The Mediating Effect of Life-style Behaviors on the Association Between Personality Traits and Cardiovascular Disease Mortality Among 29,766 Community-Dwelling Japanese

Mamoru Narita, BSc, Fumiya Tanji, PhD, Yasutake Tomata, PhD, Kentaro Mori, BSc, and Ichiro Tsuji, MD, PhD

ABSTRACT

Objective: Personality traits have been associated with an increased risk of cardiovascular disease (CVD) mortality as well as life-style-related cardiovascular risk factors. However, the mediating effects of life-style behaviors in the association between personality factors and CVD mortality remain insufficiently understood. The aim of the present study was to examine the mediating effect of life-style behaviors on the association between personality traits and CVD mortality.

Methods: We conducted a prospective cohort study of 29,766 Japanese adults aged 40 to 64 years at the baseline and followed them up for 20.8 years from 1990 to 2011. Personality was measured using the Japanese version of the Eysenck Personality Questionnaire – Revised Short Form in 1990. We estimated the multivariable hazard ratio and 95% confidence interval for CVD mortality using Cox proportional hazards models, and explored the mediating effects of life-style behaviors (smoking, drinking, body mass index, and time spent walking) on the association between personality traits and CVD mortality.

Results: We documented 1033 deaths due to CVD during 562,446 person-years of follow-up. Psychoticism represents tough-mindedness, aggressiveness, coldness, a lack of deliberateness, and egocentricity. After adjusting for confounding variables, higher psychoticism was associated with CVD mortality (base model hazard ratio = 1.36, 95% confidence interval = 1.14–1.61, p trend < .001). All the life-style behaviors together mediated this association by 19.2%, with smoking having the greatest effect at 15.7%. For the other personality traits, no significant associations with CVD mortality were found.

Conclusion: The present study demonstrated that life-style behaviors, especially smoking, partially mediate the association between psychoticism and CVD mortality.

Key words: personality, life-style behavior, mediation, cardiovascular disease, mortality.

INTRODUCTION

Many studies have investigated the relationship between personality and disease, especially cardiovascular disease (CVD). For example, some studies have reported that higher neuroticism or lower conscientiousness are associated with CVD death (1,2). Although these findings suggest that common genetic factors (e.g., the coexistence of anxiety and depression) or common developmental origins in personality traits (e.g., shared family influences) might influence the association between personality traits and CVD death, they have also indicated that life-style behaviors might mediate this association (1,2).

Some studies have demonstrated that people are more likely to exhibit life-style behaviors because of personality traits (3–8). For example, those with higher extraversion, neuroticism (3), and inadequacy (4) or lower conscientiousness are more likely to smoke (5). In addition, it has been reported that individuals with higher extraversion are more likely to drink (6); that those with type D personality, a blend of high neuroticism and low extraversion,

are less likely to have healthy dietary habits and physical activity (7); and that extraversion, neuroticism, agreeableness, and type D personality are related to body mass index (BMI) (6–8). These life-style behaviors (smoking, drinking, BMI, and time spent walking) are major risk factors for CVD. Therefore, there is a possibility that a specific personality trait would tend to be associated with health-harming behaviors, and this was partially related to CVD death.

However, few studies have examined the mediation effect of life-style behaviors in relation to personality traits. A previous study has shown that alcohol use, smoking, and central adiposity mediated the association between conscientiousness and all-cause mortality by 42% (9). Another study has shown that the

BMI = body mass index, **CI** = confidence interval, **CVD** = cardiovascular disease, **EPQ-R** = Eysenck Personality Questionnaire – Revised, **HR** = hazard ratio, **ICD** = International Classification of Diseases, **IHD** = ischemic heart disease, **n/a** = not applicable

SDC Supplemental Content

From the Division of Epidemiology, Department of Health Informatics and Public Health (Narita, Tanji, Tomata, Mori, Tsuji), Tohoku University School of Public Health, Graduate School of Medicine, Sendai; and Faculty of Nursing (Tanji), Japanese Red Cross Akita College of Nursing, Akita, Japan.

Address correspondence to Ichiro Tsuji, MD, PhD, Division of Epidemiology, Department of Health Informatics and Public Health, Tohoku University School of Public Health, Graduate School of Medicine, 2-1, Seiryomachi, Aoba-ku, Sendai, Miyagi 980-8575, Japan. E-mail: tsuji1@med.tohoku.ac.jp

M.N. and F.T. contributed equally to this article.

Received for publication July 29, 2018; revision received January 11, 2019.

DOI: 10.1097/PSY.0000000000000757

Copyright © 2019 by the American Psychosomatic Society

association between low conscientiousness and all-cause mortality was attenuated by 13% after adjustment for health behaviors (10). To our knowledge, however, no study has investigated the mediating effect of life-style behaviors on the association between personality traits and CVD mortality.

Our study aim was to estimate the mediating effect of life-style behaviors on the association between personality traits and CVD mortality. Personality traits were measured by the Eysenck Personality Questionnaire – Revised (EPQ-R). Life-style factors (smoking, drinking, BMI, and time spent walking) were tested as mediators.

METHODS

Study Cohort

The design of the Miyagi Cohort Study has been described in detail elsewhere (11–13). Briefly, we delivered two self-report questionnaires to all 51,921 residents (25,279 men and 26,642 women) aged 40 to 64 years in 14 municipalities of Miyagi Prefecture, northeastern Japan, between June and August 1990. Miyagi Prefecture has 71 municipalities, including both urban and rural areas, with a total population of 2,176,295 (1985 census). All of the study participants lived in rural areas of Miyagi Prefecture.

The first questionnaire asked about life-style-related behaviors including smoking, drinking, BMI, and time spent walking. The second questionnaire asked about personality traits using the Japanese version of the EPQ-R Short Form (14). The questionnaires were delivered to, and collected from, participants' residences by members of Health Promotion Committees appointed by the municipal government. We excluded one participant because of withdrawal before June 1990 ($n = 51,920$). The response rate for the first questionnaire was 91.7% ($n = 47,604$). In addition, we excluded 6181 participants who missed all items for the EPQ-R ($n = 41,423$). The study protocol was approved by the institutional review board of the Tohoku University School of Medicine. We considered the return of self-administered questionnaires signed by the participants to imply their consent to participate in the study.

Follow-up

The primary outcome was CVD death, and the secondary outcomes were ischemic heart disease (IHD) and stroke. To follow up the participants for mortality and migration, we established a follow-up committee (15). This committee consisted of the Miyagi Cancer Society, the Community Health Divisions of all 14 municipalities, the Department of Health and Welfare of Miyagi Prefectural Government, and the Division of Epidemiology, Tohoku University Graduate School of Medicine. The committee periodically reviewed the Residential Registration Record for each municipality. With this review, we identified participants who had either died or emigrated during the follow-up period. We discontinued follow-up of those who had emigrated from the study area because the Committee could not review the Residential Registration Record outside the study area. For decedents, we investigated the causes of death by reviewing the death certificates with permission from the Ministry of Health, Labour and Welfare, Japan. Cause of death was classified according to the *International Classification of Diseases, Ninth Revision (ICD-9)*, between June 1, 1990, and December 31, 1998 (16), and *Tenth Revision (ICD-10)*, between January 1, 1999, and March 10, 2011 (17). Deaths due to CVD, IHD, and stroke were identified as *ICD-9*: 390–459 or *ICD-10*: 100–199, *ICD-9*: 410–414 or *ICD-10*: I20–I25, and *ICD-9*: 430–438 or *ICD-10*: I60–I69, respectively. Of the 41,423 participants who responded to the two questionnaires, we excluded 54 participants who responded “yes” or “no” to all 48 items and 8600 participants for whom responses to any of the 48 items in the EPQ-R were missing. We also excluded 2493 participants who indicated that the two questionnaires had been completed by other family members because we considered that such aid might have affected the participants' response patterns. In addition, we excluded 510 participants who had entered a history of myocardial infarction or stroke

in the self-reported questionnaire. Finally, 29,766 participants (14,398 men and 15,368 women) were used for the final analysis. We counted person-years of follow-up for each participant from June 1, 1990, to the date of death; the date of emigration from the study districts; or the end of follow-up (March 10, 2011), whichever occurred first. A total of 562,446 person-years resulted. Among the 29,766 participants, the number of deaths due to CVD was 1033. A total of 2021 participants (6.8% of the analytic cohort) were lost to follow-up during the study period.

Personality

The EPQ-R has 48 questions with dichotomized responses (yes or no), and scores for each of the four traits (extraversion, neuroticism, psychoticism, lie) are calculated on the basis of 12 questions each. The scores on each trait range from 0 to 12, with higher scores indicating a greater tendency to possess the personality trait represented by each trait. Extraversion represents sociability, liveliness, and surgency; neuroticism represents emotional instability and anxiousness; psychoticism represents tough-mindedness, aggressiveness, coldness, a lack of deliberateness, and egocentricity; and lie represents a tendency to answer questions untruthfully, social naivete, and religiosity (18).

Several of Eysenck's personality questionnaires have been translated into Japanese (14). In previous work, Hosokawa and Ohyama (14) developed the Japanese version of the EPQ-R and examined its reproducibility and validity among 329 college students and 253 adults who lived in the same area as that used in the present study. Cronbach α , a measure of internal consistency, was $>.70$ for all traits except psychoticism (.42 for college students and .48 for adults). Low α values for psychoticism may be caused by low reliability, narrow range of scoring, or grossly skewed distribution (19). Test-retest reliability coefficients of the four traits over a 6-month period ranged from 0.70 to 0.85, indicating substantial stability.

Life-style Behaviors (Mediators)

For assessment of smoking status, the questionnaire first inquired if participants were current smokers, were past smokers, or had never smoked (reference category). Smokers were then asked about the number of cigarettes smoked per day and the duration of smoking. Subsequently, we classified current smokers into two categories: light smokers (<20 cigarettes per day) and heavy smokers (≥ 20 cigarettes per day). The questionnaire also inquired firstly if participants were current drinkers, were past drinkers, or had never drunk alcohol (the reference category). Current drinkers were then asked about their frequency of drinking, the amount drunk on one occasion, and the types of beverage usually consumed. From these data, we calculated the amount of ethanol (in grams) consumed per day and classified the current drinkers into two categories: light drinkers (<23.0 g ethanol per day) and heavy drinkers (≥ 23.0 g ethanol per day). We calculated BMI (in kilograms per meter squared) and grouped the participants into four categories: <18.5 , 18.5 to 24.9, ≥ 25.0 , and missing, based on the proposal by the World Health Organization. As an index of physical activity, we used time spent walking per day and grouped participants into four categories: <30 minutes, 30 minutes to 1 hour, ≥ 1 hour, or missing.

Statistical Analysis

Each personality trait was divided into four categories to distribute the total participants as closely as possible into even-sized quartiles. We used the Cox proportional hazards model to calculate the hazard ratios (HRs) and 95% confidence intervals (CIs) for CVD mortality (the primary outcome) and to adjust for potentially confounding variables. We also examined the association between personality traits and the secondary outcome (IHD and stroke mortality). Furthermore, following the method by Almada et al. (20), we estimated the HRs and 95% CIs of CVD, IHD, and stroke death associated with the difference between the 10th and 90th percentile values for each personality component score. We first examined the association between life-style factors as mediators and CVD mortality, and then the association between personality traits and CVD mortality. Trend tests were

performed by treating personality traits as continuous variables. In these analyses, we regarded the following variables as potential confounders (base model): age (continuous variable), sex, education (in school until age ≤ 15 years, age 16–18 years, age ≥ 19 years, or missing), and marital status (living with spouse, not living with spouse or missing).

In addition, we conducted a sensitivity analysis to examine the association between personality traits and CVD mortality, including participants who had missed some of the items on the personality scale or who had asked somebody else to rate them ($n = 40,560$). Multiple imputations were conducted for missing values of the 48 items in the EPQ-R to create 10 output data sets. The Cox models were then applied to the imputed data to recalculate the pooled HRs and 95% CIs for CVD mortality.

We first calculated HRs, 95% CIs, and p values for analysis of linear trends (p trend) of the base model. In addition, we added each variable of life-style behavior (smoking, drinking, BMI, or time spent walking) to the base model to evaluate the proportion of mediating effect of life-style behavior on the association between personality traits and CVD mortality. To do so, we calculated the proportion of mediation effect and its 95% CI using the publicly available %Mediate macro (21,22). In addition, the effects of each potential mediator were also tested using the Baron and Kenny causal steps approach (23) and the Sobel test (24) for sensitivity analysis. Both variables of personality traits and life-style behaviors were collected at the same time (i.e., cross-sectionally). Therefore, we used a logistic regression model to examine the association between personality traits and life-style behaviors. Path coefficients (total effect, direct effect, indirect effect) were calculated using logistic regression models.

Statistical analyses were performed using the SAS software package (version 9.4; SAS Institute Inc., Cary, North Carolina). Multiple imputations were performed using IBM SPSS Statistics version 25 (IBM SPSS Software Group, Chicago, Illinois). All reported p values were two-sided and were considered statistically significant if $< .05$.

RESULTS

During 562,446 person-years of follow-up, we documented 1033 (676 men and 357 women) deaths due to CVD. The baseline characteristics of each personality trait are shown in Table 1. People with higher extraversion were more likely to smoke, drink, be overweight, and walk ≥ 1 h/d. People with higher neuroticism were less likely to smoke, drink, be overweight, and walk ≥ 1 h/d. People with higher psychoticism were more likely to smoke and drink. People with higher lie were less likely to smoke and drink, and more likely to walk ≥ 1 h/d.

The association between life-style factors (smoking, drinking, BMI, and time spent walking per day) and CVD mortality is shown in Table S1 (Supplemental Digital Content 1, <http://links.lww.com/PSYMED/A590>). Smoking (current and past smokers), drinking (heavy and past drinkers), BMI (< 18.5 and ≥ 25.0), and time spent walking per day (< 1 h) were associated with CVD mortality in the age- and sex-adjusted model.

The association between personality traits and CVD mortality is shown in Table 2. Higher psychoticism was significantly associated with CVD mortality in the crude model (HR of the highest group = 1.34, 95% CI = 1.14–1.58, p trend $< .001$), the age- and sex-adjusted model (HR = 1.37, 95% CI = 1.16–1.63, P -trend $< .001$), and the base model (HR = 1.36, 95% CI = 1.14–1.61, p trend $< .001$). Higher lie was significantly associated with CVD mortality in the crude model (HR = 1.78, 95% CI = 1.49–2.14, p trend $< .001$), but the association was not significant in the base model (HR = 1.12, 95% CI = 0.92–1.35, p trend = .42). Higher extraversion (HR = 0.93, 95% CI = 0.78–1.10, p trend = .59) and higher neuroticism (HR = 0.97, 95% CI = 0.82–1.14, p trend = .77)

were not significantly associated with CVD mortality in the base model. We estimated the HRs and 95% CIs of CVD death associated with the difference between the 10th and 90th percentile values for each personality component score. The differences between the 10th and 90th percentile values were 8 points for the extraversion component score, 9 points for the neuroticism component score, 5 points for the psychoticism component score, and 6 points for the lie component score. The base model HR associated with a difference of 5 points on the psychoticism trait was significant (HR = 1.57, 95% CI = 1.31–1.90). For another personality traits, there was non-significant association with CVD mortality.

The result of sensitivity analysis about the association between personality traits and CVD mortality, including participants who missed some of items about the personality scale and who asked somebody to rate them, is shown in Table S2, Supplemental Digital Content 1, <http://links.lww.com/PSYMED/A590> ($n = 40,560$). The results essentially remained unchanged from those in Table 2.

Furthermore, we evaluated the association between personality traits and IHD or stroke (Tables S3, S4, Supplemental Digital Content 1, <http://links.lww.com/PSYMED/A590>). The association between higher psychoticism and IHD mortality was significant in the crude model (HR = 1.48, 95% CI = 1.05–2.09, p trend = .010), the age- and sex-adjusted model (HR = 1.42, 95% CI = 0.99–2.02, p trend = .022), and the base model (HR = 1.40, 95% CI = 0.98–2.00, p trend = .029). The association between higher neuroticism and IHD mortality was nonsignificant in the base model. In addition, the association between psychoticism and stroke mortality was significant in the crude model (HR = 1.20, 95% CI = 0.94–1.54, p trend = .040), the age- and sex-adjusted model (HR = 1.29, 95% CI = 0.99–1.66, p trend = .008), and the base model (HR = 1.27, 95% CI = 0.98–1.64, p trend = .012).

Because only psychoticism was significantly associated with CVD mortality, the mediation analysis was focused on the proportion of mediating effect for the association between psychoticism and CVD mortality. Table 3 shows HRs and 95% CIs in the base model and the model where several variables of life-style behavior were added to the base model, and the proportion of mediating effect for life-style behaviors. The proportion of mediating effect was calculated by comparing the lowest score quartile with the other groups. The proportion of mediating effect of the fourth quartile showed that smoking and BMI significantly mediated the association between psychoticism and CVD mortality by 15.7% and 2.5%, respectively. The life-style behaviors overall significantly mediated this association by 19.2%.

The results of sensitivity analysis to examine the mediating effects of life-style factors on the association between psychoticism and CVD mortality using a Sobel test are shown in Figure S1, Supplemental Digital Content 2, <http://links.lww.com/PSYMED/A591>. Only smoking had a significant mediating effect on the association between psychoticism and CVD mortality ($p < .001$).

Furthermore, in the same way as Table 3, we examined the proportion of mediating effect for the association between psychoticism and IHD or stroke mortality (Supplementary Table S5, Supplemental Digital Content 1, <http://links.lww.com/PSYMED/A590>). The association between psychoticism and IHD mortality was attenuated by life-style behaviors. The proportion of mediating effect of the fourth quartile shows that smoking mediated the association by 16.7%. The life-style behaviors overall mediated the association by 25.1%. The association between psychoticism and stroke

TABLE 1. Baseline Characteristics According to Personality Score Quartiles ($n = 29,766$)

	Extraversion					Neuroticism					Psychoticism					Lie				
	≤3	4-5	6-8	≥9	≤3	4-5	6-7	≥8	≤2	3	4	≥5	≤5	6-7	8-9	≥10				
No. participants	8812	6518	8229	6207	8562	6428	6262	8514	9688	7263	5900	6915	7226	7470	9026	6044				
Women, %	53.5	53.1	51.3	47.9	47.7	52.1	52.8	54.4	65.6	55.1	47.1	32.3	39.5	52.3	57.1	57.2				
Age, mean (SD), y	50.8 (7.5)	51.3 (7.6)	51.3 (7.5)	51.1 (7.4)	51.5 (7.6)	51.3 (7.5)	51.1 (7.5)	50.7 (7.5)	52.0 (7.6)	51.5 (7.5)	50.8 (7.4)	49.8 (7.3)	48.0 (6.9)	50.2 (7.4)	52.2 (7.4)	54.4 (7.0)				
Smoking, %																				
Heavy (≥20 cigarettes/d)	21.2	21.8	24.4	26.6	25.6	23.2	23.2	21.3	14.6	20.6	26.0	36.1	33.0	23.3	19.7	17.3				
Light (<20 cigarettes/d)	8.1	8.8	9.2	10.6	9.4	9.4	8.5	8.9	6.9	9.3	9.9	11.2	9.9	9.2	8.8	8.2				
Past	10.3	10.2	10.1	10.1	9.8	9.8	10.7	10.6	8.6	9.7	10.9	12.4	12.0	10.7	9.3	8.9				
Never	48.7	46.2	44.1	41.7	44.2	45.5	45.3	46.6	55.4	47.4	41.9	32.3	39.0	45.9	47.6	49.1				
Missing	11.7	13.0	12.2	10.9	11.0	12.1	12.3	12.6	14.5	13.0	11.3	8.0	6.1	10.9	14.6	16.5				
Drinking, %																				
Heavy (≥23.0 g ethanol/d)	23.8	26.7	29.1	32.2	29.2	28.1	26.9	26.3	19.7	25.5	31.1	38.1	36.5	28.0	24.3	21.6				
Light (<23.0 g ethanol/d)	18.7	19.6	21.8	25.1	21.8	20.0	20.8	21.4	19.6	21.2	21.8	22.5	24.3	22.4	19.5	17.9				
Past	5.2	4.8	4.6	4.5	4.3	4.3	4.9	5.7	4.3	4.9	4.5	5.8	5.2	4.5	4.8	4.9				
Never	43.4	39.0	35.3	30.0	36.1	38.2	38.2	37.5	45.9	38.8	33.7	27.3	29.3	37.0	40.4	43.3				
Missing	8.9	9.9	9.2	8.2	8.6	9.4	9.2	9.1	10.5	9.6	8.9	6.3	4.7	8.1	11.0	12.3				
Body mass index, %																				
<18.5 kg/m ²	3.2	2.1	2.0	1.5	1.5	2.1	2.4	3.2	2.6	2.3	2.0	2.1	2.4	2.2	2.3	2.3				
18.5–24.9 kg/m ²	69.6	66.5	65.6	62.4	63.8	66.3	67.1	68.2	67.4	65.5	66.3	65.7	67.6	66.2	65.2	66.4				
≥25.0 kg/m ²	24.1	27.5	29.0	32.8	31.6	28.5	26.6	25.1	27.0	28.8	28.1	28.4	27.5	28.3	28.8	27.1				
Missing	3.1	3.9	3.4	3.3	3.1	3.1	3.9	3.5	3.0	3.4	3.6	3.8	2.5	3.3	3.7	4.2				
Time spent walking, %																				
≥1 h/d	38.2	41.1	41.6	43.9	43.3	41.0	41.2	38.4	41.2	41.1	42.2	39.5	38.9	40.3	40.5	45.0				
30 m to 1 h	22.9	23.5	23.8	24.3	24.4	23.4	23.3	23.0	24.9	23.7	22.8	22.1	24.9	23.8	23.2	22.1				
<30 min	32.1	21.3	27.9	26.7	26.2	28.9	29.0	32.6	27.8	28.8	29.1	31.8	32.9	30.3	28.3	24.8				
Missing	6.8	6.1	6.7	5.1	6.1	6.7	6.5	6.0	6.1	6.4	5.9	6.6	3.3	5.6	8.0	8.1				
Education, %																				
Age ≤15 y	36.0	34.9	33.8	31.9	33.4	34.6	35.0	34.5	33.3	34.9	34.0	35.2	29.2	33.9	35.8	35.6				
Age 16–18 y	44.5	45.4	46.5	47.1	46.2	45.1	46.2	45.7	47.6	44.9	45.6	44.5	49.4	46.0	44.9	42.7				
Age ≥19 y	14.0	13.6	13.6	16.2	15.2	14.4	13.0	14.1	14.2	14.2	14.5	14.2	16.8	14.3	13.2	12.7				
Missing	5.5	6.1	6.1	4.8	5.2	5.9	5.8	5.7	4.9	6.0	5.9	6.1	4.6	5.8	6.1	6.0				

Continued on next page

TABLE 1. (Continued)

	Extraversion				Neuroticism				Psychoticism				Lie			
	≤3	4-5	6-8	≥9	≤3	4-5	6-7	≥8	≤2	3	4	≥5	≤5	6-7	8-9	≥10
Marital status, %																
Living with spouse	81.5	82.6	83.1	85.3	83.4	83.0	83.0	82.6	82.8	82.7	83.3	83.3	86.9	84.9	80.8	79.1
Single	9.9	8.5	8.6	7.6	8.1	8.5	8.8	9.5	9.3	8.4	8.5	8.5	7.7	7.9	9.4	10.0
Missing	8.6	8.9	8.3	7.1	8.5	8.5	8.2	7.9	7.9	8.9	8.2	8.2	5.4	7.2	9.8	10.9

mortality was also mediated by life-style behaviors. Smoking mediated the association by 19.0%, and the life-style behaviors overall did so by 19.7%. As post hoc analysis, we examined the proportion of the mediating effect for the association between neuroticism and IHD mortality (Table S6, Supplemental Digital Content 1, <http://links.lww.com/PSYMED/A590>). This association was not mediated by life-style behaviors.

DISCUSSION

The present study investigated the mediating effect of life-style behaviors on the relationship between personality traits and CVD mortality. Higher psychoticism was associated with an increased risk of CVD mortality. Mediation analyses indicated that life-style behaviors, especially smoking, could partly explain this association. These results did not differ when the outcome was IHD and stroke death. To our knowledge, this is the first study to have examined the mediating effect of life-style-related behaviors on the association between personality and CVD mortality.

Two previous studies have reported that the association between conscientiousness and all-cause mortality was partially mediated by life-style behaviors (9,10). One study reported that heavy drinking, smoking, and greater waist circumference mediated this association by 42% (9). The other reported that smoking, alcohol consumption, dietary quality, and physical activity mediated this association by 13% (10). The present study examined the association between four personality traits (extraversion, neuroticism, psychoticism, and lie) and CVD mortality, and found that higher psychoticism was significantly associated with an increased risk of CVD mortality. In addition, life-style behaviors mediated this association by 19.2%, with smoking having an especially marked mediation effect of 15.7%. These results seem reasonable given that psychoticism can be assumed to be an opposite measure of conscientiousness and agreeableness (25). People with higher psychoticism are more likely to have unhealthy life-style behaviors (e.g., smoking), which might increase the risk of CVD mortality.

Although an association between neuroticism and CVD mortality was not observed in the present study, higher neuroticism was associated with an increased risk of IHD mortality. This association was not mediated by life-style behaviors. As shown in Table 1, the proportion of individuals who had risk factors for CVD death (smoking, drinking, or obesity) among those with higher neuroticism was lower than that among individuals with lower neuroticism. A similar phenomenon has been reported in a study that examined the effect of interaction between personality and socioeconomic status on mortality (26). That study mentioned the concept of “healthy neuroticism”: that is, higher neuroticism with greater socioeconomic resources leads to healthy behavior such as seeking advice, requesting tests and results from screening programs, and closer monitoring of life-style. Therefore, a similar phenomenon might explain the present result. The association between neuroticism and IHD mortality might be explained by biological factors, such as dysregulation of the autonomic nervous system and the hypothalamic-pituitary-adrenal axis (27).

The present study had some strengths. We found evidence that life-style behaviors, especially smoking, mediated the association between personality and CVD mortality. Although genetic factors and developmental origins are unmodifiable, it is possible to encourage individuals to improve a health-harming behavior because

TABLE 2. Association Between Personality Traits and Cardiovascular Disease Mortality ($n = 29,766$)

	Personality Score Quantiles				<i>p</i> Trend	Point Difference (10th, 90th Percentile) ^a
	≤3	4-5	6-8	≥9		
Extraversion						
No. events	306	220	294	213		8 points (2, 10)
Person-years	166,745	123,585	154,887	117,230		
Crude HR (95% CI)	1.00 (ref)	0.97 (0.82-1.15)	1.04 (0.88-1.22)	0.99 (0.83-1.18)	.82	1.02 (0.87-1.19)
Age- and sex-adjusted HR (95% CI)	1.00 (ref)	0.91 (0.76-1.08)	0.96 (0.82-1.12)	0.91 (0.77-1.09)	.51	0.95 (0.81-1.11)
Base model HR (95% CI)	1.00 (ref)	0.91 (0.77-1.08)	0.96 (0.82-1.13)	0.93 (0.78-1.10)	.59	0.96 (0.82-1.12)
Neuroticism						
No. events	≤3	4-5	6-7	≥8		9 points (1, 10)
Person-years	318	214	232	269		
Crude HR (95% CI)	1.00 (ref)	1.00 (0.85-1.19)	1.00 (0.85-1.19)	0.86 (0.73-1.01)	.058	0.84 (0.70-1.01)
Age- and sex-adjusted HR (95% CI)	1.00 (ref)	0.94 (0.79-1.12)	1.09 (0.92-1.29)	0.98 (0.83-1.15)	.87	0.98 (0.83-1.17)
Base model HR (95% CI)	1.00 (ref)	0.94 (0.79-1.11)	1.08 (0.91-1.28)	0.97 (0.82-1.14)	.77	0.97 (0.81-1.16)
Psychoticism						
No. events	≤2	3	4	≥5		5 points (1, 6)
Person-years	292	250	220	271		
Crude HR (95% CI)	1.00 (ref)	1.15 (0.97-1.37)	1.25 (1.05-1.49)	1.34 (1.14-1.58)	<.001	1.52 (1.27-1.81)
Age- and sex-adjusted HR (95% CI)	1.00 (ref)	1.13 (0.95-1.34)	1.25 (1.04-1.49)	1.37 (1.16-1.63)	<.001	1.60 (1.33-1.93)
Base model HR (95% CI)	1.00 (ref)	1.12 (0.95-1.33)	1.23 (1.03-1.47)	1.36 (1.14-1.61)	<.001	1.57 (1.31-1.90)
Lie						
No. events	≤5	6-7	8-9	≥10		6 points (4, 10)
Person-years	192	224	332	285		
Crude HR (95% CI)	1.00 (ref)	1.12 (0.92-1.35)	1.38 (1.15-1.64)	1.78 (1.49-2.14)	<.001	1.59 (1.36-1.84)
Age- and sex-adjusted HR (95% CI)	1.00 (ref)	0.96 (0.79-1.17)	1.04 (0.87-1.25)	1.13 (0.93-1.37)	.35	1.07 (0.92-1.26)
Base model HR (95% CI)	1.00 (ref)	0.96 (0.79-1.17)	1.03 (0.86-1.24)	1.12 (0.92-1.35)	.42	1.07 (0.91-1.24)

HR = hazard ratio; CI = confidence interval; ref = reference value.

Base model HR: adjustment items are age, sex, education, and marital status.

^a Relative risk of cardiovascular disease death associated with the difference between the 10th and 90th percentile values for each personality component score.

TABLE 3. Mediation Effects of Life-style Behaviors on the Association (HR [95% CI]) Between Psychoticism and Cardiovascular Disease Mortality ($n = 29,766$)

	Psychoticism Score Quartiles				Proportion of Mediating Effect (95% CI)		
	≤2 (1st)	3 (2nd)	4 (3rd)	≥5 (4th)	3 (2nd)	4 (3rd)	≥5 (4th)
Base model	1.00 (ref)	1.12 (0.95–1.33)	1.23 (1.03–1.47)	1.36 (1.14–1.61)			
Base model + smoking ^a	1.00 (ref)	1.10 (0.93–1.30)	1.20 (1.00–1.43)	1.29 (1.09–1.54)	17.9%** (3.2–59.0)	15.4%** (6.1–33.8)	15.7%** (8.4–27.5)
Base model + drinking ^b	1.00 (ref)	1.12 (0.95–1.33)	1.23 (1.03–1.47)	1.35 (1.14–1.60)	n/a	n/a	1.9% (0.3–10.4)
Base model + BMI ^c	1.00 (ref)	1.12 (0.95–1.33)	1.23 (1.03–1.47)	1.35 (1.14–1.60)	1.6% (0.1–27.4)	1.7% (0.3–8.3)	2.5%** (1.0–5.8)
Base model + time spent walking ^d	1.00 (ref)	1.13 (0.95–1.33)	1.24 (1.04–1.48)	1.36 (1.14–1.61)	n/a	n/a	n/a
Base model + all of life-style behaviors ^e	1.00 (ref)	1.10 (0.93–1.31)	1.20 (1.00–1.43)	1.28 (1.08–1.52)	16.2%* (2.6–58.5)	14.7%** (5.4–34.2)	19.2%** (10.1–33.6)

HR = hazard ratio; CI = confidence interval; ref = reference value; n/a = not applicable; BMI = body mass index.

Base model HR: adjustment items are age, sex, education, and marital status. n/a: proportion of mediating effect (%) < 1.0.

^a Dummy variables for smoking: heavy (≥20 cigarettes/d), light (<20 cigarettes/d), past, never smoker, and missing.

^b Dummy variables for drinking: heavy (≥23.0 g ethanol/d), light (<23.0 g ethanol/d), past, never drinker, and missing.

^c Dummy variables for BMI: <18.5, 18.5–24.9, and ≥25.0 kg/m² and missing.

^d Dummy variables for time spent walking: <30 minutes, 30 minutes to 1 hour, ≥1 hour, and missing.

^e Combined a, b, c, and d.

* $p < .05$.

** $p < .01$.

of a personality trait. In addition, the present study was also based on a large sample size (29,766 adults) and involved a long follow-up period (mean, 18.9 years).

There were also some limitations to the present study. First, we had no information on potential confounders such as prescription medications and the prevalence of psychiatric disorders. Second, because we had no data on changes in the life-style behavior of our study participants during the follow-up period, we could not consider the mediating effect of such changes on the association between personality traits and CVD mortality. Third, personality traits and mediators were measured at the same time in the present study. Therefore, the present mediation analyses were prone to bias (28). Fourth, we may need to consider a multiple comparison because we have used the four personality traits in our analyses. Considering multiple tests by the Bonferroni's correction, p values were considered statistically significant if <.0125. However, the results remained statistically significant in Table 2.

Despite these limitations, the present findings highlight the importance of life-style behavior as a modifiable mediator contributing to the risk of CVD mortality linked to psychoticism. Future public health action should consider strategies for behavior modification in accordance with personality.

CONCLUSIONS

The present study has demonstrated that life-style-related behaviors, especially smoking, partially mediate the association between psychoticism and CVD mortality, whereas they do not mediate the association between neuroticism and CVD mortality.

We would like to thank Yoshiko Nakata and Mami Takahashi for their technical assistance.

Source of Funding and Conflicts of Interest: This work was supported by Health Sciences Research grants (no. H28-Junkankitou-Ippan-008) from the Ministry of Health, Labour and Welfare of Japan. The authors have no competing interests to report.

REFERENCES

1. Shipley BA, Weiss A, Der G, Taylor MD, Deary IJ. Neuroticism, extraversion, and mortality in the UK Health and Lifestyle Survey: a 21-year prospective cohort study. *Psychosom Med* 2007;69:923–31.
2. Jokela M, Pulkki-Räback L, Elovainio M, Kivimäki M. Personality traits as risk factors for stroke and coronary heart disease mortality: pooled analysis of three cohort studies. *J Behav Med* 2014;37:881–9.
3. Munafò MR, Zetteler JJ, Clark TG. Personality and smoking status: a meta-analysis. *Nicotine Tob Res* 2007;9:405–13.
4. Twisk JW, Snel J, Kemper HC, van Mechelen W. Relation between the longitudinal development of personality characteristics and biological and lifestyle risk factors for coronary heart disease. *Psychosom Med* 1998;60:372–7.
5. Hakulinen C, Hintsanen M, Munafò MR, Virtanen M, Kivimäki M, Batty GD, Jokela M. Personality and smoking: individual-participant meta-analysis of nine cohort studies. *Addiction* 2015;110:1844–52.
6. Otonari J, Nagano J, Morita M, Budhathoki S, Tashiro N, Toyomura K, Kono S, Imai K, Ohnaka K, Takayanagi R. Neuroticism and extraversion personality traits, health behaviours, and subjective well-being: the Fukuoka Study (Japan). *Qual Life Res* 2012;21:1847–55.
7. Mommersteeg PM, Kupper N, Denollet J. Type D personality is associated with increased metabolic syndrome prevalence and an unhealthy lifestyle in a cross-sectional Dutch community sample. *BMC Public Health* 2010;10:714.
8. Sutin AR, Stephan Y, Wang L, Gao S, Wang P, Terracciano A. Personality traits and body mass index in Asian populations. *J Res Pers* 2015;58:137–42.
9. Turiano NA, Chapman BP, Gruenewald TL, Mroczek DK. Personality and the leading behavioral contributors of mortality. *Health Psychol* 2015;34:51–60.
10. Hagger-Johnson G, Sabia S, Nabi H, Brunner E, Kivimäki M, Shipley M, Singh-Manoux A. Low conscientiousness and risk of all-cause, cardiovascular and cancer mortality over 17 years: Whitehall II cohort study. *J Psychosom Res* 2012;73:98–103.
11. Fukao A, Tsubono Y, Komatsu S, Tsuji I, Minami Y, Hisamichi S, Hosokawa T, Kawamura M, Takano A, Sugahara N, Ikeda T, Nishikori M. A cohort study on the relation of lifestyle, personality and biologic markers to cancer in Miyagi, Japan: study design, response rate and profiles of the cohort subjects. *J Epidemiol* 1995;5:153–7.

12. Nakaya N, Tsubono Y, Hosokawa T, Hozawa A, Kuriyama S, Fukudo S, Tsuji I. Personality and mortality from ischemic heart disease and stroke. *Clin Exp Hypertens* 2005;27:297–305.
13. Tanji F, Kakizaki M, Sugawara Y, Watanabe I, Nakaya N, Minami Y, Fukao A, Tsuji I. Personality and suicide risk: the impact of economic crisis in Japan. *Psychol Med* 2015;45:559–73.
14. Hosokawa T, Ohyama M. Reliability and validity of the Japanese version of the short form Eysenck Personality Questionnaire – Revised. *Psychol Rep* 1993;72:823–32.
15. Tsuji I, Nishino Y, Tsubono Y, Suzuki Y, Hozawa A, Nakaya N, Fujita K, Kuriyama S, Shibuya D, Fukao A, Hisamichi S. Follow-up and mortality profiles in the Miyagi Cohort Study. *J Epidemiol* 2004;14(Suppl. 1):S2–6.
16. WHO. Manual of the International Statistical Classification of Diseases, Injuries, and Causes of Death, 9th Revision. Geneva: World Health Organization; 1977.
17. WHO. International Statistical Classification of Diseases and Related Health Problems, 10th Revision. Geneva: World Health Organization; 1992.
18. Eysenck HJ, Eysenck SBG. Manual of the Eysenck Personality Scales (EPS Adult). London: Hodder and Stoughton; 1991.
19. Eysenck SBG, Eysenck HJ, Barrett P. A revised version of the psychoticism scale. *Pers Individ Diff* 1985;6:21–9.
20. Almada SJ, Zonderman AB, Shekelle RB, Dyer AR, Daviglus ML, Costa PT Jr., Stamler J. Neuroticism and cynicism and risk of death in middle-aged men: the Western Electric Study. *Psychosom Med* 1991;53:165–75.
21. Lin DY, Fleming TR, De Gruttola V. Estimating the proportion of treatment effect explained by a surrogate marker. *Stat Med* 1997;16:1515–27.
22. Jun HJ, Austin SB, Wylie SA, Corliss HL, Jackson B, Spiegelman D, Pazaris MJ, Wright RJ. The mediating effect of childhood abuse in sexual orientation disparities in tobacco and alcohol use during adolescence: results from the Nurses' Health Study II. *Cancer Causes Control* 2010;21:1817–28.
23. Baron RM, Kenny DA. The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *J Pers Soc Psychol* 1986;51:1173–82.
24. Preacher KJ, Leonardelli GL. Calculation for the Sobel test: an interactive calculation tool for mediation tests. Available at: <http://quantpsy.org/sobel/sobel.htm>. Accessed January 8, 2019.
25. Kotov R, Gamez W, Schmidt F, Watson D. Linking “big” personality traits to anxiety, depressive, and substance use disorders: a meta-analysis. *Psychol Bull* 2010;136:768–821.
26. Hagger-Johnson G, Roberts B, Boniface D, Sabia S, Batty GD, Elbaz A, Singh-Manoux A, Deary IJ. Neuroticism and cardiovascular disease mortality: socioeconomic status modifies the risk in women (UK Health and Lifestyle Survey). *Psychosom Med* 2012;74:596–603.
27. Rugulies R. Depression as a predictor for coronary heart disease. a review and meta-analysis. *Am J Prev Med* 2002;23:51–61.
28. Maxwell SE, Cole DA. Bias in cross-sectional analyses of longitudinal mediation. *Psychol Methods* 2007;12:23–44.