表4　男性の現在喫煙者かつ現在飲酒者による自覚ストレスと循環器疾患死亡の多変量補正ハザード比と95%信頼区間

	自覚ストレス			
	少ない	ふつう	多　い	*P* for trend
観察人年	390	1,681	336	
死亡数	63	261	58	
多変量補正				
ハザード比	1	1.33	1.96	<0.001
95%信頼区間	(reference)	(1.00-1.75)	(1.36-2.84)	

多変量補正ハザード比：年齢（5歳階級），Body mass index（18.5 kg/m² 未満，18.5-25.0 kg/m²，25.0 kg/m² 以上），歩行時間（1時間以上/日，30分-1時間未満/日，30分未満/日），睡眠時間（6時間以下/日，7-8時間/日，9時間以上/日），婚姻状況（既婚，離別/死別，未婚），学歴（中卒，高卒，短大/大卒），職業の有無（あり，なし），高血圧の既往（あり，なし），糖尿病の既往（あり，なし）

よび現在飲酒者の割合で説明されることが考えられる。また，男性の喫煙状況についてのみ有意な交互作用が認められたが，これについても，ベースラインにおける男女の現在喫煙者の割合の違いが示唆される。

自覚ストレスと循環器疾患死亡の関連において，男性では正の関連が観察され，女性では関連が観察されなかった本研究の結果は，女性では正の関連が観察されたが，男性では関連が観察されなかった，Isoらの結果とは対照的に異なっていた[15]。ただし，心筋梗塞に限定した解析では，自覚ストレスが低い群に対する多い群，ふつう群の有意なリスクの上昇が観察されており，その観点からは本研究の結論と同様である。

Isoらは，得られた結果における男女差について，仕事による残余交絡は否定できないとしながらも，ベースラインにおける自覚ストレスの分布は男女とも同じような傾向であったが，女性のみで正の関連が認められたのは，男性が自覚ストレスを多く抱えていることを認めない傾向にある可能性を指摘した。

しかしながら，本研究の結果はこの主張に矛盾することになる。

だが，Isoらは，喫煙状況，飲酒状況について層別化解析を行った検討はしていなかった[15]。したがって，実際のところ，本研究の結果との違いについては不明である。

また，本研究においても，まだ明らかになっていない残余交絡が存在する可能性もあり，今後もこれらについては検討していく必要性のある課題の1つであると考えられる。

ストレス反応に関する男女差について，男性では女性と比較した場合，ストレスに対して視床下部下垂体副腎系が強く反応すること[25]や，これとは対照的に，女性では男性と比較した場合，ストレスに対する視床下部下垂体副腎系の反応を制御する傾向があること[26]が既に報告されている。これらの報告からも本研究の結果から得られた男女差について説明できる可能性がある。

本研究は，一般地域住民を対象とした，大規模な前向きコホート研究である。また，自覚ストレスと循環器疾患死亡との関連について，男女別に関連性を検討した後，喫煙状況と飲酒状況について層別化解析を行って検討した，世界初の研究である。本研究は，このような検討が可能なほど，十分な統計学的検出力を持ったサンプルサイズと長期の追跡期間が保証されていた。

しかし，自覚ストレスの評価はベースライン時における質問票の中での回答の1回のみであった。自覚ストレスは時間や状況とともに変化する可能性があり，一致性についての検討も実施していなかったため，再現性があるかについても不明である。しかしながら，自覚ストレスの1回のみの評価は，non-differential misclassificationの可能性もあると考えられる。もし，複数回にわたり同じ質問項目で評価をすれば，自覚ストレスの3つの回答のカテゴリーにおけるそれぞれの割合は，真の値に近づき，より正確な分類が可能となり，各群の間に認められた効果が拡大する可能性が推測される。したがって，本研究の結果は，自覚ストレスと循環器疾患死亡との関連について過小評価している可能性があり，実際のこれらの関連は本研究における結果以上に強くなる可能性が示唆される。

男女とも現在喫煙者および現在飲酒者では，自覚ストレスと循環器疾患死亡との正の関連が顕著であり，男性で，現在喫煙者であり，現在飲酒者である場合，より顕著であった。

ストレス対処法として，男性ではとくに「飲酒」，「喫煙」を挙げていた者が多かった[16]。

しかし，本研究の結果から，今後の保健指導において，自覚ストレスを抱えている個人や集団に対して，喫煙や飲酒は短期的にはストレス解消の手段となりうるが，中長期的にはむしろ循環器疾患死亡のリスクを上昇させる可能性があるので，避けるべきであることを提言できる。したがって，本研究の結果から，自覚ストレスを抱えた対象者の喫煙習慣や飲酒習慣に関して，行動変容につながるような動機づけとしての1つの裏づけになることが期待される。

また，一方で，様々な公衆衛生活動の場におい

て，ストレスマネジメントや喫煙・飲酒に対する支援をよりいっそう強化していく必要があることを意味するものと考えられる。

喫煙や飲酒のように，自覚ストレスを抱えている場合に循環器疾患死亡のリスクを上昇させる可能性のある生活習慣は，他にもある可能性がある。今後はそれらについて，さらに検討していくことが必要ではないかと考えられる。

V　結　　論

本研究において，自覚ストレスと循環器疾患死亡について，男性では有意な正の関連が観察されたが，女性では関連は観察されなかった。一方，男女ともに現在喫煙者と現在飲酒者で自覚ストレスと循環器疾患死亡との正の関連が認められた。自覚ストレスと循環器疾患死亡との関連における男女差は，現在喫煙者および現在飲酒者の割合の違いにより説明される可能性があることが示唆された。

本研究の結果は，ストレス解消の手段としての喫煙習慣や飲酒習慣の見直し，あるいはストレスマネジメントや喫煙，飲酒に対する支援の強化を意味するものと考えられる。

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Perceived stress and cardiovascular disease mortality The Ohsaki Cohort Study

Emi KOWATA*, Atsushi HOZAWA*,2*, Masako KAKIZAKI*, Yasutake TOMATA*, Masato NAGAI*, Yumi SUGAWARA*, Shinichi KURIYAMA*,3* and Ichiro TSUJI*

Key words : perceived stress, cardiovascular disease, mortality, cohort study, smoking, drinking

Objectives Previous studies have indicated that stress can affect the circulatory system. Although prospective studies have examined the association between perceived stress and cardiovascular disease (CVD) mortality, the results are still controversial. The purpose of the present study was to elucidate the relationship with stratified analyses by alcohol intake category and smoking status.

Methods The prospective Ohsaki Cohort Study covered all National Health Insurance beneficiaries aged 40 to 79 years living in the precinct of Ohsaki Public Health Center, Miyagi, Japan. A total of 45,293 Japanese (21,552 men and 23,741 women), without a history of cancer, ischemic heart disease or stroke, and who answered all items related to stress level at the baseline in 1994, were followed prospectively. Over 12 years of follow-up, 1,751 deaths from CVD occurred (994 men and 757 women). We used Cox proportional hazards models to calculate the hazard ratios (HR) and 95% confidence intervals (CI) for CVD mortality according to the perceived stress categories. The low stress category was used as the reference in all analyses.

Results Perceived stress demonstrated a significant positive association with CVD mortality for men; the multivariate adjusted HR for high versus low stress was 1.43 (95%CI: 1.19, 1.87, $P=0.006$). No significant relationship was noted for women. With current smokers, perceived high stress versus low had a pronounced association for both men (HR=1.76, 95%CI: 1.28, 2.41, $P=0.001$) and women (HR=1.61, 95%CI: 1.20, 2.16, $P=0.004$), and a similar tendency was noted for current drinking (HR=1.56, 95%CI: 1.16, 2.09, $P=0.006$, HR=1.42, 95%CI: 1.08, 1.87, $P=0.001$). Additionally, for both smoking and drinking men, those reporting high stress had 2 times the risk of CVD mortality of their low stress counterparts (P for trend <0.001). The interaction of perceived stress with smoking for CVD mortality was of borderline statistical significance only for men (P for interaction $=0.04$).

Conclusion The results suggest that the percentage of current smoking and drinking are factors that distinguish between sexes with regard to the effects of perceived stress on the incidence of CVD mortality. Furthermore our present findings indicate that smoking and drinking habit are not the way to relieve one's stress. A review of these should be conducted and we need to enhance support for stress management as well as control over smoking and drinking habits.

* Division of Epidemiology, Department of Public Health and Forensic Medicine, Tohoku University Graduate School of Medicine
2* Department of Public Health, Yamagata University Graduate School of Medical Science
3* Department of Molecular Epidemiology, Environment and Genome Research Center, Tohoku University Graduate School of Medicine

Tooth Loss and Mortality in Elderly Japanese Adults: Effect of Oral Care

Kazuki Hayasaka, Yasutake Tomata, MSc,* Jun Aida, DDS, PhD,† Takashi Watanabe, MD,* Masako Kakizaki, PhD,* and Ichiro Tsuji, MD, PhD**

OBJECTIVES: To assess whether oral care (tooth brushing, regular dental visits, and use of dentures) affects mortality in elderly individuals with tooth loss.

DESIGN: A 4-year prospective cohort study.

SETTING: Ohsaki City, Japan.

PARTICIPANTS: Twenty-one thousand seven hundred thirty community-dwelling individuals aged 65 and older.

MEASUREMENTS: In a baseline survey in 2006, data were collected on number of remaining teeth and oral care status as measures of dental health. Data were also collected on age, sex, education level, smoking, alcohol drinking, time spent walking daily, medical history, psychological distress, and energy and protein intake as covariates. During the 4-year follow-up between 2006 and 2010, information on mortality was obtained from Ohsaki City government.

RESULTS: The multivariate-adjusted Cox proportional hazards model showed an inverse dose-response relationship between number of remaining teeth and mortality (P for trend <.001). In participants with 0 to 19 teeth, practicing oral care was inversely associated with mortality. The multivariate hazard ratio for mortality in participants who practiced all three types of oral care was 0.54 (95% confidence interval = 0.45–0.64), compared with participants who practiced none of the three.

CONCLUSION: Tooth brushing, regular dental visits, and use of dentures are inversely associated with mortality in elderly individuals with tooth loss. **J Am Geriatr Soc 61:815–820, 2013.**

Key words: number of teeth; tooth brushing; dental visit; denture; mortality

From the *Department of Public Health and Forensic Medicine, Division of Epidemiology, Graduate School of Medicine; and †Department of International and Community Oral Health, Graduate School of Dentistry, Tohoku University, Sendai, Japan.

Address correspondence to Kazuki Hayasaka, Department of Public Health and Forensic Medicine, Division of Epidemiology, Tohoku University, Graduate School of Medicine 2–1, Seiryo-machi, Aoba-ku, Sendai, Miyagi 980–8575, Japan. E-mail: a8mb1067-thk@umin.ac.jp

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Tooth loss in later life is an established risk factor for mortality.[1–3] For instance, it has been reported that the multivariate hazard ratio (HR) for overall mortality in subjects with fewer than 10 teeth is 2.68 (95% confidence interval (CI) = 1.96–3.67) compared with those with more than 25 teeth.[3] One of the major causes of tooth loss is periodontal disease. Previous epidemiological studies have shown that periodontal disease is associated with coronary heart disease,[4] stroke,[4] and pneumonia.[5]

An important concern for older people with missing teeth is whether there is a way to decrease the excess risk of associated mortality. A positive effect of oral care has been suggested. One study found that people who brushed their teeth every night had a lower mortality risk than those who did not and that those who visited a dentist at least once a year had a lower risk than those did not,[6] although as they analyzed the association between subjects regardless of the number of remaining teeth, it remained unclear whether oral care affects mortality in individuals with missing teeth. There is some evidence that the use of dentures is associated with lower risk of mortality in older people with missing teeth,[7–9] but to the knowledge of the authors of the current study, no evidence has been found as to whether tooth brushing or visiting the dentist regularly affects mortality risk in older people with tooth loss.

The purposes of the present 4-year prospective cohort study were to evaluate the relationship between all-cause mortality and the number of remaining teeth in the entire study population, to assess whether oral care affects mortality in individuals with tooth loss, and to assess which specific forms of oral care were most strongly associated with mortality reduction.

METHODS

Study Design, Setting, and Participants

The present study was derived from the Ohsaki Cohort 2006 Study, whose design has been described in detail previously.[10] In brief, the source population for the baseline survey comprised all men and women aged 65 and older living in Ohsaki City, northeastern Japan, on December 1, 2006.

0002-8614/13/$15.00

The baseline survey was conducted between December 1 and 15, 2006. The heads of individual administrative districts distributed a questionnaire to all individuals aged 65 and older living in Ohsaki city that were returned by mail. Of 31,694 eligible subjects (12,750 men, 18,944 women), 23,091 (9,605 men, 13,486 women) provided valid responses and formed the study cohort. Of valid respondents, 11 who had died or moved away during the baseline survey and 1,350 who did not enter a response for the item concerning number of teeth were excluded from analysis, leaving 21,730 participants to be analyzed for this study. During 4 years of follow-up between 2006 and 2010, information on mortality and emigration was obtained from the Residential Registry of Ohsaki City.

Measurement of Dental Status

In the baseline questionnaire, participants were asked to indicate the number of remaining teeth they had using the following six categories: all (28), most (25–27), moderate (20–24), about half (10–19), few (1–9), and none (0). They were then divided into three groups: 20 or more, 10 to 19, and 0 to 9.

They were also asked whether they used dentures, whether they visited a dental clinic at least once a year, and how many times they brushed their teeth daily.

Measurements of Other Variables

Based on modern psychometric theory,[11,12] K6 was used as an indicator of psychological distress,[12,13] the Japanese version of which has been validated.[13] As suggested previously,[12] individuals with scores of 13 or greater out of 24 were classified as having psychological distress.[14]

Energy (except that from alcohol drinking) and protein intake were calculated based on data from the baseline survey and divided into three tertiles. The survey included questions about the frequency of recent average consumption of 36 daily food items. For estimation of energy and protein intake from the food-frequency questionnaire, a food composition table was used that corresponded to the items listed in the questionnaire.[15] A validation study of the food-frequency questionnaire had been conducted previously.[16]

Information on age; sex; education level; smoking and alcohol drinking status; time spent walking daily; and medical history of stroke, hypertension, myocardial infarction, and diabetes mellitus was also obtained using the baseline questionnaire.

Ethical Concerns

The return of completed questionnaires was considered to indicate consent to participate in the study. The ethics committee of Tohoku University Graduate School of Medicine reviewed and approved the study protocol.

Statistical Analysis

Baseline characteristics were evaluated using analysis of variance for continuous variables and the chi-square test for categorical variables. These methods were used to compare variables between groups with varying numbers of teeth.

The relationship between all-cause mortality and number of teeth was first examined in the entire study population. The Cox proportional hazards model was used to calculate HRs and 95% CIs for mortality according to groups with different numbers of teeth. Participants with 20 or more teeth were established as the reference group. The confounders age, sex, education level, smoking, alcohol drinking, body mass index, time spent walking daily, medical history (stroke, hypertension, myocardial infarction, diabetes mellitus), psychological distress, and energy and protein intake were used for adjustment.

Then whether oral care factors (tooth brushing >2 times/d, visiting a dentist $\geq$1 times/yr, and use of dentures) were associated with mortality risk in those with tooth loss was examined. Participants were divided into five groups: those with 20 or more teeth, those with 10 to 19 teeth and practicing at least one of the above three oral care measures, those with 10 to 19 teeth and practicing none of the three oral care measures, those with zero to nine teeth and practicing at least one of the three oral care measures, and those with zero to nine teeth and practicing none of the three oral care measures. Cox proportional hazards models were used to calculate the HRs and 95% CIs for mortality to compare the four groups with missing teeth with the group with 20 or more teeth. Participants who did not answer the questions about oral care were excluded from the analyses.

Which specific forms of oral care were most strongly associated with mortality reduction was assessed. Participants who did not practice any oral care were defined as the reference group and were compared with other groups who practiced any one of the three oral care measures, practiced two of the three, and practiced all three.

All statistical analyses were performed using SAS version 9.2 (SAS Institute, Inc., Cary, NC), and all statistical tests were two-sided. Differences at $P < .05$ were considered to be statistically significant.

RESULTS

Characteristics of the Participants

Table 1 shows the characteristics of the participants. Those who had more teeth were younger and less likely to be female; current smokers; and to have a history of stroke, myocardial infarction, or diabetes mellitus. Having more teeth was also associated with being better educated, spending more time walking, being a current drinker, and having higher energy and protein intake.

Number of Teeth in Relation to Mortality

Of the 2,362 (10.9%) participants who died during the 4-year follow-up, 44.1% were female; 59.7% of survivors were female. The mean age of decedents was 80.2 and of survivors was 74.1. The age- and sex-adjusted model showed an inverse dose-response relationship between number of remaining teeth and mortality (P for trend <.001). compared with participants with 20 or more teeth, the multiple-adjusted HR for mortality was 1.16 (95% CI = 1.01–1.33) for participants with 10 to 19 teeth and

Table 1. Relationship Between Number of Teeth and Participant Characteristic

Characteristic	Number of Teeth			*P*-Value[a]
	≥20, n = 6,193	10–19, n = 5,103	0–9, n = 10,434	
Female, %	53.4	56.7	61.4	<.001
Age, mean ± SD	71.9 ± 5.3	73.5 ± 5.7	77.1 ± 6.8	<.001
Body mass index, kg/m^2, %				
<18.5	3.6	5.1	8.0	<.001
18.5–24.9	63.5	63.8	64.4	
≥25.0	33.0	31.1	27.6	
Current smoking, %	10.9	14.1	13.8	<.001
Current alcohol drinking, %	42.6	37.6	27.6	<.001
Education < 16 years, %	26.4	30.8	39.0	<.001
Daily walking time ≥ 1 hour, %	28.7	27.4	22.3	<.001
Medical history, %				
Stroke	3.4	4.1	5.3	<.001
Hypertension	42.9	42.8	42.5	.88
Myocardial infarction	4.2	4.7	6.1	<.001
Diabetes mellitus	10.8	12.6	12.5	.006
Cancer	8.4	7.8	8.3	.49
Psychological distress, %[b]	4.9	5.7	8.1	<.001
Food consumption, g/d, mean ± SD				
Rice	432 ± 217	422 ± 207	402 ± 206	<.001
Meat	23.2 ± 16.5	22.8 ± 17.4	21.5 ± 16.5	<.001
Green and yellow vegetables	97.5 ± 48.1	92.0 ± 48.4	90.8 ± 48.8	<.001
Sweets	15.9 ± 15.6	17.4 ± 16.6	19.0 ± 17.0	<.001
Energy intake, kcal/d, mean ± SD[c]	1,440 ± 413	1,419 ± 400	1,365 ± 441	<.001
Protein intake, g/d, mean ± SD	53.6 ± 14.5	52.3 ± 14.4	50.6 ± 15.2	<.001
Use of dentures, %	27.7	73.5	89.9	<.001
Tooth brushing (times/d)	1.93 ± 0.91	1.88 ± 1.03	1.70 ± 0.97	<.001
≥1 dental visits per year, %				
For treatment	56.0	61.5	40.8	<.001
For other reason	38.3	33.4	18.4	<.001

[a] Obtained using chi-square test for variables of proportion and one-way analysis of variance for continuous variables.
[b] Kessler six-item psychological distress scale score ≥ 13.
[c] Excluding alcohol.
SD = standard deviation.

1.31 (95% CI = 1.16–1.47) for those with zero to nine teeth, after adjustment for age, sex, education level, smoking, alcohol drinking, body mass index, time spent walking daily, medical history, psychological distress, and energy and protein intake.

Oral Care in Relation to Mortality

The relationship between oral care (tooth brushing, dental visits, and use of dentures) and mortality was examined in the five groups (Table 2).

Compared with participants with 20 or more teeth, the multivariate HR for mortality of those with 10 to 19 teeth was 1.03 (95% CI = 0.86–1.22) for participants who brushed their teeth two times per day or more, 1.02 (95% CI = 0.86–1.21) for those who visited the dentist at least once a year, and 1.11 (95% CI = 0.95–1.29) for those who used dentures. Compared with participants with 20 or more teeth, the multivariate HR for mortality of those with 0 to 9 teeth, the multivariate HR for mortality was 1.09 (95% CI = 0.95–1.26) for participants who visited a dentist at least once a year, but the HRs for mortality of those who brushed their teeth two times per day or more and those who used dentures remained significantly higher than those with 20 or more teeth.

Combination of Oral Care Types in Relation to Mortality

Table 3 shows the relationship between combinations of oral care types and mortality in participants with 0 to 19 teeth. The multivariate HRs for mortality of participants who brushed their teeth, visited the dentist, and used dentures were 0.78 (95% CI = 0.59–1.08), 0.58 (95% CI = 0.39–0.85), and 0.76 (95% CI = 0.65–0.90), respectively, compared with participants who practiced none of the three oral care measures. Of the three types of oral care, the strongest variable was dental visits. The multiple adjusted HR for mortality of participants who practiced all three types of oral care was 0.54 (95% CI = 0.45–0.64) compared with those who practiced none of the three.

DISCUSSION

The present findings confirm previous studies that have indicated a significant association between tooth loss and mortality in older people.[1–3] The study further presents the results for individuals with 10 to 19 teeth that practicing good oral care habits (tooth brushing, dental visits, and use of dentures) might help negate the expected increase in mortality, although this was true only for dental visits for participants with zero to nine teeth. In addition, practicing

Table 2. Relationship Between Oral Care and All-Cause Mortality Stratified According to Number of Teeth

Oral Care and Number of Teeth	Participants, n	Events, n (%)	Hazard Ratio (95% Confidence Interval)	
			Age and Sex Adjusted	Multiple Adjusted[a]
Tooth brushing (n = 20,297)				
≥20	6,193	371 (6.0)	1.00 (reference)	1.00 (reference)
10–19 with brushing teeth ≥2 per day	2,990	195 (6.5)	1.05 (0.88–1.25)	1.03 (0.86–1.22)
10–19 with brushing teeth <2 per day	1,843	207 (11.2)	1.39 (1.18–1.65)	1.26 (1.06–1.50)
0–9 with brushing teeth ≥2 per day	4,792	531 (11.1)	1.28 (1.12–1.48)	1.19 (1.03–1.36)
0–9 with brushing teeth <2 per day	4,479	821 (18.3)	1.67 (1.47–1.90)	1.38 (1.21–1.58)
≥1 dental visits per year (n = 20,292)				
≥20	6,193	371 (6.0)	1.00 (reference)	1.00 (reference)
10–19 with dental visits	2,987	215 (7.2)	1.06 (0.89–1.25)	1.02 (0.86–1.21)
10–19 with no dental visits	1,812	196 (10.8)	1.54 (1.30–1.84)	1.42 (1.19–1.69)
0–9 with dental visits	3,795	412 (10.9)	1.23 (1.07–1.42)	1.09 (0.95–1.26)
0–9 with no dental visits	5,505	963 (17.5)	1.71 (1.51–1.94)	1.45 (1.27–1.65)
Use of dentures (n = 21,507)				
≥20	6,193	371 (6.0)	1.00 (reference)	1.00 (reference)
10–19 with use of dentures	3,660	303 (8.3)	1.15 (0.99–1.34)	1.11 (0.95–1.29)
10–19 with no use of dentures	1,321	125 (9.5)	1.52 (1.24–1.86)	1.34 (1.09–1.64)
0–9 with use of dentures	9,294	1,266 (13.6)	1.41 (1.25–1.59)	1.24 (1.10–1.40)
0–9 with no use of dentures	1,039	266 (25.6)	2.51 (2.13–2.95)	1.73 (1.47–2.04)

[a] Adjusted for age, sex, educational level (age at completion of school <16, 16–18, ≥19, missing), smoking (never, former, current, missing), alcohol drinking (never, former, current, missing), body mass index (kg/m^2; <18.5, 18.5–24.9, ≥25.0, missing), time spent walking daily (<30 min/d, 30 min/d–1 h/d, >1 h/d, missing), medical history (stroke, hypertension, myocardial infarction, diabetes mellitus), psychological distress score (<13, ≥13, missing), energy intake (3 tertiles, missing), and protein intake (3 tertiles, missing).

Table 3. Relationship Between Combinations of Oral Care and Mortality in Participants with 0 to 19 Teeth (n = 13,202)

Combination of Oral Care					Hazard Ratio (95% Confidence Interval)	
Tooth Brushing	Dental Visits	Use of Dentures	Participants, n	Events, n (%)	Age and Sex Adjusted	Multiple Adjusted[a]
–	–	–	887	206 (23.2)	1.00 (reference)	1.00 (reference)
+	–	–	483	54 (11.2)	0.67 (0.50–0.91)	0.78 (0.59–1.08)
–	+	–	277	29 (10.5)	0.56 (0.38–0.82)	0.58 (0.39–0.85)
–	–	+	2,606	488 (18.7)	0.65 (0.55–0.77)	0.76 (0.65–0.90)
+	+	–	372	22 (5.9)	0.41 (0.27–0.64)	0.53 (0.34–0.82)
+	–	+	2,811	314 (11.2)	0.52 (0.43–0.62)	0.66 (0.55–0.79)
–	+	+	2,140	243 (11.4)	0.48 (0.40–0.57)	0.58 (0.48–0.71)
+	+	+	3,626	287 (7.9)	0.42 (0.35–0.50)	0.54 (0.45–0.64)

[a] Multiply adjusted model in Table 2 was used for adjustment.
– = participants brushed teeth fewer than two times per day, did not have dental visits at least once a year, or did not use dentures.
+ = participants brushed teeth two or more times per day, had dental visits at least once a year, or used dentures.

oral care was inversely associated with mortality in individuals with missing teeth, which is good news for older people with missing teeth.

A recent report from Japan has indicated that dental health status affects the onset of dementia.[16] In that cohort study, presence of few teeth without dentures and failure to visit a dentist regularly were associated with greater risk of dementia onset.[16] A similar association between dental status and incident falls was also demonstrated using the same cohort.[17] Dementia and falls are common health problems for older people and affect incident functional disability and even mortality. The results of the present study are consistent with those previous findings, suggesting that oral care is inversely associated with mortality.

There are several possible pathways linking oral care to mortality. First, better oral hygiene through tooth brushing and dental visits may prevent death from pneumonia, especially aspiration pneumonia.[18] Second, better oral hygiene reduces the chronic inflammation that periodontal disease causes, which increases the risk of coronary heart disease and stroke.[4] Coronary heart disease, stroke, and pneumonia are the most common causes of death in elderly adults in Japan. Therefore, prevention of these diseases would be expected to reduce mortality. Third, use of dentures prevents foreign body asphyxiation and resulting death.[19] Fourth, the use of dentures improves nutrition, which may be compromised by tooth loss and affect mortality.[20] Fifth, better masticatory function

through the use of dentures improves cognitive function[21] and may prevent incident functional disability[22,23] or even death.[23]

For individuals with 10 to 19 teeth, practicing each oral care habit might help negate the expected increase in mortality, although this was only true for dental visits for individuals with zero to nine teeth. It is unclear whether the profound effect of zero to nine teeth on mortality, effectiveness of dental visits, and so on could explain this difference.

The main strength of the present study was that it included a large sample (N = 21,730) and was adjusted for a variety of confounding factors, including psychological distress and nutrition. Second, the effect of socioeconomic status (SES) was considered by including education level as a confounder. Low SES is a risk factor for tooth loss and mortality and is also associated with limited access to dental health care.[24,25] The frequency of dental visits has been reported to be significantly higher in Danish[24] and Hispanic American[25] individuals with higher income and higher education, but Japan has a national health insurance system that covers dental services. The results of studies examining the association between access to dental care and SES have been controversial. No significant association between regular dental visits and income was reported in elderly Japanese,[26] so it is unlikely that any reduction in mortality risk from dental visits would have reflected any difference in SES.

The present study also had some limitations. First, misclassification of the number of teeth and dental visits as a result of self-reporting might have occurred, although previous studies in other countries have confirmed the validity of the self-reported number of teeth,[27,28] and the validity of self-reported dental visits has also been confirmed.[29]

Second, in the source population of 31,694, the rate of valid responses (72.9%, n = 23,091) for the present study was not high. In addition, the valid responses would have shown a bias toward healthier people living in the community, although this bias would not have affected the internal validity of the association between oral care and mortality.

Third, not all potential confounding factors were considered. Although the number of remaining teeth and dental health habits were associated with cognitive function and dementia,[7,30] such information was not obtained in the present study. Information about medication was also not obtained, and there was no information about causes of death. Thus, the mechanism(s) responsible for the reduction of mortality risk resulting from oral care remained unidentified.

Despite these limitations, the present findings that tooth brushing, regular dental visits, and use of dentures were inversely associated with mortality in individuals with tooth loss are of considerable significance for elderly adults. Further observational studies should be conducted to confirm the effects of oral care on mortality of individuals with missing teeth.

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Dietary Patterns and Incident Functional Disability in Elderly Japanese: The Ohsaki Cohort 2006 Study

Yasutake Tomata, Takashi Watanabe, Yumi Sugawara, Wan-Ting Chou, Masako Kakizaki, and Ichiro Tsuji

Division of Epidemiology, Department of Public Health and Forensic Medicine, Tohoku University Graduate School of Medicine, Sendai, Japan.

Address correspondence to Yasutake Tomata, PhD, Division of Epidemiology, Department of Public Health and Forensic Medicine, Tohoku University Graduate School of Medicine, 2-1 Seiryo-machi, Aoba-ku, Sendai, Miyagi 980-8575, Japan. Email: y-tomata@med.tohoku.ac.jp

Background. To date, little is known about the association between dietary pattern and disability in older adults. The present prospective cohort study investigated the association between dietary patterns and incident functional disability.

Methods. Information on food consumption and other lifestyle factors was collected from Japanese older persons aged ≥65 years via a questionnaire. Three dietary patterns (Japanese pattern, animal food pattern, and high dairy pattern) were derived using principal component analysis of the consumption of 39 food and beverage items. Data on functional disability were retrieved from the public Long-term Care Insurance database, in which participants were followed up for 5 years. The Cox model was used to estimate the multivariate-adjusted hazard ratios of incident functional disability.

Results. Among 14,260 participants, the 5-year incidence of functional disability was 16.6%. The Japanese pattern score was associated with a lower risk of incident functional disability (hazard ratio of the highest quartile vs the lowest, 0.77; 95% confidence interval: 0.68–0.88; p trend <.001). An animal food pattern and a high dairy pattern tended to have a higher risk of incident functional disability, but not to a significant degree.

Conclusions. In Japanese older persons, the Japanese dietary pattern is associated with a decreased risk of incident functional disability.

Key Words: Epidemiology—Functional performance—Nutrition.

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DIETARY patterns are widely employed in studies of the relationship between diet and health (1–3). Previously, epidemiological observations have indicated that the Mediterranean diet and the Japanese diet are associated with health benefits such as lower rates of mortality, cardiovascular disease, and depression (4–9).

With the aging of the populations of developed countries, a rapid increase in the proportion of elderly individuals with disability is imposing a large burden on social security systems worldwide (10). To date, three studies about the Mediterranean diet and three studies about the healthy dietary pattern (Healthy Eating Index) have investigated the association with the risk of functional decline (11–16). However, their sample sizes were not large, and only one study had a prospective design. Additionally, to our knowledge, the association between other dietary patterns and the risk of functional limitation has never been reported.

Japan has not only the longest life expectancy (79 years for men and 86 years for women), but also the longest healthy life expectancy (73 years for men and 78 years for women) of any country in the world (17). This may be partly attributable to the dietary patterns of the Japanese population, in particular, the Japanese diet. Therefore, the aim of the present analysis was to determine the association between dietary patterns and incident functional disability in elderly individuals in Japan.

Methods

Study Cohort

The design of the Ohsaki Cohort 2006 Study has been described in detail elsewhere (18). In brief, the source population for the baseline survey comprised all older citizens in Ohsaki City, Miyagi Prefecture, northeastern Japan, on December 1, 2006; 31,694 men and women aged ≥65 years. The survey included questions about the frequency of recent average consumption of 39 food items, as well as items on history of disease, blood pressure, education level, smoking, alcohol drinking, body weight, height, psychological distress score (K6) (19,20), time spent walking per day, and motor function score of the Kihon Checklist (21).

The baseline survey was conducted between December 1, 2006 and December 15, 2006. A questionnaire was distributed by the heads of individual administrative districts, and then collected by mail. For this analysis, 23,091 individuals

who provided valid responses formed the study cohort. We excluded 6,333 individuals who did not provide written consent for review of their Long-term Care Insurance (LTCI) information, 1,979 persons who had already been certified as having a disability by the LTCI at the time of the baseline survey, five persons who had died or moved during the period of the baseline survey, and 514 persons who left blank more than 24 of the 39 food items on the food frequency questionnaire (FFQ). Thus, 14,260 responses were analyzed for the purpose of this study.

During the 5-year period covered by the study, only 121 individuals were lost to follow-up because they moved away from the study area, without developing any functional disability; thus, the follow-up rate was 99.2%. From 62,755 person-years, incident functional disability was determined in 2,360 persons, and the number of all-cause deaths without incident functional disability was 842.

Dietary Assessment

We asked about the average frequency of consumption of each food using a 39-item FFQ, for which we had previously conducted a validation study in the same region (the precinct of Ohsaki Public Health Center, Miyagi) (22). In brief, 113 participants (55 men and 58 women) provided four 3-day diet records within a 1-year period and subsequently responded to the FFQ. The method used for calculating food and nutrient intake from the FFQ was developed in this study. Based on these data, we calculated the volume of consumption of individual foods according to the FFQ. For estimation of energy and protein intake from the food consumption volume based on the FFQ, we used a food composition table that corresponded to the items listed in the questionnaire. This food composition table was developed by using the Standard Tables of Food Composition published by the Science and Technology Agency of Japan (22).

Dietary Pattern Derivation

To derive dietary patterns, we used two methods: (i) factor analysis (principal component analysis) and (ii) confirmatory factor analysis.

The factor analysis was conducted by using the daily consumption (weight in grams) of 39 food items from the FFQ. If the reported frequency was blank, we assumed that the item was never consumed. We used the PROC FACTOR procedure in SAS version 9.3 to obtain a three-factor score. To achieve a simpler structure with greater interpretability, the factors were rotated by an orthogonal transformation (varimax rotation function in SAS). This allowed three major dietary patterns to be identified. We named them (i) the Japanese pattern, (ii) the animal food pattern, and (iii) the high dairy pattern. For each pattern and each participant, we calculated a factor score by summing the consumption of each food item weighted by its factor loading.

In order to strengthen our dietary pattern analysis, we further used confirmatory factor analysis, which is characterized by hypothesis-oriented approach. Recently, confirmatory factor analysis has been used increasingly as a major analytical method in dietary pattern research, such as studies of the Mediterranean diet (23–25). We identified nine food items that formed the Japanese Diet Index Score: rice, miso soup, seaweeds, pickles, green and yellow vegetables (green vegetables, carrot, pumpkin, tomato), fish (raw fish, fish boiled with soy, roast fish, boiled fish paste, dried fish), green tea, beef and pork (beef, pork, ham, sausage), and coffee. In a previous study based on the dietary record method, these items had been reported to have higher absolute factor scores for the traditional Japanese pattern (26). Another study has also reported that these items are characteristic of the traditional Japanese diet (27). For each of the seven positive components (rice, miso soup, seaweeds, pickles, green and yellow vegetables, fish, and green tea), participants received 1 point if their intake was more than or equal to the sex-specific median. For each of the two negative components (beef and pork, and coffee), participants received 1 point if their intake was below the sex-specific median. Thus, the Japanese Diet Index Score ranged from 0 to 9, with higher scores indicating greater dietary conformity.

Covariate

Body mass index was calculated as the self-reported body weight (kg) divided by the square of the self-reported body height (m).

The K6 was used as an indicator of psychological distress (19,20). Respondents were asked about their mental status over the last month by using six questions. Total point scores ranged from 0 to 24. As the optimal cutoff point for mental illness in the validation study, we classified individuals with scores of ≥13 as having psychological distress (20).

The Kihon Checklist was developed to predict functional decline in community-dwelling elderly individuals. With regard to the motor function score in the Kihon Checklist, respondents were asked about their current motor function status by using five binary questions yielding total point scores ranging from 0 to 5. As the optimal cutoff point for functional decline suggested in the validation study, we classified individuals with scores of <3 as having better motor function (21).

LTCI System in Japan

In this study, we defined incident functional disability as certification for LTCI in Japan, which uses a nationally uniform standard of functional disability. LTCI is a mandatory form of social insurance to assist daily activity in the frail elderly individuals (28–32). Everyone aged ≥40 years pays premiums, and everyone aged ≥65 years is eligible for

formal caregiving services. When a person applies to the municipal government for benefits, a care manager visits his or her home and assesses the degree of functional disability using a questionnaire developed by the Ministry of Health, Labor, and Welfare. Then, the municipal government calculates the standardized scores for physical and mental functions on the basis of the questionnaire and assesses whether the applicant is eligible for LTCI benefits (certification). There are a total of 74 items in the questionnaire, and these are classified into six dimensions: motor function (13 items), activity of daily living (12 items), cognitive function (9 items), mental and behavioral disorders (15 items), adaptation to social life (6 items), and use of medical procedures (12 items). If a person is judged to be thus eligible, the Municipal Certification Committee decides on one of seven levels of support, ranging from Support Level 1, Support Level 2, and Care Level 1 to Care Level 5. In brief, LTCI certification levels are defined as follows. Support Level 1: "limited in instrumental activities of daily living but independent in basic activities of daily living (ADLs)"; Care Level 2: "requiring assistance in at least one basic ADL task"; Care Level 5: "requiring care in all ADL tasks". A community-based study has shown that levels of LTCI certification are well correlated with ability to perform activities of daily living, and with Mini-Mental State Examination scores (33). LTCI certification has already been used as a measure of incident functional disability in the elderly individuals (34–36).

Follow-up and Case Details

Incident functional disability was set as our endpoint, which was defined as LTCI certification. The primary outcome was LTCI certification (Support Level 1 or higher), in which deaths without LTCI certification were treated as censored. In the subanalysis, we set the criteria of disability toward a more severe level, that is, Care Level 2 (requiring assistance with one basic activities of daily living task) or higher.

We obtained a data set that included information on the date of LTCI certification, death, or emigration from Ohsaki City Government based on an agreement about the secondary use of data. With regard to LTCI certification, information on care level was also provided. All data were transferred from the Ohsaki City Government under the agreement related to Epidemiologic Research and Privacy Protection yearly each December.

Ethical Issues

We considered the return of completed questionnaires to imply consent to participate in the study involving the baseline survey data and subsequent follow-up of death and emigration. We also confirmed information regarding LTCI certification status after obtaining written consent along with the questionnaires returned from the participants at the time of the baseline survey. The Ethics Committee of Tohoku University Graduate School of Medicine (Sendai, Japan) reviewed and approved the study protocol.

Statistical Analysis

We counted the person-years of follow-up for each participant from December 16, 2006 until the date of incident functional disability, date of emigration from Ohsaki City, date of death, or the end of the study period (November 30, 2011), whichever occurred first.

We used the multiple adjusted Cox proportional hazard model to calculate the hazard ratios (HRs) and 95% confidence intervals (CIs) for incident functional disability according to quartiles of the dietary pattern score. Dummy variables were created for the quartiles of each dietary pattern score, and the lowest quartile of a dietary pattern score was used as a reference category. Multivariate models were adjusted for the following variables. Model 1 was sex and age adjusted. To examine whether the association between the dietary patterns and functional disability was attributable to a healthy physical status or other lifestyle factors, Model 2 was further adjusted for history of stroke, myocardial infarction, hypertension (individuals with self-measured systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg were also defined as hypertensive), arthritis, osteoporosis and fracture, education level, smoking status, alcohol consumption, body mass index, psychological distress score, time spent walking per day, and motor function score. Model 3 was fully adjusted and included energy and protein intake (category of sex-specific tertile).

All data were analyzed using SAS version 9.3 (SAS Inc., Cary, NC). All statistical tests described here were two sided, and differences at $p < .05$ were accepted as significant.

Results

Among 14,260 participants, the proportion of men was 44.8%, mean (*SD*) age was 73.9 (6.0) years, and mean (*SD*) body mass index was 23.6 (3.4). The number of participants for whom data on the FFQ were any missing was 7,352 (the distribution of missing shows in Supplementary Figure 1).

Table 1 shows factor loadings, which are equivalent to simple correlations between the food items and dietary patterns. A positive loading indicates that a food item is positively associated with the dietary pattern, and a negative loading indicates an inverse association with the dietary pattern. That is, food items highly loaded within a dietary pattern are highly correlated with each other.

The Japanese pattern was loaded heavily on fish, vegetables, mushrooms, potato, seaweeds, pickles, soybean and fruits, whereas the animal food pattern was loaded heavily on various animal-derived foods (beef, pork, ham, sausage, chicken, liver, eggs, and butter). The high dairy pattern was heavily loaded on dairy products (yoghurt, cheeses, and butter), margarine, and

Table 1. Factor-Loading Matrix for the Major Dietary Pattern Identified by Factor Analysis (n = 14,260)*

	Japanese Pattern	Animal Food Pattern	High Dairy Pattern
Rice	0.01	0.31	−0.39
Miso soup	0.06	0.04	−0.07
Beef	−0.09	0.47	0.08
Pork (excluding ham, sausage)	0.15	0.56	0.01
Ham, sausage	0.05	0.49	0.25
Chicken	0.15	0.56	0.00
Liver	−0.06	0.42	0.15
Egg	0.25	0.33	0.04
Milk	0.19	0.01	0.26
Yoghurt	0.21	−0.09	0.47
Cheeses	−0.02	0.28	0.46
Butter	−0.07	0.39	0.45
Margarine	−0.07	0.23	0.49
Deep fried dishes, tempura	0.15	0.47	0.04
Fried vegatable	0.40	0.32	0.02
Raw fish, fish boiled with soy, roast fish	0.44	0.26	−0.11
Boiled fish paste	0.29	0.38	0.15
Dried fish	0.33	0.30	0.05
Green vegetables	0.66	0.10	0.08
Carrot, pumpkin	0.65	−0.03	0.23
Tomato	0.44	−0.12	0.37
Cabbage, lettuce	0.60	0.17	0.16
Chinese cabbage	0.64	0.15	−0.05
Wild plant	0.19	0.22	0.16
Mushrooms (shiitake, enokitake)	0.43	0.27	0.04
Potato	0.65	0.07	0.12
Seaweeds	0.63	0.02	0.19
Pickles (radish, Chinese cabbage)	0.41	0.04	−0.06
Food boiled with soy	0.23	0.23	0.32
Boiled beans	0.22	0.11	0.37
Soybean (tofu, fermented soybeans)	0.56	0.11	−0.04
Orange	0.54	−0.12	0.34
Other fruits	0.54	−0.13	0.39
Fresh juice	0.13	0.13	0.37
Confectioneries	0.26	0.16	0.17
Green tea	0.28	0.02	0.04
Black tea	0.03	0.09	0.37
Coffee	0.05	0.13	0.18
Chinese tea	0.01	0.04	0.25
Variance explained (%)	12.8	7.1	6.3

*Absolute values <−0.3 or >0.3 are underlined.

black tea, and negatively loaded on rice. These three dietary patterns explained 26.1% of the variance.

Table 2 compares the characteristics of participants according to the quartiles of each dietary pattern score. Participants with a higher Japanese pattern score were less likely to be male, to be current smokers and drinkers, and to suffer from psychological distress. Additionally, participants with a higher Japanese pattern score were more likely to have ≥19 years of education, to walk ≥1 h/d, and to have greater intake of energy and protein. Conversely, participants with a higher animal food pattern score were more likely to be male, to be current smokers and drinkers. Additionally, participants with a higher animal food pattern score were more likely to walk ≥1 h/d, to have better motor function, and to have greater intake of energy and protein, and were less likely to suffer from psychological distress and to have ≥19 years of education. Participants with a high dairy pattern score tended to be female, and were similar to those with a higher Japanese dietary pattern score except for psychological distress, time spent walking, and intake of energy and protein.

The association between the dietary patterns and functional disability, along with HRs and associated 95% CIs, are shown in Table 3. We found that a higher Japanese pattern score was inversely associated with the incident risk of functional disability (p trend <.001 in Model 3). This inverse association did not differ between the sexes (p = .057 for interaction with sex; data not shown). On the other hand, the animal food pattern and the high dairy pattern were not significantly associated with functional disability in any of the models.

Even when we set stricter criteria for disability (basic activities of daily living impairment), the results for the

Table 2. Baseline Characteristics According to Dietary Pattern Score Quartiles (n = 14,260)

Characteristics	Dietary Pattern Score Quartiles			
	1 (Low)	2	3	4 (High)
Age (y), mean (*SD*)				
Japanese pattern	74.0 (6.3)	73.7 (5.9)	73.6 (5.8)	74.3 (5.8)
Animal food pattern	74.0 (6.2)	73.9 (6.0)	73.7 (5.8)	74.0 (5.9)
High dairy pattern	74.3 (5.9)	74.2 (6.1)	73.7 (5.9)	73.4 (5.9)
Men (%)				
Japanese pattern	56.8	49.1	39.1	34.5
Animal food pattern	19.9	36.8	52.6	70.1
High dairy pattern	67.8	45.3	34.6	31.7
Education until age ≥19 y (%)				
Japanese pattern	21.6	25.8	29.2	31.7
Animal food pattern	30.3	26.6	25.5	26.1
High dairy pattern	16.2	23.4	30.0	38.7
Current smoker (%)				
Japanese pattern	20.3	15.1	10.3	7.4
Animal food pattern	6.9	11.6	15.2	19.4
High dairy pattern	21.5	12.5	10.1	9.0
Current drinker (%)				
Japanese pattern	43.2	41.2	36.1	30.2
Animal food pattern	23.4	33.4	41.1	52.2
High dairy pattern	49.6	36.2	32.9	31.9
Body mass index (kg/m^2), mean (*SD*)				
Japanese pattern	23.6 (3.5)	23.5 (3.4)	23.6 (3.3)	23.7 (3.2)
Animal food pattern	23.6 (3.4)	23.6 (3.5)	23.6 (3.2)	23.5 (3.2)
High dairy pattern	23.6 (3.3)	23.6 (3.4)	23.6 (3.4)	23.6 (3.4)
Psychological distress (%)*				
Japanese pattern	7.3	4.7	4.1	3.1
Animal food pattern	6.3	4.4	4.2	4.2
High dairy pattern	4.3	5.5	4.7	4.5
Time spent walking ≥1 h/d (%)				
Japanese pattern	24.6	24.7	28.1	31.9
Animal food pattern	23.1	26.0	28.1	32.2
High dairy pattern	31.5	26.7	26.7	24.5
Better motor function (%)†				
Japanese pattern	75.8	77.8	78.6	78.4
Animal food pattern	73.3	76.4	78.7	82.2
High dairy pattern	77.7	76.1	77.3	79.5
Energy (kcal), mean (*SD*)‡				
Japanese pattern	1,214 (395)	1,384 (366)	1,484 (365)	1,614 (374)
Animal food pattern	1,188 (301)	1,336 (322)	1,493 (344)	1,735 (409)
High dairy pattern	1,573 (436)	1,390 (393)	1,367 (379)	1,428 (368)
Protein (g), mean (*SD*)				
Japanese pattern	40.8 (12.1)	50.2 (11.3)	56.4 (11.5)	63.6 (12.2)
Animal food pattern	44.1 (11.7)	49.1 (11.7)	55.2 (11.3)	65.6 (13.1)
High dairy pattern	55.4 (14.1)	50.7 (14.6)	51.8 (14.1)	55.8 (14.1)

*Kessler six-item psychological distress scale ≥13.
†Motor function score in Kihon Checklist <3.
‡Except energy intake from alcohol drinking.

Japanese pattern score did not change. In Model 3, the multivariate HRs (95% CI) for the successive categories of the Japanese pattern score were: 1 (reference), 0.87 (0.73–1.03), 0.71 (0.59–0.86), and 0.74 (0.61–0.90) (p trend <.001; data not shown). To examine possible reverse causality, we reanalyzed the association after excluding 900 participants who experienced incident functional disability in the first 2 years of follow-up, but the results did not change substantially in Model 3 (p trend <.001; data not shown). Additionally, when we excluded participants who had any history of disease that might have affected dietary habit (stroke, myocardial infarction, diabetes, arthritis, osteoporosis, fracture, cancer, kidney disease, and hepatic disease), the results did not change substantially in Model 3 (p trend = .007; data not shown). The Japanese pattern score was also inversely associated with all-cause mortality (p trend = .028 in Model 3; data not shown).

Table 4 shows the results of incident functional disability according to the quartiles of the Japanese Diet Index Score. In this analysis, we included 514 persons who left

Table 3. Association Between Dietary Pattern Scores and Incident Functional Disability (n = 14,260)

	Dietary Pattern Score Quartiles				
	1 (Low)	2	3	4 (High)	p trend
Japanese pattern					
Number of event	711	591	522	536	
Person-years	15,159	15,649	15,948	15,999	
Model 1*	1.00 (reference)†	0.83 (0.75–0.93)	0.72 (0.64–0.81)	0.65 (0.58–0.72)	<.001
Model 2‡	1.00 (reference)	0.90 (0.80–1.00)	0.80 (0.71–0.89)	0.75 (0.67–0.84)	<.001
Model 3§	1.00 (reference)	0.91 (0.82–1.02)	0.82 (0.73–0.92)	0.77 (0.68–0.88)	<.001
Animal food pattern					
Number of event	616	620	557	567	
Person-years	15,601	15,730	15,767	15,657	
Model 1*	1.00 (reference)	1.04 (0.93–1.16)	0.97 (0.86–1.09)	1.00 (0.88–1.13)	.697
Model 2‡	1.00 (reference)	1.08 (0.96–1.21)	1.03 (0.91–1.16)	1.09 (0.96–1.23)	.313
Model 3§	1.00 (reference)	1.10 (0.98–1.23)	1.07 (0.95–1.21)	1.16 (1.02–1.31)	.053
High dairy pattern					
Number of event	615	611	558	576	
Person-years	15,502	15,618	15,905	15,730	
Model 1*	1.00 (reference)	0.96 (0.85–1.07)	0.89 (0.79–1.00)	0.98 (0.87–1.10)	.465
Model 2‡	1.00 (reference)	0.99 (0.89–1.11)	0.95 (0.84–1.07)	1.10 (0.98–1.24)	.217
Model 3§	1.00 (reference)	0.99 (0.88–1.11)	0.95 (0.84–1.07)	1.11 (0.99–1.26)	.158

*Adjusted for age (65–69, 70–74, 75–79, 80–84, and ≥85 y) and sex.

†HR (95% CI).

‡Adjusted for model 1 + history of disease (stroke, myocardial infarction, hypertension, arthritis, osteoporosis, fracture [yes, no]), educational level (age when last graduation of school <16, 16–18, ≥19 y, missing), smoking (never, former, current, missing), alcohol drinking (never, former, current, missing), body mass index (in kg/m^2: <18.5, 18.5–24.9, ≥25.0, missing), psychological distress score (<13, ≥13, missing), time spent walking (<30 min/d, 30 min to 1 h/d, ≥1 h/d, missing), and motor function score (<3, ≥3, missing).

§Adjusted for model 2 + tertile categories of energy intake and protein intake (sex-specific tertile, missing).

Table 4. Confirmatory Factor Analysis: Association Between Japanese Diet Index Score and Incident Functional Disability (n = 10,148)

	Japanese Diet Index Score (quartiles)*				
	1 (Low)	2	3	4 (High)	p trend
Index score	<4	4	5	≥6	
Number of event	374	333	374	481	
Person-years	9,793	9,293	10,661	15,261	
Model 1†	1.00 (reference)‡	0.88 (0.76–1.02)	0.82 (0.71–0.94)	0.72 (0.63–0.83)	<.001
Model 2§	1.00 (reference)	0.92 (0.79–1.07)	0.87 (0.76–1.01)	0.77 (0.67–0.88)	<.001
Model 3‖	1.00 (reference)	0.94 (0.81–1.09)	0.90 (0.77–1.05)	0.79 (0.68–0.92)	.002

*Index score was constituted by nine food items that reported to have higher absolute factor scores for the traditional Japanese pattern. For each of the seven positive components (rice, miso soup, seaweeds, pickles, green and yellow vegetables, fish, and green tea), participants received 1 point if their intake was more than or equal to the sex-specific median. For each of the two negative components (beef and pork and coffee), participants received 1 point if their intake was below the sex-specific median.

†Adjusted for age (65–69, 70–74, 75–79, 80–84, and ≥85 y) and sex.

‡HR (95% CI).

§Adjusted for model 1 + history of disease (stroke, myocardial infarction, hypertension, arthritis, osteoporosis, fracture [yes, no]), educational level (age when last graduation of school <16, 16–18, ≥19 y, missing), smoking (never, former, current, missing), alcohol drinking (never, former, current, missing), body mass index (in kg/m^2: <18.5, 18.5–24.9, ≥25.0, missing), psychological distress score (<13, ≥13, missing), time spent walking (<30 min/d, 30 min to 1 h/d, ≥1 h/d, missing), and motor function score (<3, ≥3, missing).

‖Adjusted for model 2 + tertile categories of energy intake and protein intake (sex-specific tertile, missing).

blank more than 24 items on the FFQ and then excluded 4,626 persons for whom data on items of the Japanese Diet Index Score were missing (10,148 persons were included in the analysis). We found a significant inverse association between the Japanese Diet Index Score and functional disability (p trend = .002 in Model 3).

Discussion

In this population-based cohort study, we identified three dietary patterns derived by factor analysis among the Japanese population: the Japanese pattern, animal food pattern, and high dairy pattern, which were consistent with our previous study using the same FFQ, except for the third pattern because in the present study the volume of alcohol consumption was not available (6). The Japanese pattern was associated with a decreased risk of incident functional disability. No apparent association was observed for either the animal food pattern or the high dairy pattern. To our knowledge, this is the first study to have proved the association between the Japanese dietary pattern and incident risk of functional disability.

Our study had a number of strengths: (i) it was a large population-based cohort study of 14,260 persons; (ii) it had a follow-up rate of almost 100%; (iii) many confounding factors were taken into account.

We also considered the effects of reverse causality. Even after excluding individuals who experienced incident functional disability in the first 2 years of follow-up, the strong inverse association between the Japanese pattern and functional disability persisted. The earlier findings suggest that the present results are unlikely to be explained by reverse causality.

This inverse association between the Japanese pattern and functional disability was consistent with previous studies of the Mediterranean diet and Healthy Eating Index (11–16). The Japanese pattern has some characteristics in common with the Mediterranean diet, for instance, high intake of vegetables, fruits, legumes, and fish, and low intake of meat and dairy products (4,37). Thus, the mechanism of this association might be similar to that reported in the previous studies of the Mediterranean diet. On the other hand, the Healthy Eating Index pattern in three previous studies may not be fully consistent with Japanese pattern because meat, but not fish, was recommended in the Healthy Eating Index. Furthermore, vegetables, fruits, and legumes are common components of the above three patterns. Previous studies have reported that a plant-based diet reduces cardiovascular risk, type 2 diabetes, and bone loss (37–42). Although a diet consisting only of plant-based foods may lack certain nutrients (42), a dietary pattern including an abundant amount of these plant-based items may decrease the risk of functional disability.

On the other hand, the Japanese pattern is reported to differ from the Mediterranean diet in that energy intake is lower (43). The Japanese pattern score was positively correlated with energy intake (Table 2), but the results did not change substantially even when energy intake and body mass index were added in the multivariate model. The inverse association seems difficult to explain in terms of energy intake alone, and micronutritional components might have a role. Because the Japanese pattern included a variety of foods that explained 12.8% of the overall variance, this pattern may contain various micronutritional components and have a good nutrient balance.

In the present study, we used two different dietary pattern derivation methods to strengthen the reliability of our results. When we repeated the analysis by using confirmatory factor analysis, higher conformity with the Japanese Diet Index Score was also associated with a decreased risk of incident functional disability. Because these factors in the Japanese Diet Index Score were based on nationwide validity studies of dietary pattern, the Japanese Diet Index Score may represent the most common diet items in Japanese population. However, the Japanese diet also varies in several aspects according to region. For example, residents of Okinawa, who are known for their longer average life expectancy, often eat the traditional Okinawan diet that includes unique food items such as bitter melon, mugwort, and turmeric (44).

Additionally, in the analysis using each item from the Japanese Diet Index Score as an exposure variable (dichotomous variable by sex-specific median), a significant inverse association was observed for items other than fish and vegetables (data not shown). These results suggested that traditional Japanese foods were also associated with a decreased risk of incident functional disability. Previous studies have also examined the health impact of individual Japanese foods and their nutritional components, including soybeans (as well as miso soup), seaweed, and green tea (45–49).

This study had several limitations. First, we did not investigate the causes of functional disability in participants who received LTCI certification. Thus, the mechanism responsible for reduction of functional disability by intake of a Japanese diet remained unidentified. Second, not all potential confounding factors were considered, as we used only indirect measures of physical and cognitive function for adjustment. Third, because not all candidates applied for LTCI certification, this study may not have been completely free from detection bias. The degree of this bias remains to be verified.

In conclusion, the findings of this cohort study indicate that higher conformity with the Japanese dietary pattern is significantly associated with a lower risk of incident functional disability. This result suggests that the Japanese dietary pattern contributes to extended healthy life expectancy.

Supplementary Material

Supplementary material can be found at: http://biomedgerontology.oxfordjournals.org/

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Conflict of Interest

There are no potential conflicts of interest that relate to the manuscript.

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Relationships between changes in time spent walking since middle age and incident functional disability

Wan-Ting Chou *, Yasutake Tomata, Takashi Watanabe, Yumi Sugawara, Masako Kakizaki, Ichiro Tsuji

Division of Epidemiology, Department of Public Health and Forensic Medicine, Tohoku University Graduate School of Medicine, Japan

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ABSTRACT

Objective. To examine the relationship between changes in time spent walking since middle age and incident functional disability.

Method. In 2006, we conducted a prospective cohort study of 7177 disability-free Japanese individuals aged ≥65 years who lived in Ohsaki City, Miyagi Prefecture, Japan. Participants were categorized into four groups according to changes in time spent walking based on two questionnaire surveys conducted in 1994 and in 2006. Incident functional disability was retrieved from the public Long-term Care Insurance database, and the subjects were followed up for 5 years. The Cox proportional hazards model was used to investigate the association between changes in time spent walking and the risk of incident functional disability.

Results. Compared with subjects who remained sedentary, the multivariate-adjusted hazard ratios (95% confidence intervals) were 0.69 (0.49–0.98) among those who became active and 0.64 (0.50–0.82) among those who remained active. These results did not alter when analyses were stratified by gender, age and motor function status.

Conclusion. An increase in time spent walking among sedentary adults is significantly associated with a lower risk of incident functional disability.

Introduction

Physical activity is a well-known modifiable behavior associated with lower risks of mortality (Haskell et al., 2009; Leitzmann Mf, 2007; Nelson et al., 2007; Wagner and Brath, 2012; Wen et al., 2011). In addition to keeping physically active, increasing physical activity is also known to be beneficial in terms of cardiovascular risk and longevity (Aadahl et al., 2009; Balboa-Castillo et al., 2011; Gregg et al., 2003; Petersen et al., 2012; Schnohr et al., 2003; Talbot et al., 2007; Wannamethee et al., 1998). Previous longitudinal studies have shown that, in comparison with individuals who remain sedentary, those who increase their physical activity have a total mortality risk reduction of more than 40% (Balboa-Castillo et al., 2011; Gregg et al., 2003; Schnohr et al., 2003; Wannamethee et al., 1998).

In countries with rapidly aging populations, such as Japan, the health and economic impacts of disability have been attracting increasing attention (Fried et al., 2001). Disability is the endpoint of the disablement process, which includes four distinct but correlated concepts: active pathology, impairment, functional limitation, and disability (Nagi, 1991). According to the Nagi's disablement model, functional limitation is a limitation in performance at the level of the whole organism or person, which includes motor dysfunction; disability is an inability or limitation in performing socially defined roles and tasks expected of an individual within a sociocultural and physical environment. During the disablement process, not only physical inactivity could be a predisposing risk factor, but changes in physical behavior may avoid, retard or reverse the outcomes (Verbrugge and Jette, 1994). However, data are limited regarding the effects of changes in physical activity on disability or functional status. One study of older American women has shown that in comparison with women who remained inactive after middle age, those who remained active or became active had fewer difficulties with activities of daily living (ADL), better scores in the Physical Performance Test, and faster walking speeds (Brach Js, 2003). Another two recent studies have also observed that increasing physical activity from middle age was associated with a lower disability score in old age (Berk et al., 2006; Gretebeck et al., 2012). Otherwise, the British Regional Heart Study has also shown that in comparison with men who had remained inactive, those who became active or remained active had a lower risk of mobility limitation (Wannamethee et al., 2005).

However, those studies mostly employed self-reported endpoints (Berk et al., 2006; Gretebeck et al., 2012; Wannamethee et al., 2005), and some had small numbers of participants (Berk et al., 2006; Brach Js, 2003); furthermore, none of them measured the incidence of disability. In Japan, Long-term Care Insurance (LTCI) certification of requiring assistance with ADL, based on a nationally uniform standard of functional disability, has been frequently used in previous epidemiological

Abbreviations: ADL, activities of daily living; LTCI, Long-term Care Insurance.

* Corresponding author at: Division of Epidemiology, Department of Public Health and Forensic Medicine, Tohoku University Graduate School of Medicine, 2-1 Seiryo-machi, Aoba-ku, Sendai, 980-8575, Japan. Fax: +81 22 717 8125.
E-mail address: cutewenty@gmail.com (W.-T. Chou).

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