ポピドンヨードによる含漱を実施

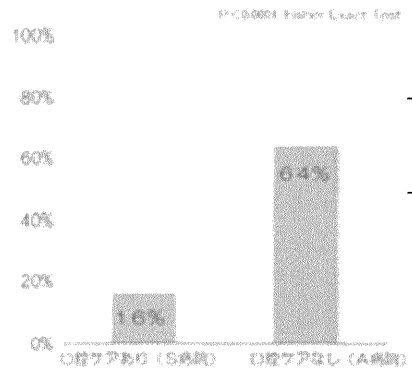
Yoneyama T, Yoshida Y, Matsui T, Sasaki H : Lancet 354(9177), 515, 1999.

10

口腔ケアと術後合併症との関係

頭頸部進行がん患者の再建手術における口腔ケアの介入効果

- 術後合併症率（単変量解析）



	口腔ケアあり 静岡がんセンター（日）	口腔ケアなし A病院（日）
平均	25. 6	72.4
中央値	21	36

P<0.0001　Wilcoxon順位和検定

手術後の在院日数の違いは、静岡がんの方が口腔・咽頭の局所感染が発症がなく早く傷が治り、食事が早期にできて退院したことを示している。
中央値で約2週間（15日）の差が認められた。

大田洋二郎, 米山武義：口腔ケアについての情報提供：PRACTICE IN PROSTHODONTICS, 38(5), 500-583, 2005

静岡がんセンター（大田，歯界展望 2005）

11

Social Science & Medicine 75 (2012) 940e 945

Contents lists available at SciVerse ScienceDirect

Social Science & Medicine

journal homepage: www.elsevier.com/locate/socscimed

Gender differences on the impacts of social exclusion on mortality among older Japanese: AGES cohort study

Masashige Saito [a,*], Naoki Kondo [b], Katsunori Kondo [c], Toshiyuki Ojima [d], Hiroshi Hirai [e]

[a] Department of Social Welfare, Nihon Fukushi University, Okuda, Mihama-cho, Chita-gun, Aichi-pref 470-3295, Japan
[b] Department of Health Economics and Epidemiology Research, Graduate School of Medicine, The University of Tokyo, Japan
[c] Center for Well-being and Society, Nihon Fukushi University, Japan
[d] Department of Community Health and Preventive Medicine, Hamamatsu University School of Medicine, Japan
[e] Department of Civil Environmental Engineering, Iwate University, Japan

a r t i c l e i n f o

Article history:
Available online 14 May 2012

Keywords:
Social exclusion
Relative poverty
Social isolation
Cohort study
Aged
Mortality
Japan

a b s t r a c t

To evaluate the gender-specific impact of social exclusion on the mortality of older Japanese adults, we performed a prospective data analysis using the data of the Aichi Gerontological Evaluation Study (AGES). In AGES, we surveyed functionally independent residents aged 65 years or older who lived in six municipalities in Aichi prefecture, Japan. We gathered baseline information from 13,310 respondents in 2003. Information on mortality was obtained from municipal databases of the public long-term care insurance system. All participants were followed for up to 4 years. We evaluated social exclusion in terms of the combination of social isolation, social inactivity, and relative poverty. Cox's proportional hazard model revealed that socially excluded older people were at significantly increased risk (9e 34%) for premature mortality. Those with simultaneously relative poverty and social isolation and/or social inactivity were 1.29 times more likely to die prematurely than those who were not socially excluded. Women showed stronger overall impact of social exclusion on mortality, whereas relative poverty was significantly associated with mortality risks for men. If these associations are truly causal, social exclusion is attributable to 9000e 44,000 premature deaths (1e 5%) annually for the older Japanese population. Health and social policies to mitigate the issue of social exclusion among older adults may require gender-specific approaches.

Introduction

There is a growing interest in the concept of social exclusion. Social exclusion is closely associated with material deprivation due to poverty but it covers wider and dynamic dimensions, including deprivation in social networks, living arrangements, goods, employment, access to benefits, and cultural capitals (Berghman, 1995). Social exclusion is a "multidimensional" problem and a "dynamic process", whereas the traditional concept of poverty focuses on "income" and "static outcome". As shown in Table 1, various methods for measuring social exclusion exist. Barnes (2002) emphasized the importance of measuring the dimensions of interpersonal relationships and social participation. As Barnes argued, because "poverty is not simply about income, but about a lack of resources that impedes participation in society, measuring poverty requires detailed analysis of multiple deprivation and participation issues. Social exclusion focuses more on relational issues; in other words, inadequate social participation, lack of social integration and lack of power." Note that the term "social exclusion" has been used in a different context in social psychology. Specifically, the negative consequence of unfavorable interpersonal relationships (e.g., being rejected by one's peers) is similar to other concepts, such as social rejection and social ostracism (Baumeister, DeWall, Ciarocco, & Twenge, 2005; Nolan, Flynn, & Garber, 2003; Williams, Forgas, & von Hippel, 2005).

The World Health Organization has mentioned that "Poverty, relative deprivation and social exclusion have a major impact on health and premature death" (Wilkinson & Marmot, 2003). In fact, there are a large number of studies that focus on specific dimensions of social exclusion and health, for example, relative poverty, socioeconomic inequality, and neighborhood relationships (Kawachi, 2000; Kondo, Kawachi, Subramanian, Takeda, & Yamagata, 2008; Kondo, Sembajwe, et al., 2009; Leclerc, Chastang, Menvielle, & Luce, 2006). However, there are few studies that have analyzed the impact of accumulation of poverty and social disintegration. It is highly likely that an individual's experiences overlap in multiple dimensions of social exclusion, and we should

* Corresponding author.
E-mail address: masa-s@n-fukushi.ac.jp (M. Saito).

0277-9536/$ e see front matter © 2012 Elsevier Ltd. All rights reserved.
doi:10.1016/j.socscimed.2012.04.006