総合機能評価の項目は、身長・体重、既往歴・抑うつ・認知機能・生活習慣等に関する自記式アンケートや、面接調査、運動機能の測定や採血である。このうち研究非同意者、要介護認定追跡調査の非同意者、ベースライン時点で要介護認定を受けていた者、睡眠に関する質問に欠損のあった者を除外した820名（男性女性）を追跡対象とした。

追跡は、介護保険の被保険者名簿との照合により行った。仙台市に介護保険閲覧に関する同意書の写を提出した上で本研究における個人情報の保護状況について報告し、介護保険の利用状況に関する情報提供を依頼し、平成21年6月末までの要支援・要介護認定の有無、要介護状態区分および初回認定年月日について情報の提供を受けている。被保険者名簿から離脱した場合、離脱年月日および理由（死亡、転居）についても調査した。

2）倫理面への配慮

本研究は東北大学医学部倫理委員会の承認のもとに行われている。

3）調査項目

自記式アンケートの起床時間、就寝時間より、夜間睡眠時間を算出し、日中睡眠時間と夜間睡眠時間を合計し、1日の総睡眠時間とした。

4）エンドポイント

初回の要介護認定（要支援以上）または死亡をエンドポイントをとした。

5）分析方法

要介護認定・死亡リスクはCox比例ハザードモデルを用いて算出した。①総睡眠時間6時間以下群を基準とした7時間、8時間以上群、②夜間睡眠時間6時間以下群を基準とした7時間、8時間以上群、③日中睡眠無し群を基準とした有り群の多変量調整ハザード比（HRs）と95%信頼区間（CIs）を算出した。

共変量は年齢、身体機能、抑うつ、認知機能、夜間尿回数、不眠、婚姻状況、body mass index (BMI)、主観的健康度、痛み、ストレス、喫煙状況、飲酒状況、就業状況、睡眠薬使用、脳卒中・高血圧・心筋梗塞・がん・肺炎・糖尿病・消化器潰瘍・関節炎・骨粗鬆症・高脂血症の各疾患既往とし、夜間睡眠時間についてハザード比を算出する際は日中睡眠の有無を、日中睡眠時間の有無についてハザード比を算出する際は夜間睡眠時間も共変量として投入した。

すべての解析は、統計ソフトSAS Version 9.1 (SAS Inc, Cary NC)を用いた。

C．研究結果

1）基本特性

対象者の基本特性を表1に示す。解析対象者820名のうち、男性は391名、女性は429名であった。総睡眠時間が8時間以上の群においては、男女とも夜間尿回数が2回以上の者、日中睡眠有りの者、不眠症状のある者が多い傾向にあった。女性では身体機能に制限がある者、MMSE得点が24点未満の者、うつ症状がある者が多い傾向にあった。

2）睡眠と介護認定・死亡リスクとの関連

表2に、睡眠と要介護認定・死亡リスクとの関連についての結果を示す。

男性では、1日の総睡眠時間、夜間睡眠時間が長くなるほど、要介護認定・死亡リスクが上昇することが示されたが、男性において日中睡眠の有無と要介護認定・死亡リスクとの関連は示されなかった。一方女性では、1日の総睡眠時間、夜間睡眠時間と要介護認定・死亡リスクとの関連は見られなかったが、日中睡眠有り群において要介護認定・死亡リスクの有意な上昇が示された。

男性では、1日の総睡眠時間、夜間睡眠時間と要介護認定・死亡リスクとの関連は、アウトカムを要介護認定のみ、要介護度2以上のみ、死亡のみに限った場合においても同様であった。一方女性では、日中睡眠の有無と要介護認定・死亡リスクとの関連は、要介護認定のみの場合は日中睡眠有り群でリスクの上昇が見られたものの、要介護度2以上、死亡のみのリスクに上昇は見られなかった。

表１　１日の総睡眠時間別の基本特性

	男性			女性		
総睡眠時間（時間／日）	≤6	7	≥8	≤6	7	≥8
対象者数	93	122	176	116	142	171
平均年齢（年、SD）	74.6 (3.98)	74.3 (3.17)	75.3 (4.71)	75.3 (4.37)	75.2 (4.50)	75.9 (5.09)
平均BMI (kg/m^2、SD)	24.1 (3.38)	24.0 (3.23)	24.0 (3.02)	24.5 (3.43)	24.4 (3.39)	23.9 (3.79)
疾患既往歴（%）						
脳卒中	2.2	8.2	5.1	0.9	0.7	2.9
高血圧	45.2	46.7	44.3	36.2	38.7	38.6
心筋梗塞	10.8	12.3	15.9	6.9	8.5	6.4
がん	4.3	10.7	14.2	8.6	7.0	5.9
肺炎	10.8	11.5	8.5	5.2	9.2	9.4
糖尿病	23.7	19.7	13.6	11.2	12.7	12.9
胃潰瘍	30.1	25.4	27.3	17.2	12.7	13.5
関節炎	6.5	11.5	13.1	27.6	17.6	22.2
骨粗しょう症	4.3	1.6	3.4	24.1	21.1	25.2
高脂血症	22.6	21.3	19.9	31.9	33.8	32.2
職業有り（%）	21.5	13.9	11.4	4.3	2.8	3.5
既婚者（%）	87.1	92.6	89.8	41.4	56.4	44.4
飲酒習慣（%）						
非飲酒者	12.9	18.9	15.3	53.5	60.6	57.3
過去飲酒者	15.1	12.3	14.8	5.2	6.3	9.4
現在飲酒者	71.0	68.9	69.3	24.1	17.6	17.5
喫煙状況（%）						
非喫煙者	25.8	21.3	18.2	86.2	90.1	88.9
過去喫煙者	58.1	57.4	62.5	9.5	2.8	6.4
現在喫煙者	16.1	20.5	19.3	1.7	2.8	2.9
自覚的ストレスが高い者（%）	11.8	7.4	9.1	14.7	12.0	18.7
主観的健康度が悪い者（%）	7.5	13.9	11.9	16.5	11.3	18.3
身体機能に制限がある者（%）	8.6	13.9	12.5	24.1	19.7	31.8
夜間尿回数2回以上（%）	44.1	50.8	58.5	37.1	35.9	48.0
MMSE得点24点未満（%）	1.1	3.3	2.9	1.7	2.2	8.8
うつ症状あり（GDS10点以上、%）	15.2	21.3	16.6	30.4	21.4	38.7
日中睡眠あり（%）	28.0	32.8	48.3	30.2	26.8	52.1
身体の痛みあり（%）	8.7	9.8	17.8	22.1	15.9	21.1
睡眠薬または安定剤の使用者（%）	8.8	18.9	11.4	23.9	16.9	22.5
不眠症状あり（%）	12.9	19.7	22.7	12.9	19.7	22.7
いびきあり（%）	3.2	1.6	4.0	3.2	1.6	4.0

D．考　察

本研究は、地域在住の高齢者において、１日の睡眠時間、夜間睡眠時間、日中睡眠の有無と要介護認定・死亡リスクを明らかにした初めての前向きコホート研究である。睡眠時間が長い者、日中睡眠がある者で死亡リスクが上昇するという先行研究は、すでにいくつかのコホートにおいて示されており、本研究の結果はこれらの先行研究の結果と一致している。

しかし本研究においては、男性では１日の総睡眠時間、夜間睡眠時間と要介護認定・死亡リスクとの関連が示され、女性では日中睡眠と要介護認定・死亡リスクとの関連が示されるという、性別により異なる結果が示された。これは、性別によって要介護認定の原疾患が異なることがひとつの原因として考えられる。しかしながら本研究においては、要介護認定の原疾患の情報は得られていないため、睡眠と要介護認定・死亡リスクとの関連に、要介護認定の原疾患がどのように影響を及ぼしているか不明である。

また、基本特性では男女とも、総睡眠時間が長い者で夜間尿回数が２回以上の者、日中睡眠有りの者、不眠症状がある者が多い傾向にあったため、これらの要因について層別化解析を行った。夜間尿回数、不眠症状では結果に違いは

表２　１日の総睡眠時間、夜間睡眠時間、日中睡眠の有無と要介護認定・死亡リスク

	人年	要介護認定・死亡リスク イベント数	HRs	95% CIs	要介護認定リスク イベント数	HRs	95% CIs	要介護度２以上のリスク イベント数	HRs	95% CIs	死亡リスク イベント数	HRs	95% CIs
男性													
１日の総睡眠時間[a]													
6時間以下	504	14	1.00	(reference)	9	1.00	(reference)	10	1.00	(reference)	3	1.00	(reference)
7時間	634	32	1.90	(0.96-3.78)	24	1.99	(0.86-4.63)	22	1.72	(0.74-4.01)	15	1.89	(0.74-4.86)
8時間以上	869	59	2.25	(1.20-4.24)	42	2.08	(0.95-4.55)	37	1.91	(0.88-4.16)	29	2.39	(0.99-5.76)
P for trend[b]			0.0005			0.002			0.05			0.01	
夜間睡眠時間[c]													
6時間以下	584	19	1.00	(reference)	13	1.00	(reference)	12	1.00	(reference)	9	1.00	(reference)
7時間	720	34	1.42	(0.77-2.61)	15	1.36	(0.65-4.04)	26	1.77	(0.83-3.78)	18	1.84	(0.77-4.38)
8時間以上	704	52	2.17	(1.22-3.83)	27	2.01	(1.00-4.04)	31	1.95	(0.93-4.80)	25	2.54	(1.09-5.95)
P for trend[b]			0.0009			0.004			0.14			0.02	
日中睡眠[d]													
無	1,250	59	1.00	(reference)	42	1.00	(reference)	39	1.00	(reference)	28	1.00	(reference)
有	757	46	1.13	(0.72-1.76)	33	1.08	(0.62-1.88)	30	1.20	(0.69-2.06)	24	1.20	(0.69-2.06)
女性													
１日の総睡眠時間[a]													
6時間以下	592	38	1.00	(reference)	37	1.00	(reference)	16	1.00	(reference)	3	1.00	(reference)
7時間	711	42	1.00	(0.62-1.60)	38	0.93	(0.57-1.52)	19	0.87	(0.41-1.81)	8	1.43	(0.31-6.62)
8時間以上	781	63	0.94	(0.60-1.48)	59	0.93	(0.58-1.49)	27	0.75	(0.36-1.58)	10	0.94	(0.20-4.39)
P for trend[b]			0.14			0.99			0.69			0.95	
夜間睡眠時間[c]													
6時間以下	693	50	1.00	(reference)	48	1.00	(reference)	18	1.00	(reference)	4	1.00	(reference)
7時間	735	44	0.97	(0.62-1.53)	41	0.96	(0.60-1.54)	20	0.96	(0.46-1.99)	9	1.22	(0.30-4.98)
8時間以上	655	49	0.75	(0.47-1.19)	45	0.73	(0.45-1.18)	24	0.95	(0.46-1.97)	8	0.64	(0.14-2.95)
P for trend[b]			0.08			0.008			0.73			0.69	
日中睡眠[d]													
無	1,371	77	1.00	(reference)	70	1.00	(reference)	40	1.00	(reference)	11	1.00	(reference)
有	713	70	1.60	(1.12-2.29)	64	1.65	(1.14-2.38)	22	0.80	(0.45-1.44)	10	1.08	(0.32-3.64)

[a, c, d]多変量調整ハザード比：年齢、身体機能、抑うつ、認知機能、夜間尿回数、不眠、婚姻状況、body mass index (BMI)、主観的健康度、痛み、ストレス、喫煙状況、飲酒状況、就業状況、睡眠薬使用、脳卒中・高血圧・心筋梗塞・がん・肺炎・糖尿病・消化器潰瘍・関節炎・骨粗鬆症・高脂血症の各疾患既往、日中睡眠の有無[c]または夜間睡眠時間[d]で調整

[b]総睡眠時間または夜間睡眠時間を連続変量として投入し、算出

なかったものの、日中睡眠有り群では、男性において１日の総睡眠時間８時間以上群、夜間睡眠時間８時間以上群において、日中睡眠なし群と比較して要介護認定・死亡リスクが高い傾向にあった。また、睡眠時間８時間以上群とそうでない群で層別化解析を行った結果、女性において夜間睡眠時間８時間以上の群で日中睡眠有り群の要介護認定・死亡リスクが高い傾向が見られた。

このことから、１日の総睡眠時間、夜間睡眠時間、日中睡眠の有無と要介護認定・死亡リスクとの関連は、男女によって結果が異なるものの、夜間睡眠時間、日中睡眠双方を含む１日の総睡眠時間だけではなく、夜間睡眠時間、日中睡眠の有無それぞれが密接に関連している可能性が示唆される。

今回は要介護認定・死亡リスクのみの層別化解析の結果を示したが、今後は要介護認定のみのリスク、要介護度２以上のリスク、死亡リスクにおいても、夜間睡眠時間、日中睡眠時間の組み合わせがどのように影響しているかを検討し、睡眠と要介護認定・死亡リスクにどのような影響が関連しているか検討していく必要がある。

E．結　論

本研究において、男性では１日の総睡眠時間、夜間睡眠時間と要介護認定・死亡リスクとの関連が示され、女性においては日中睡眠と要介護認定・死亡リスクとの関連が示されるという、性別により異なる結果が示された。しかし、これらの関連は男性においては日中睡眠と、女性においては夜間睡眠８時間以上の者でリスクのさらなる上昇が見られ、男女ともに、夜間睡眠、日中睡眠の影響が相互に関連していることが示唆される。今後、これらの関連について更に検討を進める必要がある。

F．健康危険情報

なし

G．研究発表

１．論文発表

なし

２．学会発表

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H．知的財産権の出願・登録状況

なし

Ⅳ．研究成果の刊行に関する一覧

研究成果の刊行に関する一覧

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Association between green tea consumption and tooth loss: Cross-sectional results from the Ohsaki Cohort 2006 Study

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ABSTRACT

Objective. To examine the association between green tea consumption and tooth loss.

Methods. We analyzed cross-sectional data from the Ohsaki Cohort 2006 Study. Usable self-administered questionnaires about green tea consumption and tooth loss were returned from 25,078 persons (12,019 men and 13,059 women) aged 40 to 64 years in Japan. Multivariate logistic regression analysis was used to calculate odds ratios (ORs) for tooth loss using 3 cut-off points of 10, 20, and 25 teeth relative to each category of green tea consumption.

Results. Consumption of ≥1 cup/day of green tea was significantly associated with decreased odds for tooth loss, and the association appeared to fit a threshold model. In men, the multivariate-adjusted ORs for tooth loss with a cut-off point of <20 teeth associated with different frequencies of green tea consumption were 1.00 (reference) for <1 cup/day, 0.82 (95% CI, 0.74–0.91) for 1–2 cups/day, 0.82 (95% CI, 0.73–0.92) for 3–4 cups/day, and 0.77 (95% CI, 0.66–0.89) for ≥5 cups/day. The corresponding data for women and the results for cut-off points of 10 and 25 teeth were essentially the same.

Conclusions. The present findings indicate an association of green tea consumption with decreased odds for tooth loss.

Introduction

Tooth loss reduces masticatory ability, leading to detrimental changes in food selection. Restricted food selection may increase the risk of certain systemic diseases (Hung et al., 2003; Joshipura et al., 1996; Shimazaki et al., 2002; Willett, 1994). Therefore, prevention of tooth loss is important from the viewpoint of overall human health.

A number of experimental studies have shown that green tea has a profound suppressive effect on the activities of oral bacteria such as *Streptococcus mutans* and *Porphyromonas gingivalis* (Hamilton-Miller, 2001; Hirasawa et al., 2002, 2006; Otake et al., 1991; Sakanaka and Okada, 2004; Smullen et al., 2007; Socransky and Haffajee, 2002). The antibacterial effects of green tea are thought to be due to catechins (Hirasawa et al., 2002; Sakanaka and Okada, 2004; Smullen et al., 2007). Tea catechins inhibit acid production by oral bacteria such as *S. mutans* and exert bactericidal activity against *P. gingivalis* (Hirasawa et al., 2006; Sakanaka and Okada, 2004). These bacteria are strongly implicated in the development of dental caries and periodontal disease (Dietrich et al., 2004; Hamilton-Miller, 2001; Hirasawa et al., 2006; Sakanaka and Okada, 2004; Socransky and Haffajee, 2002), which are the main causes of tooth loss (Aida et al., 2006). Therefore, tea catechins may have potential oral health benefits, reducing the likelihood of tooth loss.

To date, however, there has been only one cross-sectional study of 1002 pregnant women on the association between green tea consumption and tooth loss (Tanaka et al., 2008), and the findings of that study must be verified by epidemiological observation of a large general population. Therefore, we conducted a cross-sectional study in Japan, where consumption of green tea is one of the highest in the world (Kuriyama et al., 2006a,b), to clarify the above association.

Methods

Study sample

We analyzed cross-sectional data from a baseline survey conducted for the Ohsaki Cohort 2006 study. The details of this cohort have been reported elsewhere (Kuriyama et al., 2009). In brief, we delivered a self-administered questionnaire to all 46,407 residents aged 40 to 64 years, who were included in the Residential Registry for Ohsaki City, Miyagi Prefecture, northeastern Japan, as of December 1, 2006. The survey was conducted from December 1 to 15, 2006. The questionnaire consisted of 15 items: history of diseases, family history of diseases, physical health status during the last year, smoking habit, drinking habit, dietary habits, occupation or education, body weight and height, health status during the last month, exercise, psychological distress, social support, participation in community activities, and dental status, plus reproductive history for women. The questionnaire

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was distributed by the heads of individual administrative districts to individual households and collected by mail. Since 409 subjects were found to have died, moved out of the area, in hospital, or absent for a prolonged period, the questionnaire could not be distributed to them. Among 45,998 eligible individuals, 26,512 responded, giving a response rate of 57.6%. We considered the return of self-administered questionnaires signed by the subjects to imply their consent to participate in the study. The study protocol was approved by the Ethics Committee of Tohoku University Graduate School of Medicine.

Of the 26,512 individuals, we excluded 1434 who did not provide answers to the items on green tea consumption and the number of retained teeth. A final total of 25,078 persons (12,019 men and 13,059 women) were included the present analysis.

Measurement

Dietary intake was assessed using a self-administered food frequency questionnaire (FFQ). In this questionnaire, we asked participants to report their frequency of recent consumption of 40 food and beverage items. The questionnaire provided 5 categories of response to describe the participant's frequency of green tea consumption: never, occasionally, 1–2 cups/day, 3–4 cups/day, and ≥5 cups/day. The volume of a typical cup of green tea was 100 ml in the study region (Kuriyama et al., 2006a). We conducted a validation study of the FFQ, in which 113 participants provided four 3-day dietary records within a period of 1 year and subsequently responded to the questionnaire (Ogawa et al., 2003). The results showed that the Spearman rank coefficient for the correlation between the amounts of green tea consumed according to the questionnaire and the amounts consumed according to the records was 0.71 for men and 0.53 for women; the correlation between consumption measured by the 2 questionnaires administered 1 year apart was 0.63 for men and 0.64 for women. Since only 5.2% of the participants said they never drank green tea, data from participants who never and occasionally drank green tea were collapsed into the single category of <1 cup/day for the purpose of our analysis.

We assessed the number of teeth using the self-administered questionnaire, which was structured with categorical responses: none (zero teeth), few (1–9 teeth), nearly half (10–19 teeth), most (20–24 teeth), almost all (25–27 teeth), or all (28 teeth). We did not take third molars into account. Because there are no specific markers for tooth loss, we used 3 cut-off points to conduct our analyses. The initial cut-off point was <10 teeth, a category including 0–9 teeth, the second was <20 teeth, a category including 0–19 teeth, and the third was <25 teeth, a category including 0–24 teeth.

Statistical analyses

To determine the relationship between green tea consumption and tooth loss, we used logistic regression analyses to derive adjusted odds ratios (ORs). The main independent variables were the levels of green tea consumption. Odds for tooth loss were calculated by dividing the number of persons with a low number of teeth by the number of persons with a high number of teeth. The ORs were computed as the odds among subjects in each green tea consumption category divided by the odds among subjects in the "<1 cup/day" category. The ORs and 95% confidence intervals (CIs) were estimated using SAS Version 9.1 (SAS Institute Inc., 2004). All statistical tests are two-sided. Differences at $P<0.05$ were accepted as statistically significant.

We considered the following variables as potential confounders: age (40–44, 45–49, 50–54, 55–59, or 60–64 years), the number of times teeth were brushed per day (<2, 2, or >2 times/day), years of education (<10, 10–12, or ≥13 years), body mass index calculated with self-reported weight and height (<18.5, 18.5–22.9, 23.0–24.9, 25.0–29.9, or ≥30.0 kg/m^2), time spent walking (<1 or ≥1 h/day), history of stroke, myocardial infarction, diabetes mellitus, cancer (for each disease, yes or no), smoking status (never, former, currently smoking 1–19 cigarettes/day, or currently smoking ≥20 cigarettes/day), alcohol drinking (never, former, or current), weekly consumption of sweets such as *manju* (a steamed bean-jam bun), *yokan* (sweetened and jellied bean paste), or cake (<3 or ≥3 times/week), daily dietary consumption of *miso* (soybean paste) soup, soybean products, milk (for each food, almost everyday or not), oolong tea, black tea, and coffee (for each beverage, <1, 1–2, 3–4, or ≥5 cups/day), daily consumption of total fish, which was categorized into quartile by sex, daily consumption of total calories, which was also categorized into quartiles by sex, and the details were given as follows: the intake of total calories was calculated from daily rice consumption, daily *miso* soup consumption, daily consumption of green tea, oolong tea, black tea, or coffee, alcohol consumption, and FFQ using the *Standard Tables of Food Composition* published by the Science and Technology Agency of Japan. The confounders were selected for their relationship to green tea consumption and tooth loss (Bahekar et al., 2007; Elter et al., 2003; Hanioka et al., 2007; Heitmann and Gamborg, 2008; Klein et al., 2004; Okamoto et al., 2006; Pischon et al., 2007; Pitiphat et al., 2003; Susin et al., 2005; Tu et al., 2007).

We also estimated ORs for tooth loss for other beverages such as oolong tea and coffee for the cut-off point of <20 teeth, since the results for green tea consumption revealed that ORs for tooth loss were similar at each cut-off point. We calculated ORs for tooth loss stratified by coffee consumption with or without sugar or syrup since adding sugar or syrup to coffee is widespread in Japan. In the stratified analyses we excluded participants who never consumed coffee, since they were included in each reference group. We did not estimate ORs for black tea consumption since the number of persons who consumed black tea was extremely small.

Results

Baseline characteristics of the participants are shown in Tables 1 and 2 for men and women, respectively. Men consuming more cups of green tea tended to be older, brush their teeth more often, have a higher calorie intake, and consume more sweets, *miso* soup, and soybean products, but they were less likely to consume coffee. They showed a higher prevalence of chronic diseases such as stroke, myocardial infarction, or cancer. Women consuming green tea more often tended to be older, have a higher calorie intake, and consume more *miso* soup, soybean products, and total fish, but they were less likely to consume coffee. They also showed a higher prevalence of chronic diseases such as myocardial infarction, diabetes mellitus, or cancer. Women who drank no alcohol were less likely to consume a higher number of cups of green tea.

Table 3 shows the ORs of tooth loss with the 95% CIs. We found that consumption of ≥1 cup/day of green tea was significantly associated with decreased odds for tooth loss in both the age-adjusted and multivariate-adjusted ORs. The association appeared to fit a threshold model. In men, the multivariate-adjusted ORs for tooth loss at the <20 teeth cut-off point associated with different frequencies of green tea consumption were 1.00 (reference) for <1 cup/day, 0.82 (95% CI, 0.74–0.91) for 1–2 cups/day, 0.82 (95% CI, 0.73–0.92) for 3–4 cups/day, and 0.77 (95% CI, 0.66–0.89) for ≥5 cups/day (P for trend <0.0001). The corresponding data for women were 1.00, 0.87 (95% CI, 0.78–0.97), 0.87 (95% CI, 0.77–0.98), and 0.89 (95% CI, 0.78–1.01), respectively (P for trend = 0.011). The results for the cut-off points of <10 teeth and <25 teeth were essentially the same as those for the <20 teeth cut-off point. Since we found a threshold association, we conducted additional analysis at the <20 teeth cut-off point, categorizing the green tea consumption level into two groups (<1 cup/day versus ≥1 cup/day). The multivariate-adjusted ORs for men and women were 0.81 (95% CI, 0.74–0.89) and 0.87 (95% CI, 0.79–0.96), respectively.

Table 4 presents the ORs of tooth loss for oolong tea. We found an inverse dose–response relationship, rather than a threshold relationship, for oolong tea consumption with tooth loss.

Table 5 shows the ORs of tooth loss for coffee consumption. We found that higher coffee consumption was significantly associated with increased odds for tooth loss in both age-adjusted and multivariate-adjusted ORs. In women, analyses stratified by addition of sugar or syrup exhibited a pronounced increase of ORs for tooth loss due to sugar or syrup, while ORs for coffee consumption in men were almost unchanged, irrespective of addition of sugar or syrup.

Discussion

Our findings showed that green tea consumption was significantly associated with decreased odds for tooth loss.

Table 1
Baseline characteristics of men according to green tea consumption (December 2006, Ohsaki City, Miyagi Prefecture, Northeastern Japan).[a]

Characteristics	Green tea consumption, cups/day				
	<1 ($n=4108$)	1–2 ($n=4180$)	3–4 ($n=2395$)	≥5 ($n=1336$)	*P*-value[b]
Total number of teeth					
0–9	428 (10.4)	356 (8.5)	223 (9.3)	154 (11.5)	<0.0001
10–19	894 (21.8)	770 (18.4)	477 (19.9)	263 (19.7)	
20–24	1283 (31.2)	1352 (32.3)	797 (33.3)	425 (31.8)	
≥25	1503 (36.6)	1702 (40.7)	898 (37.5)	494 (37.0)	
Age, mean (SD), years	52.2 (6.7)	52.7 (6.5)	54.7 (6.5)	56.0 (6.3)	<0.0001
Daily tooth brushing					
<2 times/day	1925 (47.4)	1745 (42.0)	955 (40.2)	574 (43.5)	<0.0001
2 times/day	1716 (42.2)	1826 (44.0)	1066 (44.9)	533 (40.4)	
>2 times/day	424 (10.4)	582 (14.0)	356 (15.0)	213 (16.1)	
Years of education					
<10	442 (11.1)	342 (8.4)	252 (10.8)	181 (14.0)	<0.0001
10–12	2388 (59.9)	2473 (60.6)	1356 (58.1)	748 (57.7)	
≥13	1158 (29.0)	1265 (31.0)	727 (31.1)	367 (28.3)	
Body mass index, kg/m^2					
<18.5	108 (2.7)	78 (1.9)	49 (2.1)	30 (2.3)	0.0001
18.5–22.9	1554 (38.2)	1502 (36.2)	897 (37.7)	492 (37.2)	
23.0–24.9	1009 (24.8)	1115 (26.9)	641 (26.9)	394 (29.8)	
25.0–29.9	1220 (30.0)	1299 (31.3)	734 (30.8)	372 (28.1)	
≥30.0	176 (4.3)	156 (3.8)	61 (2.6)	36 (2.7)	
Time spent walking, h/day					
<1	2689 (66.5)	2881 (69.9)	1632 (69.4)	843 (64.7)	0.0002
≥1	1355 (33.5)	1238 (30.1)	721 (30.6)	461 (35.4)	
History of chronic disease					
Stroke	55 (1.3)	60 (1.4)	36 (1.5)	25 (1.9)	0.57
Myocardial infarction	51 (1.2)	55 (1.3)	33 (1.4)	27 (2.0)	0.19
Diabetes mellitus	323 (7.9)	338 (8.1)	223 (9.3)	121 (9.1)	0.14
Cancer	85 (2.1)	99 (2.4)	71 (3.0)	50 (3.7)	0.0033
Smoking status					
Never	617 (15.3)	757 (18.3)	449 (19.1)	248 (19.0)	<0.0001
Former	1205 (29.8)	1419 (34.4)	842 (35.7)	437 (33.5)	
Current, 1–19 cigarettes/day	586 (14.5)	535 (13.0)	289 (12.3)	151 (11.6)	
Current, ≥20 cigarettes/day	1633 (40.4)	1418 (34.3)	776 (32.9)	469 (35.9)	
Alcohol drinking					
Never	596 (14.7)	494 (11.9)	310 (13.1)	206 (15.6)	<0.0001
Former	287 (7.1)	232 (5.6)	138 (5.8)	104 (7.9)	
Current	3182 (78.3)	3418 (82.5)	1924 (81.1)	1007 (76.5)	
Consumption of sweets (such as *manju*[c], *yokan*[d] or cake)					
<3 times/week	3240 (80.5)	3234 (79.1)	1790 (76.2)	925 (71.3)	<0.0001
≥3 times/week	785 (19.5)	854 (20.9)	558 (23.8)	373 (28.7)	
Daily consumption					
Miso (soybean paste) soup[e]	2875 (70.0)	3227 (77.2)	1937 (80.9)	1102 (82.6)	<0.0001
Soybean products[e]	1182 (29.4)	1470 (35.9)	1035 (43.8)	658 (50.0)	<0.0001
Milk[e]	1163 (28.8)	1286 (31.2)	753 (31.9)	440 (33.8)	0.0018
Total fish, mean (SD), g	40.4 (28.4)	44.1 (29.1)	48.3 (29.1)	54.1 (32.0)	<0.0001
Oolong tea, ≥3cups/day	126 (3.2)	91 (2.4)	69 (3.2)	47 (4.0)	0.025
Black tea, ≥3 cups/day	25 (0.6)	17 (0.5)	28 (1.3)	19 (1.6)	<0.0001
Coffee, ≥3 cups/day	1541 (37.9)	1271 (31.0)	720 (31.0)	359 (28.1)	<0.0001
Total calories, mean (SD), kcal	1590.1 (509.3)	1627.7 (494.0)	1702.6 (515.0)	1734.2 (510.0)	<0.0001

[a] Data were expressed as No. (%) unless otherwise indicated.
[b] *P*-values calculated by analysis of variance or χ^2 test.
[c] A steamed bean-jam bun.
[d] Sweetened and jellied bean paste.
[e] Almost everyday.

The association appeared to fit a threshold model, such that persons who consume at least one cup of green tea per day might receive some benefit in terms of tooth retention. The catechin content of green tea might be able to explain the threshold association. Dental caries and periodontal disease are the main causes of tooth loss in persons aged over 45 years in Japan (Aida et al., 2006). These diseases are mainly due to the actions of oral bacteria. A number of experimental studies have shown that green tea catechins inhibit oral bacteria (Hirasawa et al., 2002; Sakanaka and Okada, 2004; Smullen et al., 2007), while some experiments have indicated that the concentration of tea catechin conferring the above effect should be more than 100 mg/100 ml (Hirasawa et al., 2002; Otake et al., 1991; Sakanaka and Okada, 2004). A typical preparation of green tea contains a catechin concentration of 50–150 mg/100 ml (Sakanaka and Okada, 2004). Therefore, this amount of catechin contained in one cup of green tea might be sufficient to aid tooth retention.

An inverse dose–response relationship should be observed for any beverage with a weaker catechin concentration, for instance oolong tea (Ooshima et al., 1994). Indeed, we found that ORs for oolong tea indicated an inverse dose–response relationship. Shimada et al. reported that oolong tea contained about 13 mg/100 ml catechin, which was far weaker than that in green tea (Shimada et al., 2004). Because of the low catechin concentration, the amount of catechin contained in one cup of oolong tea is insufficient to reach a level that will inhibit oral bacteria. Hence, in order to be exposed to a level of catechins necessary to prevent tooth loss, many more cups of oolong tea might have to be consumed. Therefore, the results for oolong tea might explain the apparent threshold association for green tea consumption from the viewpoint of the amount of catechin.

Table 2
Baseline characteristics of women according to green tea consumption (December 2006, Ohsaki City, Miyagi Prefecture, Northeastern Japan).[a]

Characteristics	Green tea consumption, cups/day				
	<1 (n=3693)	1–2 (n=4070)	3–4 (n=3026)	≥5 (n=2270)	P-value[b]
Total number of teeth					
0–9	369 (10.0)	355 (8.7)	301 (10.0)	256 (11.3)	<0.0001
10–19	668 (18.1)	708 (17.4)	599 (19.8)	516 (22.7)	
20–24	1107 (30.0)	1184 (29.1)	940 (31.1)	669 (29.5)	
≥25	1549 (41.9)	1823 (44.8)	1186 (39.2)	829 (36.5)	
Age, mean (SD), years	51.3 (6.6)	52.5 (6.7)	54.9 (6.4)	56.7 (5.9)	<0.0001
Daily tooth brushing					
<2 times/day	771 (21.0)	625 (15.4)	443 (14.7)	372 (16.5)	<0.0001
2 times/day	2081 (56.7)	2287 (56.3)	1597 (53.0)	1213 (53.7)	
>2 times/day	821 (22.4)	1150 (28.3)	971 (32.3)	674 (29.8)	
Years of education					
<10	316 (8.9)	298 (7.6)	243 (8.4)	226 (10.4)	0.0015
10–12	1991 (55.8)	2219 (56.3)	1580 (54.3)	1230 (56.5)	
≥13	1262 (35.4)	1428 (36.2)	1087 (37.4)	723 (33.2)	
Body mass index, kg/m^2					
<18.5	208 (5.7)	189 (4.7)	135 (4.5)	104 (4.6)	<0.0001
18.5–22.9	1739 (47.7)	1961 (48.7)	1369 (45.7)	982 (43.6)	
23.0–24.9	729 (20.0)	875 (21.7)	690 (23.1)	484 (21.5)	
25.0–29.9	795 (21.8)	858 (21.3)	679 (22.7)	589 (26.1)	
≥30.0	173 (4.8)	148 (3.7)	120 (4.0)	95 (4.2)	
Time spent walking, h/day					
<1	2566 (71.1)	2866 (71.9)	2170 (73.4)	1554 (70.7)	0.12
≥1	1044 (28.9)	1122 (28.1)	788 (26.6)	644 (29.3)	
History of chronic disease					
Stroke	24 (0.7)	20 (0.5)	16 (0.5)	6 (0.3)	0.24
Myocardial infarction	9 (0.2)	11 (0.3)	14 (0.5)	15 (0.7)	0.037
Diabetes mellitus	145 (3.9)	162 (4.0)	137 (4.5)	133 (5.9)	0.0016
Cancer	133 (3.6)	156 (3.8)	136 (4.5)	142 (6.3)	<0.0001
Smoking status					
Never	2645 (75.0)	3184 (82.6)	2465 (86.6)	1813 (86.3)	<0.0001
Former	297 (8.4)	254 (6.6)	152 (5.3)	110 (5.2)	
Current, 1–19 cigarettes/day	399 (11.3)	296 (7.7)	155 (5.5)	109 (5.2)	
Current, ≥20 cigarettes/day	185 (5.3)	120 (3.1)	73 (2.6)	69 (3.3)	
Alcohol drinking					
Never	1734 (48.4)	1986 (50.3)	1621 (55.9)	1291 (59.9)	<0.0001
Former	271 (7.6)	224 (5.7)	165 (5.7)	143 (6.6)	
Current	1577 (44.0)	1737 (44.0)	1114 (38.4)	720 (33.4)	
Consumption of sweets (such as *manju*[c], *yokan*[d] or cake)					
<3 times/week	2278 (62.6)	2389 (59.5)	1655 (55.7)	1265 (56.7)	<0.0001
≥3 times/week	1364 (37.5)	1628 (40.5)	1314 (44.3)	966 (43.3)	
Daily consumption					
Miso (soybean paste) soup[e]	2469 (67.0)	3068 (75.5)	2401 (79.6)	1808 (79.8)	<0.0001
Soybean products[e]	1698 (46.8)	2194 (54.7)	1839 (61.9)	1491 (67.0)	<0.0001
Milk[e]	1351 (37.0)	1622 (40.2)	1271 (42.6)	946 (42.4)	<0.0001
Total fish, mean (SD), g	37.8 (24.3)	42.0 (24.9)	46.8 (25.5)	51.2 (26.7)	<0.0001
Oolong tea, ≥3 cups/day	198 (5.6)	119 (3.1)	105 (3.7)	91 (4.3)	<0.0001
Black tea, ≥3 cups/day	47 (1.3)	38 (1.0)	46 (1.6)	38 (1.8)	0.035
Coffee, ≥3 cups/day	1538 (42.0)	1360 (33.8)	847 (28.4)	515 (23.4)	<0.0001
Total calories, mean (SD), kcal	1177.2 (299.0)	1231.1 (299.0)	1279.2 (294.9)	1299.0 (303.1)	<0.0001

[a] Data were expressed as No. (%) unless otherwise indicated.
[b] P-values calculated by analysis of variance or χ^2 test.
[c] A steamed bean-jam bun.
[d] Sweetened and jellied bean paste.
[e] Almost everyday.

The ORs for coffee consumption (Table 5) showed that persons who consumed more cups of coffee had a lower number of teeth. Tooth loss in the case of coffee consumption might be due to exacerbation of dental caries by addition of sugar or syrup (Jones et al., 1999), since 44.2% of men and 30.7% of women in this study added sugar or syrup to their coffee. Our analyses stratified by addition of sugar or syrup showed that the effects attributable to sugar or syrup were remarkable for women but almost negligible for men. Therefore, addition of sugar or syrup might be one possible explanation for the remarkable reduction of ORs in women. Furthermore, the non-decreasing ORs of tooth loss for those consuming coffee without sugar or syrup might be explained by the absence of catechin in coffee.

The effects of mouth rinses on tooth retention should be taken into account. If mouth rinsing itself prevents tooth loss, other beverages lacking catechin such as coffee without sugar or syrup might produce effects similar to the result of green tea consumption. However, we did not observe any decrease in ORs for tooth loss among subjects consuming coffee. Hence, mouth rinsing might have no effect on tooth retention.

Study strengths

Our study had several methodological strengths. First, this was a population-based study with a large sample size of 25,078 subjects from the general population in Japan. Second, the validity and reproducibility of green tea consumption among subjects in our previous validation study were reasonably high (Ogawa et al., 2003). Third, many of the subjects drank green tea and were distributed nearly evenly among the four categories of consumption frequency.

Table 3
Odds ratios (ORs) and 95% confidence intervals (CIs) of tooth loss according to green tea consumption (December 2006, Ohsaki City, Miyagi Prefecture, Northeastern Japan).

	Green tea consumption, cups/day				
	<1	1–2	3–4	≥5	*P*-values for trend
Cut-off point: <10 teeth					
	Men				
Number of cases/number of participants	428/4108	356/4180	223/2395	154/1336	
Age-adjusted OR (95% CI)	1.00	0.76 (0.65, 0.88)	0.69 (0.58, 0.83)	0.79 (0.64, 0.96)	<0.0001
Multivariate-adjusted OR (95% CI)[a]	1.00	0.87 (0.74, 1.02)	0.81 (0.68, 0.97)	0.82 (0.66, 1.01)	0.0063
	Women				
Number of cases/number of participants	369/3693	355/4070	301/3026	256/2270	
Age-adjusted OR (95% CI)	1.00	0.74 (0.63, 0.87)	0.67 (0.57, 0.79)	0.66 (0.55, 0.79)	<0.0001
Multivariate-adjusted OR (95% CI)[a]	1.00	0.87 (0.74, 1.02)	0.81 (0.68, 0.97)	0.75 (0.62, 0.91)	0.0006
Cut-off point: <20 teeth					
	Men				
Number of cases/number of participants	1322/4108	1126/4180	700/2395	417/1336	
Age-adjusted OR (95% CI)	1.00	0.73 (0.67, 0.81)	0.72 (0.64, 0.80)	0.72 (0.63, 0.83)	<0.0001
Multivariate-adjusted OR (95% CI)[a]	1.00	0.82 (0.74, 0.91)	0.82 (0.73, 0.92)	0.77 (0.66, 0.89)	<0.0001
	Women				
Number of cases/number of participants	1037/3693	1063/4070	900/3026	772/2270	
Age-adjusted OR (95% CI)	1.00	0.79 (0.71-0.88)	0.76 (0.68-0.85)	0.81 (0.71-0.91)	<0.0001
Multivariate-adjusted OR (95% CI)[a]	1.00	0.87 (0.78-0.97)	0.87 (0.77-0.98)	0.89 (0.78-1.01)	0.011
Cut-off point: <25 teeth					
	Men				
Number of cases/number of participants	2605/4108	2478/4180	1497/2395	842/1336	
Age-adjusted OR (95% CI)	1.00	0.80 (0.73, 0.87)	0.81 (0.73, 0.90)	0.76 (0.67, 0.87)	<0.0001
Multivariate-adjusted OR (95% CI)[a]	1.00	0.89 (0.81, 0.98)	0.94 (0.84, 1.05)	0.85 (0.74, 0.97)	0.011
	Women				
Number of cases/number of participants	2144/3693	2247/4070	1840/3026	1441/2270	
Age-adjusted OR (95% CI)	1.00	0.80 (0.72, 0.87)	0.83 (0.74, 0.92)	0.80 (0.72, 0.90)	<0.0001
Multivariate-adjusted OR (95% CI)[a]	1.00	0.86 (0.78, 0.95)	0.94 (0.84, 1.04)	0.89 (0.79, 1.00)	0.083

[a] The multivariate OR has been adjusted for age (40–44, 45–49, 50–54, 55–59, or 60–64 years), daily tooth brushing (<2, 2, or >2 times/day), years of education (<10, 10–12, or ≥13), body mass index (calculated as weight in kilograms divided by height in meters squared; <18.5, 18.5–22.9, 23.0–24.9, 25.0–29.9, or ≥30.0), time spent walking (<1 or ≥1 h/day), history of stroke, myocardial infarction, diabetes mellitus, and cancer (for each disease, yes or no), smoking status (never, former, currently smoking 1–19, or currently smoking ≥20 cigarettes/day), alcohol drinking (never, former, current), consumption of sweets such as *manju* (a steamed bean-jam bun), *yokan* (sweetened and jellied bean paste), or cake (<3 or ≥3 times/week), daily consumption of *miso* (soybean paste) soup, soybean products, milk (for each food, almost everyday or not), total fish (categorized into quartiles: <21.7, 21.7–47.5, 47.5–53.4, or ≥53.4 g/day for men; <22.8, 22.8–41.3, 41.3–53.4, or ≥53.4 g/day for women), oolong tea, black tea, and coffee (for each beverage, never or occasionally, 1–2, 3–4, or ≥5 cups/day), and total intake of calories (categorized into quartiles: <1265.8, 1265.8–1603.4, 1603.4–1933.2, or ≥1933.2 kcal/day for men; <1027.3, 1027.3–1242.8, 1242.8–1439.0, or ≥1439.0 kcal/day for women).

Study limitations

Several methodological limitations should also be considered when interpreting our results. First, our study had a cross-sectional design and no temporal relationship between green tea consumption and tooth loss can be inferred. However, teeth are not considered to play an indispensable role in drinking green tea, since green tea is a liquid. Therefore, we can reasonably speculate that teeth are retained as a result of consuming green tea. Second, we had no information on the validity of the self-reported number of residual teeth. However, previous studies had shown that the general population was able to provide reasonably accurate estimates of the self-reported number of teeth present (Axelsson and Helgadóttir, 1995; Douglass et al., 1991; Pitiphat et al., 2002). If a large proportion of the subjects gave vague answers in the questionnaires as to the number of their remaining teeth, misclassification regarding green tea consumption would occur. If data containing misclassifications were used for estimation of ORs, the general results would probably have been distorted, and any effect of green tea consumption in decreasing the odds for tooth loss might have been attenuated. Third, we had no information about dental

Table 4
Odds ratios (ORs) and 95% confidence intervals (CIs) of tooth loss according to oolong tea consumption; cut-off point: <20 teeth (December 2006, Ohsaki City, Miyagi Prefecture, Northeastern Japan).

	Oolong tea consumption, cups/day				
	<1	1–2	3–4	≥5	*P*-values for trend
	Men				
Number of cases/number of participants	2966/10,031	171/700	56/231	29/115	
Age-adjusted OR (95% CI)	1.00	0.90 (0.75, 1.08)	0.84 (0.61, 1.14)	0.85 (0.54, 1.30)	0.0019
Multivariate-adjusted OR (95% CI)[a]	1.00	0.93 (0.77, 1.12)	0.87 (0.63, 1.20)	0.85 (0.54, 1.33)	0.042
	Women				
Number of cases/number of participants	3116/10,988	208/815	80/344	54/187	
Age-adjusted OR (95% CI)	1.00	0.99 (0.83, 1.17)	0.77 (0.59, 1.00)	1.07 (0.76, 1.48)	<0.0001
Multivariate-adjusted OR (95% CI)[a]	1.00	0.99 (0.83, 1.18)	0.72 (0.55, 0.94)	0.85 (0.60, 1.20)	<0.0001

[a] The multivariate OR has been adjusted for age (40–44, 45–49, 50–54, 55–59, or 60–64 years), daily tooth brushing (<2, 2, or >2 times/day), years of education (<10, 10–12, or ≥13), body mass index (calculated as weight in kilograms divided by height in meters squared; <18.5, 18.5–22.9, 23.0–24.9, 25.0–29.9, or ≥30.0), time spent walking (<1 or ≥1 h/day), history of stroke, myocardial infarction, diabetes mellitus, and cancer (for each disease, yes or no), smoking status (never, former, currently smoking 1–19, or currently smoking ≥20 cigarettes/day), alcohol drinking (never, former, current), consumption of sweets such as *manju* (a steamed bean-jam bun), *yokan* (sweetened and jellied bean paste), or cake (<3 or ≥3 times/week), daily consumption of *miso* (soybean paste) soup, soybean products, milk (for each food, almost everyday or not), total fish (categorized into quartiles: <21.7, 21.7–47.5, 47.5–53.4, or ≥53.4 g/day for men; <22.8, 22.8–41.3, 41.3–53.4, or ≥53.4 g/day for women), green tea, black tea, and coffee (for each beverage, never or occasionally, 1–2, 3–4, or ≥5 cups/day), and total intake of calories (categorized into quartiles: <1265.8, 1265.8–1603.4, 1603.4–1933.2, or ≥1933.2 kcal/day for men; <1027.3, 1027.3–1242.8, 1242.8–1439.0, or ≥1439.0 kcal/day for women).

Table 5
Odds ratios (ORs) and 95% confidence intervals (CIs) of tooth loss according to coffee consumption with or without sugar or syrup; cut-off point: <20 teeth (December 2006, Ohsaki City, Miyagi Prefecture, Northeastern Japan).

	Coffee consumption, cups/day				
	<1	1–2	3–4	≥5	*P*-values for trend
Coffee consumption					
	Men				
Number of cases/number of participants	887/3003	1521/5206	953/3142	335/972	
Age-adjusted OR (95% CI)	1.00	1.12 (1.01, 1.24)	1.30 (1.16, 1.45)	1.58 (1.34, 1.85)	<0.0001
Multivariate-adjusted OR (95% CI)[a]	1.00	1.06 (0.96, 1.18)	1.16 (1.03, 1.31)	1.30 (1.10, 1.54)	0.0003
	Women				
Number of cases/number of participants	855/2766	1731/6041	939/3384	313/1025	
Age-adjusted OR (95% CI)	1.00	1.06 (0.96, 1.18)	1.18 (1.05, 1.33)	1.40 (1.19, 1.65)	0.0001
Multivariate-adjusted OR (95% CI)[a]	1.00	1.11 (1.00, 1.24)	1.18 (1.04, 1.33)	1.28 (1.07, 1.52)	0.0034
Coffee consumption excluding participants who never drink coffee					
	Men				
Number of cases/number of participants	670/2222	1521/5206	953/3142	335/972	
Age-adjusted OR (95% CI)	1.00	1.08 (0.96, 1.21)	1.25 (1.11, 1.42)	1.52 (1.29, 1.80)	<0.0001
Multivariate-adjusted OR (95% CI)[a]	1.00	1.02 (0.91, 1.15)	1.12 (0.98, 1.27)	1.25 (1.05, 1.49)	0.0055
	Women				
Number of cases/number of participants	636/2079	1731/6041	939/3384	313/1025	
Age-adjusted OR (95% CI)	1.00	1.10 (0.98, 1.23)	1.23 (1.08, 1.39)	1.45 (1.22, 1.72)	<0.0001
Multivariate-adjusted OR (95% CI)[a]	1.00	1.14 (1.01, 1.28)	1.21 (1.06, 1.39)	1.32 (1.10, 1.58)	0.0010
Coffee consumption with sugar or syrup excluding participants who never drink coffee					
	Men				
Number of cases/number of participants	403/1140	871/2463	464/1219	139/322	
Age-adjusted OR (95% CI)	1.00	1.12 (0.97, 1.31)	1.39 (1.16, 1.65)	1.70 (1.31, 2.20)	<0.0001
Multivariate-adjusted OR (95% CI)[a]	1.00	1.04 (0.89, 1.22)	1.17 (0.97, 1.41)	1.31 (0.99, 1.72)	0.024
	Women				
Number of cases/number of participants	310/907	710/1940	279/804	98/222	
Age-adjusted OR (95% CI)	1.00	1.33 (1.12, 1.58)	1.42 (1.15, 1.75)	2.11 (1.54, 2.89)	<0.0001
Multivariate-adjusted OR (95% CI)[a]	1.00	1.34 (1.11, 1.60)	1.35 (1.08, 1.69)	1.88 (1.35, 2.63)	0.0002
Coffee consumption without sugar or syrup excluding participants who never drink coffee					
	Men				
Number of cases/number of participants	267/1082	650/2743	489/1923	196/650	
Age-adjusted OR (95% CI)	1.00	1.06 (0.90, 1.26)	1.27 (1.06, 1.52)	1.63 (1.30, 2.04)	<0.0001
Multivariate-adjusted OR (95% CI)[a]	1.00	1.02 (0.86, 1.22)	1.16 (0.97, 1.41)	1.35 (1.06, 1.72)	0.0041
	Women				
Number of cases/number of participants	326/1172	1021/4101	660/2580	215/803	
Age-adjusted OR (95% CI)	1.00	1.02 (0.88, 1.19)	1.23 (1.05, 1.45)	1.37 (1.11, 1.69)	<0.0001
Multivariate-adjusted OR (95% CI)[a]	1.00	1.06 (0.90, 1.24)	1.22 (1.03, 1.45)	1.24 (0.99, 1.56)	0.0063

[a] The multivariate OR has been adjusted for age (40–44, 45–49, 50–54, 55–59, or 60–64 years), daily tooth brushing (<2, 2,or >2 times/day), years of education (<10, 10–12, or ≥13), body mass index (calculated as weight in kilograms divided by height in meters squared; <18.5, 18.5–22.9, 23.0–24.9, 25.0–29.9, or ≥30.0), time spent walking (<1 or ≥1 h/day), history of stroke, myocardial infarction, diabetes mellitus, and cancer (for each disease, yes or no), smoking status (never, former, currently smoking 1–19, or currently smoking ≥20 cigarettes/day), alcohol drinking (never, former, current), consumption of sweets such as *manju* (a steamed bean-jam bun), *yokan* (sweetened and jellied bean paste), or cake (<3 or ≥3 times/week), daily consumption of *miso* (soybean paste) soup, soybean products, milk (for each food, almost everyday or not), total fish (categorized into quartiles: <21.7, 21.7–47.5, 47.5–53.4, or ≥53.4 g/day for men; <22.8, 22.8–41.3, 41.3–53.4, or ≥53.4 g/day for women), green tea, oolong tea, and black tea (for each beverage, never or occasionally, 1–2, 3–4, or ≥5 cups/day) and total intake of calories (categorized into quartiles: <1265.8, 1265.8–1603.4, 1603.4–1933.2, or ≥1933.2 kcal/day for men; <1027.3, 1027.3–1242.8, 1242.8–1439.0, or ≥1439.0 kcal/day for women).

caries and periodontal disease. However, as these diseases represent an intermediate state leading to tooth loss, we consider that absence of information about them did not largely modify our results. Finally, since the response rate was not high (57.6%), the respondents might not have been a representative sample of the source population of Ohsaki City residents. The relatively low response rates should be kept in mind when interpreting the results.

Conclusions

The present findings indicate that green tea consumption is associated with decreased odds of tooth loss.

Conflict of interest statement
The authors declare that there are no conflicts of interest.

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Study Profile

The Ohsaki Cohort 2006 Study: Design of Study and Profile of Participants at Baseline

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ABSTRACT

Background: Large-scale cohort studies conducted in Japan do not always include psychosocial factors as exposures. In addition, such studies sometimes fail to satisfactorily evaluate disability status as an outcome.

Methods: This prospective cohort study comprised 49 603 (22 438 men and 27 165 women) community-dwelling adults aged 40 years or older who were included in the Residential Registry for Ohsaki City, Miyagi Prefecture, in northeastern Japan. The baseline survey, which included psychosocial factors, was conducted in December 2006. Follow-up of death, immigration, cause of death, cancer incidence, and long-term care insurance certification was started on 1 January 2007.

Results: The response rate was 64.2%. In general, lifestyle-related conditions in the study population were similar to those of the general Japanese population; however, the proportion of male current smokers was higher in the cohort. The association between age and the proportion of those reporting psychological distress showed a clear U-shaped curve, with a nadir at age 60 to 69 years in both men and women, although more women were affected by such distress than men. The proportion of those who reported a lack of social support was highest among those aged 40 to 49 years. Most men and women surveyed did not participate in community activities. Among participants aged 65 years or older, 10.9% of participants were certified beneficiaries of the long-term care insurance system at baseline.

Conclusions: The Ohsaki Cohort 2006 Study is a novel population-based prospective cohort study that focuses on psychosocial factors and long-term care insurance certification.

Key words: long-term care insurance; population-based; psychosocial factors; study design; the Ohsaki Cohort 2006 Study

INTRODUCTION

Increasing evidence suggests that, in addition to biomedical factors, a broad range of psychosocial factors influences general health.[1–3] However, large-scale cohort studies performed in Japan may not have sufficiently considered these factors as exposures in evaluating health outcomes.[4–9]

In addition to this tendency to overlook psychosocial exposures, some types of health outcomes, such as disability status, have not been satisfactorily examined in large-scale epidemiological studies in Japan.[4–9] Although there is growing concern about the quality of life of seniors,[10,11] assessment of quality of life—in particular disability status—by means of general population surveys presents many challenges.[12–14] In 2000, the Japanese government implemented a mandatory social long-term care insurance (LTCI) system to promote the independence of seniors by facilitating access to appropriate high-quality services of their choice, whenever and wherever needed.[15,16] Therefore, there is now an opportunity to use LTCI certification status as an alternative to the evaluation of physical and mental disability.

Based on the need for a novel cohort that accounts for the recent diversification in the abovementioned exposures and outcomes, we initiated a large population-based prospective cohort study, the Ohsaki Cohort 2006 Study, the main

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Table 1. Response rate and number of adults in source population, eligible population, and study population

	Aged 40–64 years		Aged ≥65 years		Total
	Men	Women	Men	Women	
No. of source population	23647	22760	12750	18944	78101
No. of eligible population (A)	23359	22639	12606	18631	77235
No. of persons responding to the survey	12967	13849	9690	13704	50210
No. of study population (B)	12833	13679	9605	13486	49603
Response rate (B/A) (%)	54.9	60.4	76.2	72.4	64.2

objective of which is to examine the association between psychosocial factors and both physical and mental disability status. Here, we report the design of the study and the profile of participants at baseline.

METHODS

Study design, setting, and participants

In this prospective cohort study, the source population for the baseline survey comprised community-dwelling individuals aged 40 years or older who were included in the Residential Registry for Ohsaki City, Miyagi Prefecture, northeastern Japan, as of 1 December 2006. The Residential Registry identified 78 101 persons (36 397 men; 41 704 women) in the area.

The baseline survey was conducted from 1 December to 15 December 2006. A questionnaire was distributed by the heads of individual administrative districts to individual households, after which it was collected by mail.

Baseline survey

The baseline questionnaire for persons aged 40 to 64 years requested information on the following, in sequence: (1) history of diseases, (2) family history of diseases, (3) health status over the last year, (4) smoking status, (5) alcohol drinking status, (6) dietary habits,[17] (7) job status and educational status, (8) present and past body weight and height, (9) general health status, (10) sports and exercise,[18,19] (11) psychological distress (using the K6, a 6-item instrument that assesses nonspecific psychological distress developed by Kessler and colleagues),[20–23] (12) social support,[24] (13) participation in community activities, (14) dental status, and (15) reproductive factors (in women).

Question items for persons aged 65 years or older were the same as those for persons aged 40–64, excluding family history of diseases, job status and educational status, present and past body weight and height, and reproductive factors. In addition, we included a frailty checklist (the Kihon Checklist, in Japanese),[25] along with (1) past body weight and height, (2) pain, and (3) daily activities. The Kihon Checklist is a tool developed by the Japanese Ministry of Health, Labour, and Welfare to screen for frailty, and is designed to measure actual task performance.[25]

All people who supplied their name and address, and completed most of the questionnaire, were regarded as eligible; all others were excluded. The reasonableness of data was evaluated according to predetermined rules.

Follow-up

We conducted this prospective cohort study with the cooperation of the Ohsaki City municipal government after obtaining their written agreement. The aim is to follow the cohort participants for mortality and immigration using the Residential Registry of Ohsaki City. We also confirm information regarding LTCI certification status among individuals aged 65 years or older, after obtaining written consent for review of these data. Causes of death are confirmed by review of death certificates, with approval from the Japanese Ministry of Internal Affairs and Communications and the Japanese Ministry of Health, Labour, and Welfare. Cancer incidence is also confirmed by review of data from the Miyagi Prefectural Cancer Registry, with approval from the Miyagi Prefectural Cancer Registry Committee.

Ethical issues

The return of questionnaires completed by the participants was regarded as consent to participate in the study, which involves cross-sectional analysis of baseline survey data and information on subsequent mortality and immigration. We provided an explanatory note on the questionnaire that stated we would follow the cohort participants for mortality and cancer incidence. The study protocol was reviewed and approved by the Ethics Committee of Tohoku University Graduate School of Medicine.

RESULTS

Data on the source population, eligible population, study population, and response rate by age and sex are shown in Table 1. Of the 78 101 people in the source population, we were unable to contact 866, yielding an eligible population of 77 235. Baseline questionnaires were collected from 50 210 persons, and valid responses were received from 49 603 (22 438 men and 27 165 women), who formed the study population of cohort participants. Among the invalid responses, 252 persons aged 65 years or older completed

Table 2. Selected baseline medical and lifestyle-related profiles of study population, by sex and age category

Variables	Age category (years)									
	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	≥85
Men										
No. of participants	1857	2365	2884	3427	2300	2477	2846	2391	1256	635
History of serious disease (%)										
Hypertension	7.7	14.6	18.8	25.4	32.7	37.8	41.9	44.0	39.7	35.3
Diabetes mellitus	3.6	5.2	7.5	11.0	12.8	14.4	16.2	13.6	11.5	10.1
Stroke	0.4	0.6	1.3	2.0	3.4	4.4	5.6	7.1	7.9	8.8
Myocardial infarction	0.1	0.7	1.0	1.8	3.5	4.7	5.9	8.5	9.7	11.5
Cancer	0.8	1.5	2.1	2.8	5.0	7.4	10.4	13.0	12.3	9.8
Current smokers (%)	59.5	56.7	50.6	46.8	40.4	31.4	25.9	21.3	19.2	11.1
Current alcohol drinkers (%)	81.5	80.6	80.7	79.2	77.0	69.1	61.6	53.2	45.3	30.3
Body mass index (%)										
<18.5 kg/m^2	2.7	2.5	1.7	2.0	2.5	3.0	3.7	6.2	11.0	10.9
≥25.0 kg/m^2	35.1	33.8	34.7	34.7	30.8	32.1	29.1	26.3	19.7	16.6
Time spent walking <1 hr/day (%)	69.4	68.4	67.5	67.2	67.3	63.9	67.9	74.2	79.0	85.3
Women										
No. of participants	1935	2488	3025	3638	2593	3070	3623	3303	2021	1469
History of serious disease (%)										
Hypertension	3.3	8.3	15.0	23.5	30.1	37.0	43.0	46.4	47.7	46.1
Diabetes mellitus	0.8	2.6	3.3	6.0	8.4	8.5	10.4	11.6	12.0	10.2
Stroke	0.3	0.2	0.6	0.5	1.1	1.6	2.5	3.8	4.6	6.3
Myocardial infarction	0.1	0.0	0.2	0.5	1.0	1.5	2.9	4.4	6.1	7.2
Cancer	2.0	2.7	4.3	4.7	6.9	6.0	5.9	6.2	6.9	7.9
Current smokers (%)	19.6	15.2	11.0	9.1	7.3	4.7	3.8	2.8	2.5	2.1
Current alcohol drinkers (%)	56.7	49.5	40.3	34.1	29.9	20.7	14.4	11.6	10.8	9.2
Body mass index (%)										
<18.5 kg/m^2	7.5	6.3	4.8	4.2	3.3	3.7	4.8	6.4	9.1	16.1
≥25.0 kg/m^2	20.1	22.6	27.4	28.3	32.2	34.9	35.2	31.9	27.7	22.0
Time spent walking <1 hr/day (%)	74.0	70.3	70.2	71.6	73.4	70.0	72.5	78.8	84.4	91.6

the questionnaires intended for those aged 40 to 64 years. Among the study population, 26 512 persons (53.4%) were aged 40 to 64 years, and 23 091 (46.6%) were aged 65 years or older. The response rate was calculated by dividing the study population by the total eligible population, yielding 64.2%. The response rate for men was 62.4% (22 438/35 965), and was somewhat lower than that for women, at 65.8% (27 165/41 270). By age, the response rate for persons aged 65 years or older was high, at 73.9% (23 091/31 237), while that for persons aged 40 to 64 years was 57.6% (26 512/45 998).

Selected baseline medical and lifestyle-related profiles of the study population

The selected baseline medical and lifestyle-related profiles of the study population are shown in Table 2. The prevalence of a history of serious disease rose with increasing age in both men and women. In men, the distributions of a history of hypertension, diabetes mellitus, and cancer all peaked at age 70 to 79 years. More than 40% of men aged 75 to 79 years had a history of hypertension. About 60% of men, and 20% of women, aged 40 to 44 years currently smoked, and more than 80% of men, and 50% of women, in the same age group currently drank alcohol at baseline, which decreased with increasing age. The proportion of obese individuals, defined as a BMI ≥25.0 kg/m^2, was inversely associated with age in men, but weakly positively associated with age in women, with a peak at age 70 to 79 years. The association between age and the proportion of individuals who were underweight, defined as a BMI <18.5 kg/m^2, was J-shaped for men and U-shaped for women. The association between age and the proportion of those who spent less than 1 hour per day walking was J-shaped for both men and women.

Selected baseline psychosocial profiles of the study population

With regard to psychosocial profiles (Table 3), the association between age and the proportion of participants who had psychological distress showed a clear U-shaped curve in both sexes, with a nadir in those aged 60 to 69 years; psychological distress was more common in women than in men. The proportion of those who reported lack of social support was highest among those in their 40s, and decreased with age for every component of social support in both men and women. More men than women reported lack of social support. About 20% of men in their 40s reported lack of social support for consultation when in trouble. In contrast, the association between age and the proportion of those who did not participate in community activities showed a J-shape curve with a nadir at age 60 to 69 years.

Table 3. Selected baseline psychosocial profiles of study population, by sex and age category

Variables	Age category (years)									
	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	≥85
Men										
Psychological distress[a], yes (%)	7.1	7.4	6.2	5.1	4.7	4.1	4.8	5.7	7.0	6.9
Lack of social support (%)										
(i) To consult when you are in trouble	19.0	20.1	18.0	18.0	18.1	14.5	12.7	13.3	13.1	13.7
(ii) To consult when you are in bad physical condition	15.8	15.7	15.1	13.9	12.6	8.9	8.0	7.7	5.9	7.4
(iii) To help with your daily housework	18.2	18.9	17.8	17.5	18.8	17.6	15.8	16.2	13.0	9.0
(iv) To take you to a hospital	13.5	12.3	11.7	9.5	9.5	7.8	7.6	8.0	6.9	5.3
(v) To take care of you	10.8	11.0	11.6	9.6	10.5	8.8	9.1	9.0	9.9	8.9
No participation in community activities (%)										
(i) Neighborhood association activities	50.1	46.0	45.8	44.6	45.5	42.9	48.0	50.2	59.5	70.6
(ii) Sports or exercise	47.9	49.6	51.6	53.9	49.5	45.8	50.3	55.4	61.7	70.9
(iii) Volunteering	69.3	63.6	61.4	60.4	60.5	56.1	60.8	65.1	75.6	88.7
(iv) Social gatherings	52.7	53.0	50.8	48.5	46.3	40.3	44.9	50.7	61.0	78.9
Women										
Psychological distress[a], yes (%)	9.9	8.7	7.4	6.6	5.4	5.3	6.4	7.5	10.5	13.9
Lack of social support (%)										
(i) To consult when you are in trouble	11.1	10.8	10.2	10.5	9.9	7.9	7.4	7.1	7.7	4.9
(ii) To consult when you are in bad physical condition	11.5	10.8	9.2	9.1	8.9	6.3	5.8	5.1	4.8	2.7
(iii) To help with your daily housework	16.5	15.4	13.5	16.2	16.8	15.3	15.7	13.0	9.7	4.5
(iv) To take you to a hospital	13.3	11.6	7.5	8.8	8.2	8.0	7.8	7.4	5.5	3.4
(v) To take care of you	16.5	15.6	13.4	16.4	17.3	17.8	19.0	17.1	12.9	7.0
No participation in community activities (%)										
(i) Neighborhood association activities	42.3	52.0	57.3	56.3	54.2	53.7	55.8	59.5	69.8	86.8
(ii) Sports or exercise	61.1	58.8	60.5	56.4	51.4	50.0	54.1	62.5	75.0	88.3
(iii) Volunteering	78.8	75.7	73.7	70.1	67.3	67.0	74.3	81.0	88.9	97.4
(iv) Social gatherings	59.5	59.7	60.3	56.9	53.2	51.1	56.2	61.0	74.0	91.9

[a]The K6 was used as an indicator of psychological distress.[20–23]

Table 4. Number (%) of participants certified in the long-term care insurance system of Japan at baseline

Care level	Age category (years)				
	65–69	70–74	75–79	80–84	≥85
Men					
Uncertified	1817 (97.6)	2037 (95.5)	1683 (92.6)	808 (85.0)	316 (65.8)
Support level 1[a]	4 (0.2)	7 (0.3)	13 (0.7)	14 (1.5)	12 (2.5)
Support level 2[a]	4 (0.2)	17 (0.8)	16 (0.9)	22 (2.3)	11 (2.3)
Care level 1[b]	10 (0.5)	21 (1.0)	27 (1.5)	23 (2.4)	47 (9.8)
Care level 2[b]	15 (0.8)	11 (0.5)	25 (1.4)	34 (3.6)	30 (6.3)
Care level 3[b]	3 (0.2)	15 (0.7)	20 (1.1)	28 (2.9)	27 (5.6)
Care level 4[b]	5 (0.3)	18 (0.8)	25 (1.4)	11 (1.2)	18 (3.8)
Care level 5[b]	4 (0.2)	6 (0.3)	9 (0.5)	11 (1.2)	19 (4.0)
Women					
Uncertified	2153 (98.3)	2411 (95.0)	2076 (90.2)	1090 (77.2)	520 (49.4)
Support level 1[a]	4 (0.2)	24 (0.9)	41 (1.8)	49 (3.5)	36 (3.4)
Support level 2[a]	7 (0.3)	31 (1.2)	45 (2.0)	52 (3.7)	59 (5.6)
Care level 1[b]	9 (0.4)	25 (1.0)	57 (2.5)	92 (6.5)	126 (12.0)
Care level 2[b]	3 (0.1)	13 (0.5)	26 (1.1)	48 (3.4)	93 (8.8)
Care level 3[b]	8 (0.4)	10 (0.4)	20 (0.9)	28 (2.0)	83 (7.9)
Care level 4[b]	5 (0.2)	15 (0.6)	22 (1.0)	29 (2.1)	70 (6.7)
Care level 5[b]	2 (0.1)	10 (0.4)	15 (0.7)	24 (1.7)	65 (6.2)

[a]Those who require support for daily activities; a higher number indicates a need for greater support.
[b]Those who require continuous care; a higher number indicates a need for greater continuous care.

LTCI certification at baseline

The percentages of participants aged 65 years or older at baseline who received LTCI certification are shown in Table 4. Among participants in this age group, 16 739 (72.5%) provided written consent for our review of the information. Among these seniors, 10.9% had been LTCI-certified as of 15 December 2006. The proportion of those who were LTCI-certified increased linearly in relation to age

category in both men and women; more women were LTCI-certified than men. Among participants aged 85 years or older, about 34% of men and 51% of women were LTCI-certified.

DISCUSSION

To characterize the study population, we compared selected health-related characteristics of the population with those of the Japanese general population, by sex and age, using data from The National Health and Nutrition Survey in Japan, 2005.[26] Among men, the proportion of current smokers was higher in the study population than in the general population. The proportions of current smokers at baseline in the present cohort population by age category were 56.7% to 59.5%, 46.8% to 50.6%, 31.4% to 40.4%, and 21.3% to 25.9% for men in their 40s, 50s, 60s, and 70s, respectively (Table 2); the corresponding figures from the national survey were 44.1%, 42.5%, 34.0%, and 20.0% (≥70 years). In contrast, smoking status among women in the study population was very similar to that in the general population. Other variables, including obesity, underweight, history of serious diseases, alcohol drinking, and time spent walking, were similarly prevalent among middle-aged and elderly men and women in the study population and general population. To take one example, the proportions of men who were obese (BMI of ≥25.0) at baseline in the present cohort population by age category were 33.8% to 35.1%, 34.7%, 30.8% to 32.1%, and 26.3% to 29.1% for those in their 40s, 50s, 60s, and 70s, respectively (Table 2); the corresponding figures from the national survey were 34.1%, 31.4%, 30.7%, and 26.0% (≥70 years), respectively.

We also compared the LTCI certification status of the participants with that of the Japanese population by sex and age.[27] The proportions of those certified at baseline in the present cohort population, by age category, were 2.4%, 4.5%, 7.4%, 15.0%, and 34.2% for men aged 65–69, 70–74, 75–79, 80–84, and ≥85 years (Table 4); the corresponding figures from the estimated national survey were 3.0%, 6.2%, 11.9%, 22.1%, and 45.0%, respectively.[27] The same comparison among women yielded similar results, with smaller proportions in the present cohort population. These observed smaller proportions were not unexpected, because people with disabilities have more difficulties in responding to questionnaires. However, the small magnitude of the difference indicates that the selection bias was not serious.

Our study had some limitations. First, the response rate (64.2%) was not very high. The response rates of men and women aged 40 to 64 years were lower (54.9% and 60.4%, respectively) than those of men and women aged 65 years or older (76.2% and 72.4%, respectively). These relatively low response rates, especially among participants aged 40 to 64 years, should be kept in mind when interpreting the study results. Second, among the psychosocial variables studied, the items regarding job status and educational status, social support, and participation in community activities have not been adequately validated. Third, LTCI certification does not directly indicate an individual's disability status; however, it does reflect the burden of disability on society.[15,16]

We have already conducted a prospective cohort study in the catchment area of Ohsaki Public Health Center. This study began in 1995 and was named the Ohsaki National Health Insurance (NHI) beneficiary's Cohort Study, or the Ohsaki Cohort Study.[5] The primary purpose of that study was to demonstrate quantitatively the economic impact of health-related lifestyles; the Ohsaki Cohort 2006 Study, in contrast, does not assess medical costs. The catchment area of the Ohsaki Public Health Center included Furukawa City, and the towns of Nakaniida, Onoda, Miyazaki, Shikama, Matsuyama, Sanbongi, Kashimadai, Iwadeyama, Naruko, Wakuya, Tajiri, Kogota, and Nango. Among these areas, the city of Furukawa, and the towns of Matsuyama, Sanbongi, Kashimadai, Iwadeyama, Naruko, and Tajiri were consolidated to form the city of Ohsaki on 31 March 2006. The population of the present study and that investigated in the Ohsaki Cohort overlap by about one-third.

In conclusion, we have begun a large population-based prospective study that focuses on psychosocial factors and LTCI certification status. The psychological factors include measurements of job status and educational status, psychological distress,[20–23] social support,[24] participation in community activities, and the Kihon Checklist.[25] LCTI certification is followed up as an alternative to individual disability status, and as a measure of the economic burden of disability on society.

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