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Author(s)	Ukawa, Shigekazu; Tamakoshi, Akiko; Wakai, Kenji; Noda, Hiroyuki; Ando, Masahiko; Iso, Hiroyasu
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Prospective cohort study on television viewing time and incidence of lung cancer: findings from the Japan Collaborative Cohort Study

Shigekazu Ukawa PhD[a], Akiko Tamakoshi MD, PhD[a,*], Kenji Wakai MD, PhD[b], Hiroyuki Noda MD, PhD[c], Masahiko Ando MD, PhD[d], Hiroyasu Iso MD, PhD[c] for the JACC STUDY GROUP

[a]Department of Public Health, Hokkaido University Graduate School of Medicine

[b]Department of Preventive Medicine, Nagoya University Graduate School of Medicine

[c]Public Health, Department of Social and Environmental Medicine, Osaka University Graduate School of Medicine

[d]Center for Advanced Medicine and Clinical Research Nagoya University Graduate School of Medicine

The members of the JACC Study Group is provided in the appendix 1.

Running title: television viewing time and incidence of lung cancer

*Corresponding Author: Akiko Tamakoshi, Department of Public Health, Hokkaido University Graduate School of Medicine, N15 W7, Kita-ku, Sapporo 060-0812, Japan. Tel: +81 11 7065068; fax: +81 11 7067805. E-mail: tamaa@med.hokudai.ac.jp

Abstract

PURPOSE: To ascertain whether prolonged television viewing time was associated with lung cancer incidence in Japanese adults aged 40 to 79 years from a nationwide large-scale cohort study.

METHODS: A total of 54,258 adults (23,090 men and 31,168 women) without a history of cancer at baseline (1988-1990) were enrolled and followed for a median of 15.6 years. The Cox proportional hazard model was used to calculate hazard ratios (HR) and 95% confidence interval (CI) for lung cancer according to television viewing time adjusted for age and other possible confounding factors.

RESULTS: During the study period, 798 participants were diagnosed with lung cancer. The HR of male participants who watched television for more than 4 hours daily was 1.36 (95% CI, 1.04-1.80) compared with less than 2 hours per day.

CONCLUSION: Our findings suggest that reducing the amount of time spent watching television may be beneficial for preventing lung cancer.

KEY WORDS: Lung Neoplasms, Sedentary behavior, Cohort Study, Lung cancer, Risk

assessment, Tobacco

List of abbreviation

BMI=body mass index

CI=confidence interval

HR=hazard ratio

ICD=International Classification of Disease

JACC Study=Japan Collaborative Cohort Study

TV=television

Introduction

Lung cancer is the third most common cause of cancer related deaths in Japan [1]. Cigarette smoking is a well-established independent and strong risk factor for lung cancer [2]. However, since the population attributable risk of smoking on lung cancer mortality is smaller in Japan than in the US (men: 69.2% for Japanese vs. 87.9% for American, women: 19.8% for Japanese vs. 70.9% for American) [3], other life-style behaviors should also be considered in the development of lung cancer. Excessive alcohol consumption [4] and lower daily consumption of green leafy vegetables or fruits [5] has been reported to be a risk factor for lung cancer, whereas physical activities such as sports, exercise, or walking have been reported to reduce this risk [6-8].

A recent review indicated that sedentary behavior causes poor health such as obesity, diabetes, cardio vascular disease, and several cancers [9,10]. Sedentary behavior, distinct from the absence of moderate-vigorous physical activity, is the broad categorical name for all behaviors of low energy expenditure range less than 1.5 METs (multiples of the basal metabolic rate) and characterized by prolonged sitting or reclining and the absence of whole-body movement [11]. Television (TV) viewing time

has been reported as the most important leisure-time associated with sedentary and sitting behavior [12-15]. The average number of hours Japanese adults spend watching TV has been reported to be about 3 to 4 hours [12]; for Americans it has been estimated at about 5 hours [14]. TV viewing time has been reported as a risk factor for cardiovascular disease [16,17], type 2 diabetes [18], and several cancers [19-23]. Hypothesized biological pathways between these diseases and TV viewing have been reported as follows: adiposity [24], metabolic dysfunction [25], and chronic inflammation[26].

Although two studies indicated that standing occupations that have required walking or laboring decrease risk for lung cancer compared to sitting professions [27,28], the impact of sedentary behavior on lung cancer has not been directory examined. Therefore, the aim of this study was to ascertain if prolonged TV viewing time was associated with lung cancer incidence in Japanese participants aged 40 to 79 years.

Material and Methods

Study population

The Japan Collaborative Cohort Study for Evaluation of Cancer Risk (JACC Study) was established between 1998 and 1990 and has been described in detail elsewhere [29]. In brief, 110,585 (46,395 men and 64,190 women) apparently healthy inhabitants aged 40 to 79 years from 45 areas throughout Japan were enrolled at baseline, who mostly participated in municipal health screening examinations under the Health Law for the Aged with the response rate of 86–91%. Participants in this study were limited to 24 study areas where the incidence of cancer could be ascertained. Of the 65,042 (26,429 men and 38,613 women) original cohort members, 968 participants were excluded because they had a history of cancer. A further 3,612 participants in two areas were also excluded because the questionnaire used there did not include an item on average daily hours of TV viewing. Finally, 6,564 participants with missing data on average daily hours of TV viewing and smoking status were excluded. Consequently, 54,258 (23,090 male and 31,168 female) participants were evaluated in the present study.

Informed consent was mainly obtained from participants. In several

communities, informed consent was obtained from the community leaders and mayors based on guidelines of the Council for International Organizations of Medical Science [30] after the study purpose, methods, and data confidentiality were described. This study was approved by the Ethical Board of Nagoya University School of Medicine.

Data collection

Participants were mostly recruited at the time of their health check-up using a self-administered questionnaire. Information on the average daily number of hours spent watching TV was obtained in the baseline questionnaire as following question "How many average hours a day do you spend watching TV?". Three categories of TV viewing time (<2, from ≥2 to <4, ≥4 hours/day) were created based on previously reported associations with mortality from cardiovascular disease [17].

Follow-up

The incidence of cancer could be ascertained in 24 of the 45 study areas where population-based cancer registries or the reviewing process of local major hospital

records were available and coded according to the tenth revision of the International Classification of Disease (ICD-10). In regard to subjects who had moved out from the study area during the study period, we treated as a censored case.

Statistical analysis

Age-adjusted and multivariate hazard ratios (HR) and confidence intervals (CI) for lung cancer incidence based on average daily hours spent watching TV were calculated using Cox proportional model. We tested the assumption of proportional hazards for categories of average daily hours spent watching TV and found no violation of proportionality. Demographic information such as age (as a continuous variable), smoking status (never smokers of exposure to environmental tobacco smoke at home or in public places almost everyday or less or unknown, former smokers of time since quitting ≥10 or <10 years or unknown, and current smokers of ≥20 or <20 pack years or unknown), body mass index (BMI<18.5, 18.5-24.9, ≥25.0, unknown), educational level (school up to age 15, 15-18, ≥19 years, unknown), marital status (single, married, divorced/widowed, unknown), alcohol consumption (never, former, current alcohol

drinker, unknown) were included in the multivariate models. We also included variables such as daily dietary consumption of green leafy vegetables (1-2 times/month or less, 1-2 times/week or less, 3-4 times/week or more, unknown), oranges (1-2 times/month or less, 1-2 times/week or less, 3-4 times/week or more, unknown), and fruits other than oranges (1-2 times/month or less, 1-2 times/week or less, 3-4 times/week or more, unknown) in the multivariate models because these variables were known to be associated with a reduction in lung cancer mortality [5]. However, we did not include daily walking time because it did not make a meaningful contribution to the model. Tests for linear trend were conducted to assess associations between the original continuous variables of daily hours spent watching TV and risk of lung cancer incidence. An alpha level of 0.05 was considered to be statistically significant. All statistical analyses were performed using JMP Pro version 10.0.2 for Mac (SAS Institute Inc., Cary, NC, USA).

Results

The median follow-up period was 15.6 years. There were over 720,883 (male: 306,450, female: 414,433) person years of follow-up, 798 (598 male and 200 female) participants

diagnosed with lung cancer (ICD-10=C34), 3,025 participants who left the study area and 12,654 participants who died from causes other than lung cancer. The mean age±standard deviation of participants at baseline was 57.6±10.2 (male: 57.7±10.3, female: 57.6±10.1) years.

Table 1 shows baseline characteristics of participants according to TV viewing time. About 21.6% of male and 27.5% of female participants watched TV for longer than 4 hours daily. Compared to participants who viewed TV for less than two hours, participants who viewed TV for more than two hours tended to be older, more likely to be a smoker, single, consume oranges, and fruits daily, less likely to be educated, be a daily walker and daily consumer of green leafy vegetables among both male and female participants. Among male participant, the tendency to be drinkers was higher, while among female participants it was lower.

The HRs for lung cancer incidence associated with TV viewing time is shown in Table 2. There was a significant association between daily hours spent TV viewing and lung cancer after adjusting for variables such as age, body mass index, education, marital status, alcohol drinking, smoking status, time since quitting for former smokers,

and smoking intensity for current smokers, walking, intake of green leafy vegetables, oranges, and fruits other than oranges. Among male participants, compared with participants who watched TV for less than 2 hours per day, participants who watched TV for more than 4 hours per day were 36% (HR, 1.36 95% CI, 1.04-1.80) more likely to be diagnosed with lung cancer with a marginally linear relationship (p for trend=0.06) according to prolonged TV viewing time. Among female participants, daily hours spent viewing TV was not associated with lung cancer incidence.

HRs for lung cancer incidence associated with daily hours spent TV viewing according to smoking status was also calculated. Although small number of cases among never and former smokers, non-significant risk increases of approximately 80% were found among never smokers and former smokers, whereas the non-significant risk increase seen amongst current smokers was only 20% among male participants. Similar associations were not found among female participants.

Discussion

In this prospective cohort study, we found prolonged TV viewing time increased the risk of lung cancer after adjusting for potential risk factors among Japanese men, whereas

similar associations were not found among women.

To our knowledge, this is the first report investigating the association between daily hours spent watching TV and lung cancer incidence. Our results are consistent with previous studies that reported prolonged TV viewing time as a risk factor for colon [19,20], ovarian [21,22], and endometrial cancer [23].

One major form of sedentary behavior in many industrialized countries such as Japan, the United Kingdom, and the United States of America is watching TV[12-14]. Thus, watching TV should be an indicator of leisure time sedentary behavior [31]. There are several potential mechanisms involved in the development of lung cancer by sedentary behavior. Prolonged sedentary behavior has been shown to increase levels of inflammatory factors such as tumor-necrosis factor-alpha, interlueukin-6, and leptin [32,33] which may in turn be associated with lung cancer [34-36]. In addition, sedentary behavior causes metabolic dysfunction [25] which is a risk factor for lung cancer [37]. This could lead to hyperinsulinemia that may interrupt cell differentiation, proliferation, and apoptosis [38] and also leads to hyperglycemia, all of which promote carcinogenesis [39].

In this study, daily hours spent watching TV affected lung cancer incidence for only male participants. The average number of hours Japanese people spend household affairs has been reported to be about 4 to 5 hours for women, 1 hour for men [40]. Daily hours spent watching TV may not appropriate as an indicator of sedentary behavior for Japanese female.

In additional analyses according to smoking status, associations did not reached statistical significant in any group. Cigarette smoking has been estimated to be the major risk factor for lung cancer, and was associated with 52.2% of lung cancer cases among male smokers in this cohort [41], therefore, cigarette smoking rather than TV viewing time may strongly affect the development of lung cancer among current smokers. With regards to never and former smokers, the relatively low prevalence of never smokers (20.7%) and former smokers (27.1%) and lung cancer cases (never smokers: n=38; former smokers: n=112, respectively) in our study could lead to the subsequent potential risk of type II statistical errors.

A major strength of this study is its prospective cohort design with participants from all over Japan and long follow-up period. Also information on

potential confounders for lung cancer was collected at baseline and adjusted in the analysis as much as possible.

This study has some limitations that we have to keep in mind when interpreting the results. First, we obtained information on TV viewing time through self-reporting, which was therefore subjective. Also information was collected only at baseline and was not updated during the follow-up. Thus, some reporting bias such as misclassification might have occurred. However, any misclassification would be random, because participants could not foresee subsequent events that may occur, at baseline. Accordingly, such misclassification might lead to an underestimation of the true associations. Secondly, histological types of lung cancer are not available for all cases in our study. Smoking causes all types of lung cancer but is strongly associated with small-cell lung cancer and squamous-cell carcinoma [42]. On the other hand, adenocarcinoma is a common type in never smokers [43]. Information on histological types of lung cancer would make our results more clear. Thirdly, TV viewing time is a highly prevalent leisure-time sedentary behavior, but it is not always a good indicator of total sedentary time. Using the questionnaire covering broad domains of sedentary

behavior such as IPAQ (the International Physical Activity Questionnaire) instrument, which used wide international studies [44], would make our result more clear. Finally, potential reverse causation could be occurred. However, since subjects were recruited in municipal health screening examinations and we excluded subjects had a history of cancer at baseline, our results would be valid.

Conclusions

This large-scale cohort study indicated that prolonged TV viewing time (more than 4 hours daily compared to less than 2 hours) was associated with an elevated risk of lung cancer incidence among Japanese men aged between 40 and 79 years. Our findings suggest that reducing sedentary behavior may be benefit in the prevention of lung cancer.

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Appendix 1. The Japan Collaborative Cohort Study Group

The present members of the JACC Study Group and their affiliations are as follows: Dr. Akiko Tamakoshi (present chairperson of the study group), Hokkaido University Graduate School of Medicine; Drs. Mitsuru Mori & Fumio Sakauchi, Sapporo Medical University School of Medicine; Dr. Yutaka Motohashi, Akita University School of Medicine; Dr. Ichiro Tsuji, Tohoku University Graduate School of Medicine; Dr. Yosikazu Nakamura, Jichi Medical School; Dr. Hiroyasu Iso, Osaka University School of Medicine; Dr. Haruo Mikami, Chiba Cancer Center; Dr. Michiko Kurosawa, Juntendo University School of Medicine; Dr. Yoshiharu Hoshiyama, Yokohama Soei University; Dr. Naohito Tanabe, University of Niigata Prefecture; Dr. Koji Tamakoshi, Nagoya University Graduate School of Health Science; Dr. Kenji Wakai, Nagoya University Graduate School of Medicine; Dr. Shinkan Tokudome, National Institute of Health and Nutrition; Dr. Koji Suzuki, Fujita Health University School of Health Sciences; Dr. Shuji Hashimoto, Fujita Health University School of Medicine; Dr. Shogo Kikuchi, Aichi Medical University School of Medicine; Dr. Yasuhiko Wada, Faculty of Nutrition, University of Kochi; Dr. Takashi Kawamura, Kyoto University Center for

Student Health; Dr. Yoshiyuki Watanabe, Kyoto Prefectural University of Medicine Graduate School of Medical Science; Dr. Kotaro Ozasa, Radiation Effects Research Foundation; Dr. Tsuneharu Miki, Kyoto Prefectural University of Medicine Graduate School of Medical Science; Dr. Chigusa Date, School of Human Science and Environment, University of Hyogo; Dr. Kiyomi Sakata, Iwate Medical University; Dr. Yoichi Kurozawa, Tottori University Faculty of Medicine; Drs. Takesumi Yoshimura & Yoshihisa Fujino, University of Occupational and Environmental Health; Dr. Akira Shibata, Kurume University; Dr. Naoyuki Okamoto, Kanagawa Cancer Center; and Dr. Hideo Shio, Moriyama Municipal Hospital.

Conflicts of interest

The authors have no conflicts of interest to disclose.

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Table 1. Baseline characteristics of participants according to television viewing time (hours/day).

Characteristics		**Male**			**Female**		
		Television Viewing Time			Television Viewing Time		
		<2 (n=4,233)	≥2 to <4 (n=13,866)	≥4 (n=4,991)	<2 (n=5,836)	≥2 to <4 (n=16,765)	≥4 (n=8,567)
Age (years)		55.6±10.5	56.7±10.0	61.4±9.6	54.8±10.3	57.0±9.9	60.7±9.5
Smoking status							
Never smoker of exposure to	4 days/week or less	86(2.0)	293(2.1)	103(2.1)	622(10.7)	1633(9.7)	771(9.0)
ETS at home or in public places	Almost everyday	351(8.3)	828(6.0)	187(3.7)	2,145(36.8)	5,950(35.5)	2,501(29.2)
	Unknown	682(16.1)	1,708(12.3)	535(10.7)	2,817(48.2)	8,192(48.9)	4,407(51.4)
Former smoker	Quit ≥10 years ago	502(11.9)	1,596(11.5)	688(13.8)	22(0.4)	87(0.5)	73(0.9)
	Quit <10 years ago	426(10.1)	1,601(11.5)	625(12.5)	30(0.5)	84(0.5)	113(1.3)
	Unknown	117(2.8)	499(3.6)	195(3.9)	11(0.2)	51(0.3)	30(0.4)
Current smoker	<20 pack years	392(9.2)	1,140(8.2)	306(6.1)	136(2.3)	516(3.1)	378(4.4)
	≥20 pack years	1,558(36.8)	5,900(42.6)	2,239(44.9)	37(0.6)	180(1.1)	230(2.7)
	Unknown	119(2.8)	1,708(12.3)	113(2.3)	16(0.3)	72(0.4)	64(0.7)
Body mass index (kg/m^2)	18.5-24.9	3,118(73.7)	10,123(73.0)	3,510(70.3)	4,098(70.2)	11,569(69.0)	5,501(64.2)
College education		913(21.6)	2,310(16.7)	706(14.1)	764(13.1)	1,550(9.2)	659(7.7)
Married		3,770(89.1)	12,125(87.4)	4,155(83.3)	4,763(81.6)	13,178(78.6)	5,943(69.4)
Current alcohol drinker		3,250(76.8)	10,233(73.8)	3,181(63.7)	1,208(20.7)	3,746(22.3)	2,032(23.7)
Daily walking time (hours)	>1	1,859(48.4)	6,202(49.8)	1,913(43.1)	2,780(52.4)	7,676(51.5)	3,339(44.5)
Daily dietary consumption	Green leafy vegetables	2,145(57.1)	7,623(55.0)	2,623(52.6)	3,683(63.1)	10,395(62.0)	5,165(60.3)
	Oranges	1,932(45.6)	6,618(47.7)	2,475(49.6)	3,563(61.1)	10,779(64.3)	5,665(66.1)
	Fruits other than oranges	2,077(49.1)	6,828(49.2)	2,419(48.5)	3,745(64.2)	10,987(65.5)	5,498(63.8)

Values are expressed as mean±standard deviation or number (%).
ETS, Environmental Tobacco Smoke

Table 2. HRs for lung cancer incidence associated with television viewing time (hours/day)

Television Viewing Time	Person-years	Cases	Age-adjusted HR(95%CI)	Multivariate HR(95%CI)[1]	Multivariate HR(95%CI)[2]
Male					
<2	59,039	79	Ref	Ref	Ref
≥2 to <4	189,295	356	1.34(1.06-1.72)*	1.23(0.97-1.58)	1.24(0.98-1.60)
≥4	58,114	163	1.56(1.19-2.05)*	1.36(1.04-1.79)*	1.36(1.04-1.80)*
P for linear trend			0.004	0.06	0.06
Female					
<2	80,648	32	Ref	Ref	Ref
≥2 to <4	229,398	111	1.11(0.76-1.67)	1.09(0.74-1.64)	1.11(0.76-1.67)
≥4	104,386	57	1.08(0.70-1.69)	1.01(0.66-1.59)	1.03(0.67-1.62)
P for linear trend			0.63	0.37	0.40

HR: Hazard ratio. CI: confidence intervals. *P<0.05.

[1]adjusted for age, smoking status. [2]adjusted for age, body mass index, education, marital status, alcohol drinking, smoking status, intake of green leafy vegetables, oranges, and fruits other than oranges.

Tests for linear trend were conducted to assess associations between the original continuous variables of daily hours spent watching TV and risk of lung cancer incidence.