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# Association of Lifestyle with Physical and Mental Health in Japanese Radiological Technologists

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**To elucidate the effects of low-dose radiation exposure and lifestyle on physical health and mental health, we evaluated the relationship of age, cumulative radiation dose, and lifestyle (cigarette smoking, alcohol drinking and physical exercise) to physical and mental health in Japanese radiological technologists. The study subjects were 932 Japanese radiological technologists who participated in a health study from 1981 to 1985. A self-administered questionnaire was mailed to each subject to obtain information on the items listed above. Items that measured the status of physical and mental health were summarized as several indices and several categories based on the principal component analysis and quantification method III, respectively. The association of age, cumulative radiation dose and respective categories of lifestyle with summarized indices for physical health and summarized categories for mental health were analyzed using multivariate linear regression and multiple linear logistic regression, respectively. A significant decrease with age was observed in physical health but not in mental health except for stress and physical complaints. No significant effects of cumulative radiation dose were observed on physical or mental health. Unfavorable effects of current-smoking were observed in some categories of physical health and mental health. In contrast to cigarette smoking, current alcohol drinking, especially light-drinking, showed favorable effects in several categories of physical health and mental health, while ex-drinking showed unfavorable effects in some categories of mental health. Favorable effects of physical exercise, especially of high-intensity exercise were observed on both physical and mental health. Effects of occupational exposure to radiation may be negligible in Japanese radiological technologists and improvement of lifestyle is the essential factor for enhancing physical and mental health conditions.**

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**Key Words:** *low-dose radiation exposure, physical health, mental health, smoking, drinking, exercise*

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## Introduction

Along with a recent increase in concern about health, lifestyle issues such as cigarette smoking, alcohol drinking and physical exercise have been recognized to be closely related to health status. From the viewpoint of individual and public health, promotion of interest in health and establishment of practical strategies for improving and promoting health are important topics. Many epidemiological studies on the association of lifestyle with physical health and cancer mortality have been conducted.[1−13] With regard to the relationship between lifestyle and mental health, cigarette smoking, for example, was reported to be associated with symptoms of depression, and risk of depressed mood[14−16] and vague complaints.[17] Furthermore, habitual exercise, for example, was reported to have favorable effects on subjective health[18] and mental health.[19]

Health effects of low-dose radiation have been one of the major concerns. Association between occupational exposure to radiation and cancer mortality,[20−22] and cancer mortality in a high background radiation area have been studied.[23−26] Effects of radiation on clinical test data were observed to be smaller than those of smoking and drinking in Japanese radiological technologists.[27] Radiological technologists complained of irritation in eyes and upper airways more frequently than physiotherapists.[28]

To elucidate the effects of occupational exposure to low-dose radiation and lifestyle on health, we evaluated the relationship of age, cumulative radiation dose,

cigarette smoking, alcohol drinking and physical exercise to physical and mental health in Japanese radiological technologists.

## Subjects and Methods

The study subjects were radiological technologists of the Japan Association of Radiological Technologists who participated in its health study from 1981 to 1985. The objective of the study and participants' rights were explained by written documents and the participants received a free health examination. A total of 1,035 radiological technologists in 24 prefectures of Japan participated in the study after giving written consent. A self-administered questionnaire was mailed to each subject to obtain information on gender, age, cumulative radiation dose, lifestyle (cigarette smoking, alcohol drinking and physical exercise), physical health and mental health. In the present analysis, 103 subjects were excluded because they were females; the date of the survey was missing; estimate of cumulative radiation dose was unavailable; or they were aged 70 years or more. The present analysis was based on the remaining 932 subjects.

Individual cumulative radiation dose was obtained from the records of the film badge worn to monitor the exposure since 1960 when the film badge system was introduced in Japan. For exposure before 1960, the individual cumulative dose was estimated based on the average working condition, average number of daily examinations, average number of monthly working days and months of the work. See Nakamura et al.[29] for the details of the estimation method. A study on 30 of the subjects demonstrated a good correlation between the estimates obtained by the method described above and those obtained by the electron spin resonance (ESR) examination of the subjects' teeth.[30]

We evaluated lifestyle by cigarette smoking, alcohol drinking and physical exercise as follows.

Cigarette smoking was classified into 3 categories of no-smoking, ex-smoking and current smoking based on the subject's responses that he never smoked cigarettes, had smoked but stopped or was currently smoking, respectively.

Alcohol drinking was classified into 4 categories of no-drinking, ex-drinking, light drinking and heavy drinking. The definitions for the first two categories were similar as that of those for smoking. A subject was classified as light-drinking or heavy-drinking based on responses indicating that he drank a few times per month or less and that the amount of alcohol taken per session was less than 46 g or that he drank more than once a week or that the amount of alcohol taken per session was 46 g or more.

Physical exercise was classified into 3 categories of no-exercise, low-intensity exercise and high-intensity exercise. A subject who answered that he did not exercise intentionally was classified as no-exercise. A subject was classified as low-intensity exercise if he answered that he performed light exercise such as walking, cycling, rope skipping, radio gymnastic exercise, pitch and catch, and golf, while he was classified as high-intensity exercise if he answered that he played hard sports such as baseball, table tennis, running, tennis and so on.

We classified physical health into two categories of cardio-pulmonary function and physical function. We measured the following 9 items for evaluation of the cardio-pulmonary function: heart rate (beats/min), resting breath holding (sec), vital capacity (ml), forced vital capacity (ml), forced expiratory volume in one second (ml), forced expiratory volume in one second percent (%), maximal expiratory flow rate (l/min), percent vital capacity (%) and expected vital capacity (%); and the following 12 items for physical function: vertical jump (cm), standing trunk flexion (cm), trunk extension (cm), grip strength (kg), back strength (kg), zig-zag dribble (sec), side step (point), closed-eyes foot-balance (sec), floor push-ups (times), sit-ups (times), bar-gripping reaction time (cm) and fast walk (sec). However, we excluded from the analysis the forced vital capacity, forced expiratory volume in one second and percent vital capacity because these values were strongly correlated with vital capacity and forced expiratory volume in one second percent.

To summarize the measurements of the remaining 6 items for cardio-pulmonary function, we performed principal component analysis and used the first principal component score as the index of general cardio-pulmonary function; we used a logarithm of measurements instead of the original measurements if necessary to adjust these distributions close to normal distribution.

To summarize the measurements of 12 items for physical function, we first classified 12 items into the following 6 categories: muscular power (vertical jump), flexibility (standing trunk flexion, trunk extension), muscular strength (grip strength, back strength, floor push-up, sit-up), agility (zig-zag dribble, side step, bar-gripping reaction time), balance (closed-eyes foot-balance) and cardiac-respiratory endurance (fast walk). We then performed principle component analysis for each category and used the first principal component score as the index of the category.

We evaluated mental health based on the subjective

symptoms and fatigue status as follows.

We asked subjects the following 11 items regarding their subjective symptoms: poor appetite, poor sleeping, becoming fatigued easily, shortness of breath on exercise, weak stomach, poor bowel movement, pain in shoulders or waist, stiff shoulders, being in a fret, poor will to work and other symptoms. We assigned a score of 1 or 0 to each item based on the subject's responses. We classified 11 items based on quantification method Ⅲ into 3 complaint categories: stress complaints (4 items), physical complaints (4 items) and digestive complaints (3 items). A subject was considered positive for a complaint category if he complained of at least one of the items composing the complaint category.

We evaluated fatigue status of the subjects using the Fatigue Test[31] developed by Industrial Fatigue Research Committee of the Japan Society of Industrial Health. The original test consisted of 30 items but we excluded 2 items that were essentially the same as questions regarding subjective symptoms. We classified the remaining 28 items into 3 fatigue categories: drowsiness and dullness (10 items), difficulty in concentration (10 items) and projection of physical disintegration (8 items). A subject was considered positive for a fatigue category if he complained of more than two of the items composing the fatigue category. A subject was considered to have whole fatigue if he was positive for 3 fatigue categories.

Association of age (in years), cumulative radiation dose (in units of 0.01 Gy), cigarette smoking, alcohol drinking, and physical exercise with an index of general cardio-pulmonary function and each of six categories of physical function was analyzed using multivariate linear regression, while those associations with complaint categories and with fatigue categories were analyzed using multiple linear logistic regression. For categorical variables such as cigarette smoking, we introduced indicator variables to present the respective categories. For example, for cigarette smoking, we defined two indicator variables, $X_1$ and $X_2$; $X_1$=1 or 0 depending on whether the subject was classified as ex-smoking or not; and $X_2$=1 or 0 depending on whether the subject was classified as a current smoking. Thus, $X_1$=0 and $X_2$=0 indicated a subject classified as a no-smoking. REG and LOGISTIC in the SAS® system[32] were used for the calculations.

## Results

The distributions of age, cumulative radiation dose and lifestyle status of the subjects are shown in Table 1. Subject ages ranged from 22 to 69 years and the mean age was 46.9 years. Cumulative radiation dose ranged from 0.01 Gy to 4.91 Gy and the mean cumulative dose was 0.17 Gy. Figure 1 presents scatter plots of age and cumulative radiation dose.

**Table 1.** Distribution of age, cumulative radiation dose and lifestyle status in 932 Japanese radiological technologists examined in 1981-1985

| Factor | Number of subjects (%) |
|---|---|
| Age (years) | |
| < 40 | 233 (25.0) |
| 40 - 49 | 358 (38.4) |
| 50 - 59 | 241 (25.9) |
| 60 - 69 | 100 (10.7) |
| Cumulative radiation dose (Gy) | |
| < 0.1 | 258 (27.7) |
| 0.1 - 0.49 | 520 (55.8) |
| 0.5 ≦ | 154 (16.5) |
| Cigarette smoking | |
| No-smoking | 229 (24.6) |
| Ex-smoking | 236 (25.3) |
| Current smoking | 456 (48.9) |
| Data unavailable | 11 (1.2) |
| Alcohol drinking | |
| No-drinking | 142 (15.2) |
| Ex-drinking | 27 (2.9) |
| Light-drinking | 357 (38.3) |
| Heavy-drinking | 278 (29.8) |
| Data unavailable | 128 (13.7) |
| Physical exercise | |
| No-exercise | 247 (26.5) |
| Low-intensity exercise | 347 (37.2) |
| High-intensity exercise | 318 (34.1) |
| Data unavailable | 20 (2.2) |

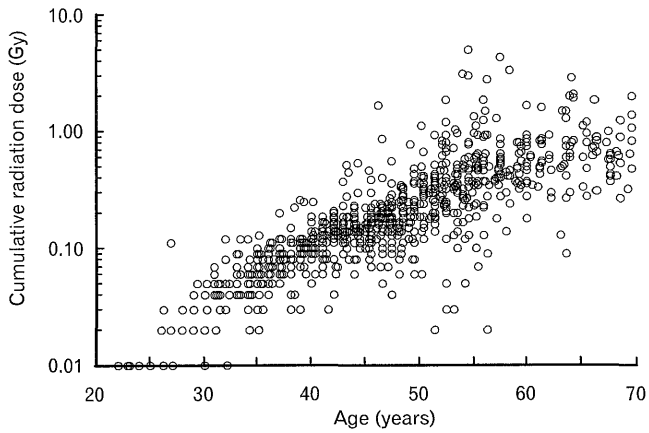


**Figure 1.** Scatter plots of age and cumulative radiation dose in 932 Japanese radiological technologists.

*Association between lifestyle and physical health*

Effects of age, cumulative radiation dose, cigarette smoking, alcohol drinking and exercise on the

**Table 2.** Estimates (95% confidence interval) of respective regression coefficients in the models predicting cardio-pulmonary function and physical function of Japanese radiological technologists: based on 932 radiological technologists examined in 1981-1985

| Factor | Cardio-pulmonary function | Physical function | | | | | |
|---|---|---|---|---|---|---|---|
| | General cardio-pulmonary function | Muscular power | Flexibility | Muscular strength | Agility | Balance | Cardiac-respiratory endurance |
| Age (year) | −0.10* (−0.11,−0.08) | −0.07* (−0.08,−0.06) | −0.02* (−0.02,−0.01) | −0.04* (−0.05,−0.03) | −0.04* (−0.05,−0.04) | −0.04* (−0.06,−0.03) | −0.04* (−0.05,−0.03) |
| Cumulative radiation dose (0.01 Gy) | 0.18* (0.01,0.35) | 0.06 (−0.03,0.14) | −0.04 (−0.08,0.01) | −0.04 (−0.12,0.04) | −0.03 (−0.09,0.03) | 0.05 (−0.06,0.16) | 0 (−0.11,0.10) |
| Cigarette smoking | | | | | | | |
| Ex-smoking | 0.17 (−0.10,0.43) | 0.04 (−0.09,0.17) | 0.04 (−0.03,0.11) | 0.10 (−0.03,0.22) | 0.10* (0.00,0.20) | −0.02 (−0.20,0.15) | 0.02 (−0.14,0.19) |
| Current-smoking | −0.16 (−0.39,0.08) | 0.05 (−0.07,0.16) | 0.02 (−0.04,0.08) | −0.08 (−0.19,0.02) | −0.07 (−0.15,0.01) | −0.17* (−0.31,−0.02) | −0.32* (−0.46,−0.18) |
| Alcohol drinking | | | | | | | |
| Ex-drinking | −0.31 (−0.92,0.30) | 0.32* (0.02,0.62) | 0.15 (−0.01,0.30) | 0.28* (0.00,0.55) | 0.11 (−0.12,0.34) | 0.07 (−0.31,0.45) | 0.45* (0.05,0.85) |
| Light-drinking | −0.15 (−0.39,0.08) | 0.37* (0.25,0.49) | 0.07 (0.01,0.14) | 0.12* (0.01,0.23) | −0.01 (−0.09,0.08) | −0.08 (−0.24,0.07) | 0.41* (0.27,0.56) |
| Heavy-drinking | 0.01 (−0.24,0.26) | 0.32* (0.20,0.44) | 0.10* (0.03,0.16) | 0.23* (0.12,0.35) | 0.07 (−0.02,0.16) | −0.21* (−0.37,−0.04) | 0.45* (0.30,0.61) |
| Physical exercise | | | | | | | |
| Low-intensity | 0.09 (−0.15,0.33) | 0.03 (−0.09,0.15) | 0.03 (−0.03,0.09) | 0.02 (−0.10,0.13) | 0.08 (−0.01,0.16) | 0.08 (−0.08,0.23) | 0.22* (0.07,0.37) |
| High-intensity | 0.16 (−0.09,0.40) | 0.19* (0.06,0.31) | 0.11* (0.05,0.18) | 0.20* (0.08,0.31) | 0.22* (0.13,0.31) | 0.14 (−0.02,0.30) | 0.35* (0.19,0.50) |

*$p < 0.05$ (two-sided)

physical health are presented in Table 2 as the estimates of regression coefficients with 95% confidence intervals.

A significant decrease with age was observed in the general cardio-pulmonary function and all categories of physical function, i.e., muscular power, flexibility, muscular strength, agility, balance and cardiac-respiratory endurance.

No significant effects of cumulative radiation dose on physical health were observed except for general cardio-pulmonary function.

Effects of cigarette smoking were observed in agility, balance and cardiac-respiratory endurance: the agility was significantly higher in subjects classified as ex-smoking than in those classified as no-smoking; balance and cardiac-respiratory endurance were significantly lower in subjects classified as current smoking than in those classified as no-smoking.

In contrast to cigarette smoking, alcohol drinking showed favorable effects in several categories of physical function: muscular power, muscular strength and cardiac-respiratory endurance were significantly higher in subjects classified as ex-drinking, and light- and heavy-drinking than in those classified as no-drinking; and flexibility was significantly higher in subjects classified as heavy-drinking than in those classified as no-drinking. Balance, however, was significantly decreased in subjects classified as heavy-drinking as compared to that in those classified as no-drinking.

Physical exercise showed favorable effects as a whole: all of the categories except for balance were significantly higher in subjects classified as performing high-intensity exercise than in those classified as no-exercise. Cardiac-respiratory endurance was also significantly higher in subjects classified as performing low-intensity exercise than in those classified as no-exercise.

*Association between lifestyle and mental health*

Effects of age, cumulative radiation dose, cigarette smoking, alcohol drinking and exercise on mental health are presented in Table 3 as the estimates of odds ratio with 95% confidence interval.

The frequency of subjects with stress complaint significantly decreased with age, while the frequency of subjects with physical complaint significantly increased with age. No significant effects of age were observed in digestive complaint or any of the categories of fatigue status.

No significant effects of cumulative radiation dose on mental health were observed.

On the whole, subjects with subjective symptoms or unfavorable fatigue status were observed more frequently in those classified as ex- or current-smoking than in those classified as no-smoking: the frequency of digestive complaint was significantly higher in subjects classified as ex- or current-smoking than in those classified as no-smoking; and the frequency of physical complaint was significantly higher in those classified as current-smoking than in those classified as no-smoking.

**Table 3.** Estimates (95% confidence interval) of odds ratio of respective factors for subjective symptoms and fatigue status in Japanese radiological technologists: based on multiple logistic regression analysis of 932 radiological technologists examined in 1981-1985

| Factor | Subjective symptoms | | | Fatigue status | | | |
|---|---|---|---|---|---|---|---|
| | Stress complaint | Physical complaint | Digestive complaint | Drowsiness and dullness | Difficulty in concentration | Projection of physical disintegration | Whole fatigue |
| Age | 0.98* (0.96,0.99) | 1.03* (1.01,1.05) | 1.00 (0.98,1.02) | 1.00 (0.98,1.02) | 1.01 (0.99,1.02) | 1.01 (0.99,1.03) | 1.01 (0.99,1.03) |
| Cumulative radiation dose(Gy) | 1.00 (0.99,1.01) | 1.00 (0.99,1.01) | 1.00 (0.99,1.01) | 1.00 (0.99,1.01) | 1.00 (0.99,1.01) | 1.00 (0.99,1.01) | 1.00 (0.99,1.01) |
| Cigarette smoking | | | | | | | |
| No-smoking (Reference) | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Ex-smoking | 1.29 (0.88,1.91) | 1.29 (0.87,1.93) | 1.70* (1.15,2.53) | 1.41 (0.96,2.07) | 0.8 (0.54,1.17) | 1.35 (0.91,2.03) | 1.23 (0.72,2.09) |
| Current-smoking | 1.39 (0.99,1.95) | 1.79* (1.26,2.55) | 1.90* (1.35,2.69) | 1.30 (0.93,1.82) | 1.05 (0.76,1.45) | 1.14 (0.80,1.64) | 1.26 (0.80,2.02) |
| Alcohol drinking | | | | | | | |
| No-drinking (Reference) | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Ex-drinking | 2.08 (0.90,4.85) | 1.15 (0.45,3.31) | 1.92 (0.84,4.44) | 2.51* (1.10,6.12) | 2.27 (0.99,5.52) | 2.09 (0.92,4.83) | 4.36* (1.82,10.32) |
| Light drinking | 1.10 (0.78,1.56) | 0.93 (0.65,1.35) | 0.93 (0.66,1.31) | 0.71* (0.50,0.99) | 0.64* (0.46,0.90) | 0.81 (0.57,1.16) | 0.79 (0.50,1.26) |
| Heavy drinking | 1.11 (0.77,1.61) | 1.22 (0.82,1.82) | 1.29 (0.90,1.85) | 0.91 (0.64,1.30) | 0.82 (0.58,1.16) | 0.94 (0.65,1.37) | 0.92 (0.57,1.50) |
| Physical exercise | | | | | | | |
| No-exercise (Reference) | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Low-intensity | 1.09 (0.78,1.55) | 0.72 (0.48,1.06) | 0.73 (0.52,1.03) | 0.89 (0.63,1.25) | 0.86 (0.61,1.20) | 0.95 (0.67,1.35) | 0.50* (0.32,0.77) |
| High-intensity | 0.84 (0.58,1.20) | 0.64* (0.43,0.94) | 0.63* (0.44,0.90) | 0.81 (0.57,1.15) | 0.86 (0.61,1.22) | 0.70 (0.48,1.02) | 0.53* (0.33,0.85) |

* $p < 0.05$ (two-sided)

In contrast to cigarette smoking, current alcohol drinking, especially light-drinking showed favorable effects on mental health: the frequency of drowsiness and dullness, and difficulty in concentration were significantly lower in subjects classified as light-drinking than in those classified as no-drinking; and no significant unfavorable effects were observed even in subjects classified as heavy-drinking. However, the frequency of subjective symptoms and unfavorable fatigue status were highest in subjects classified as ex-drinking: the frequency of drowsiness and dullness and that of whole fatigue were significantly higher in subjects classified as ex-drinking than in those classified as no-drinking.

Physical exercise showed generally favorable effects on mental health: the frequency of physical complaints, digestive complaints and whole fatigue were significantly lower in subjects classified as performing high-intensity exercise than in those classified as no-exercise; and the frequency of whole fatigue was also significantly lower in subjects classified as performing light-intensity exercise than in those classified as no-exercise.

## Discussion

The influence of low-dose radiation on the health was one of the primary objectives of the present study. There were, however, no significant effects of cumulative radiation dose on physical and mental health in the present study of Japanese radiological technologists except for general cardio-pulmonary function, which showed a significant increase with cumulative radiation dose. Although these subjects had been continuously exposed to relatively low-dose radiation, the effects of low-dose radiation have not yet been clarified and remain controversial. Chronic exposure to low-dose radiation has been reported to en hance the risk of lymphatic and hematopoietic cancers,[26] but a cohort study conducted in high background radiation areas in Yangjiang of China[23] reported that no significant correlation was observed between radiation dose and cancer risk; on the contrary, it was reported that mortality from all cancers in high-background radiation areas was generally lower than that in the control area though the difference was not significant. Similarly, a study conducted at the Misasa spa, an area in Japan with a high background level of radon, indicated a significantly lower mortality from stomach cancer in the Misasa area as compared to that in the control area.[24] Another study conducted in similar areas indicated that no significant difference observed in the incidence of all cancers between the Misasa area and the control area and that the incidence of stomach cancer seemed to be lower in both areas

compared to that in Japan overall.[25] A study reporting a correlation between cumulative radiation dose and mortality in Japanese radiological technologists[22] indicated that there was no significant difference in the mean cumulative radiation dose between cancer and non-cancer deaths.

The results described above suggest that low-dose radiation does not increase the cancer incidence, but rather decreases the risk for certain types of cancer. It is difficult, however, to attribute these directly to the hormesis effect in low-dose radiation as proposed by some researchers.[33, 34]

Although a significant decrease with age was observed in physical function, no significant effects of age on mental health were observed in the present study except for those on stress complaint and physical complaint; the latter was closely related to physical function in the subjects. Berkman[35] reported that the scores for psychological well-being were lower in young and elderly groups than in the middle-aged group suggesting a non-linear relationship between age and mental health. We therefore re-analyzed the data by adding a quadratic term of age to the model we had used. However, the new models were found to be less appropriate than those used in the previous analysis and there were no significant changes in the estimates. Unhealthy habits such as smoking, heavy drinking and no exercise were reported to increase the risk of depression,[21] depressive mood and neurasthenia.[17] A study of Japanese factory workers[19] indicated that healthy practices such as not smoking, not drinking alcohol every day and performing exercise twice or more every week were related to good mental health. These results suggest that good health practices facilitate the maintenance and promotion of good mental health conditions irrespective of age.

Although not statistically significant, a reduction in the general cardio-pulmonary function was suggested in the subjects classified as current-smoking. We should note that reduction in pulmonary function was reported to increase the risk of respiratory symptoms[3, 4, 36] and cancer.[20]

Agility was significantly improved (at least to the level in subjects classified as no-smoking) in subjects classified as ex-smoking probably due to improvement in the respiratory organ system as suggested by the following studies. Higgins et al.[3] reported that those who stopped smoking after the age of 60 years showed better pulmonary functions than those who continued smoking and Finkelstein[20] observed a large reduction in the risk of lung cancer among uranium miners who discontinued of smoking. Furthermore, smoking is a strongly habitual behavior,[37] and those who have stopped smoking tend to show dependence on a substitute for favorite beverages such as coffee during abstention from smoking[38], greater diversity of dietary contents and more attention to the health than smokers.[5, 6] The present results also suggest that efforts to stop smoking have some effects on other factors of health behavior.

In the present study, physical complaints and digestive complaints were observed more frequently in subjects classified as current-smoking than in those classified as no-smoking or ex-smoking. A study on Japanese workers conducted using the Todai Health Index[39] indicated that mental health was improved by not smoking.[17] This is consistent with our results and suggests that smoking has some unfavorable effects on mental health.

Cigarette smoking is therefore considered to have unfavorable effects on aspects of physical health and mental health.

Habitual alcohol intake is considered to increase the HDL cholesterol level resulting in the prevention of arteriosclerosis. Since favorable effects of moderate alcohol drinking[40-44] and unfavorable effects of alcohol drinking[7, 8, 45] have been reported, the relationship between alcohol drinking and physical health seems to be dependent on pattern of alcohol intake, type of alcohol,[46] drinking history and other factors. In the present study, favorable effects of alcohol drinking on muscle power, flexibility, muscle strength and cardiorespiratory endurance were observed in subjects classified as heavy-drinking as well as in those classified as light-drinking. This suggests that the heavy drinkers diagnosed as having alcohol dependence comprised very few if any of the subjects in the present study and hence the results reflected the favorable effects of moderate alcohol drinking.

With regard to the association between alcohol drinking and mental health, moderate wine intake was reported to bring good mental health,[47] while elevation of aggressiveness by alcohol drinking[48] and the danger in certain people of alcohol drinking to cope with tension[49] were reported. In the present study, drowsiness and dullness, and whole fatigue in fatigue status were less frequent complaints in subjects classified as ex-drinking as compared to no-drinking or light- and heavy-drinking: not a small number of subjects classified as ex-drinking were probably required to cease alcohol drinking due to disease. However, the frequency of complaints of drowsiness and dullness, and difficulty in concentration was significantly lower in subjects classified as light-drinking than in those classified as no-drinking. This would be the consequence of the spirit-elevating effect of alcohol, which

blows off stress.

The present study demonstrated a significant enhancement of physical function except for balance by high-intensity physical exercise. The association between physical exercise and physical health has been extensively discussed from the viewpoint of life expectancy. Extension of life expectancy by physical activity[7] and reduction of cardiac disease risk by high-intensity exercise in elderly people[9] have been reported. Furthermore, Wannamethee et al.[10] reported that the cancer mortality risk in middle-aged men was higher in those with the heart rate of 90 beats/min or more than in those with the heart rate less than 60 beats/min, but that the cancer mortality risk was significantly reduced in those engaged in routine physical activity at high intensity. Favorable effects of physical exercise on life expectancy were reported as well.[11-13] Endurance of considerable physical exercise is considered to promote a favorable status in the muscles and the oxygen transporting system.

Physical exercise showed overall favorable effects on mental health in the present study. Habitual physical exercise has been reported to be related to mental health.[14, 15, 17-19] Farmer et al.[16] showed that physical inactivity was a risk factor for depressive symptoms and suggested the enhancement of mental health by physical exercise. It is considered from these results that physical exercise has favorable effects not only because it is fun but also because it offers a change of pace. Furthermore, the feeling of refreshment after exercise may bring mental contentment. Hiraoka et al.[50] reported that exercise was strongly correlated with physical strength and related to a good mental health status and that exercise accelerated recovery from fatigue. Thus, moderate exercise contributes to mental stability by alleviating mental fatigue and stress. In addition, physical activities stimulate various organs of the body and exerts beneficial effects on physical and mental health.

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