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Relationship of socioeconomic status to C-reactive protein and arterial stiffness in urban Japanese civil servants.

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Relationship of Socioeconomic Status to C-reactive Protein and Arterial Stiffness in Urban Japanese Civil Servants

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Abstract

This study aims to investigate whether two socioeconomic status indicators, educational level and employment grade, are associated with C-reactive protein (CRP) levels and arterial stiffness among Japanese urban civil servants. Brachial-ankle pulse wave velocity (baPWV) as an indicator of arterial stiffness, CRP, occupational stress and conventional risk factors were evaluated in 3412 men and 854 women. Although the socioeconomic gradient showed a significant association with the CRP levels in men after adjustment for age, the significance disappeared after multivariate adjustment, whereas in women, the socioeconomic gradient showed no significant association with the CRP levels. In men, educational level was significantly associated with the baPWV value after adjustment for conventional risk factors, CRP and occupational stress (P for trend <0.0001). With regards to employment grade, only low-level non-manual workers had a significantly lower baPWV value as compared to manual workers at a fully adjusted model, and trend significance disappeared. However, in women, neither educational level nor employment grade was associated with the baPWV value. In summary, the socioeconomic gradient, especially the educational level, was significantly inversely related to the baPWV value in men. In women, the socioeconomic gradient was not related to the PWV value. An inverse relationship between the socioeconomic gradient and CRP levels was found in men only after age adjustment. Because the educational level is an important aspect in the adolescent environment and hence might influence the future lifestyle, early health education should be provided to prevent an unfavourable lifestyle and atherosclerotic diseases in later life.

Key Words*:* socioeconomic status; education; employment grade; C-reactive protein; pulse wave velocity; arterial stiffness

Introduction

The health status of the Japanese population is reported to be the best worldwide, and several studies suggested that relatively smaller socioeconomic disparities partly contribute to this excellent health status (Marmot & Smith, 1989; Wilkinson, 1992). However, the gap between social classes has been increasing in Japan since the late 1980s, and the effect of the socioeconomic gradient on health status is now becoming a cause for concern (Honjo, Kawakami, Takeshima, Tachimori, Ono, Uda et al., 2006).

The influence of the socioeconomic gradient on and the incidence of cardiovascular diseases (CVD) have been well established in Western countries (Brunner, Marmot, Nanchahal, Shipley, Stansfeld, Juneja et al., 1997; Cox, McKevitt, Rudd, & Wolfe, 2006; Gonzalez, Rodriguez Artalejo, & Calero, 1998; Kunst, Groenhof, Andersen, Borgan, Costa, Desplanques et al., 1999; Kuper, Adami, Theorell, & Weiderpass, 2007). In Japan, the influence of the socioeconomic gradient on the incidence of CVD has been little investigated, but its relationship with coronary risk factors has been reported (Anzai, Ohkubo, Nishino, Tsuji, & Hisamichi, 2000; Ishizaki, Martikainen, Nakagawa, & Marmot, 2000; Ishizaki, Yamada, Morikawa, Noborisaka, Ishida, Miura et al., 1999; Martikainen, Ishizaki, Marmot, Nakagawa, & Kagamimori, 2001; Morikawa, Nakagawa, Ishizaki, Tabata, Nishijo, Miura et al., 1997; Nakamura, Nakamura, & Tanaka, 2000; Nishi, Makino, Fukuda, & Tatara, 2004). These reports examined traditional risk factors such as obesity, blood pressure, HDL cholesterol levels, and diabetes, as well as fibrinogen levels.

C-reactive protein (CRP) is one of the newly identified risk factors for cardiovascular disease (Danesh, Whincup, Walker, Lennon, Thomson, Appleby et al., 2000; Koenig, Sund, Frohlich, Fischer, Lowel, Doring et al., 1999; Ridker, Hennekens, Buring, & Rifai, 2000; Ridker, Rifai, Rose, Buring, & Cook, 2002). The relationship between low socioeconomic status and increased CRP levels has been reported (Jousilahti, Salomaa, Rasi, Vahtera, & Palosuo, 2003; Koster, Bosma, Penninx, Newman, Harris, van Eijk et al., 2006; Owen, Poulton, Hay, Mohamed-Ali, & Steptoe, 2003). However, no relationships between CRP levels and the various social deprivation indices such as owning a car or a house, education, and employment (Danesh, Muir, Wong, Ward, Gallimore, & Pepys, 1999) have been reported. One study showed that CRP levels are positively related to the socioeconomic status in early life, but not to that in adulthood (Mendall, Strachan, Butland, Ballam, Morris, Sweetnam et al., 2000). The relationship between socioeconomic status and CRP levels in the Japanese population has not been fully investigated. Although the CRP levels in the Japanese populace are lower than those among the Westerners (Saijo, Kiyota, Kawasaki, Miyazaki, Kashimura, Fukuda et al., 2004; Yamada, Gotoh, Nakashima, Kayaba, Ishikawa, Nago et al., 2001), in Japan, elevated CRP was significantly related to carotid atherosclerosis (Kawamoto, Tomita, Inoue, Ohtsuka, & Kamitani, 2006; Makita, Nakamura, & Hiramori, 2005). In addition, a cohort study reported that elevated CRP was an independent risk factor for stroke in men

(Wakugawa, Kiyohara, Tanizaki, Kubo, Ninomiya, Hata et al., 2006). Therefore, the relationship between socioeconomic status and CRP levels among the Japanese populace should be investigated independently.

Pulse wave velocity (PWV) is known to be an indicator of arterial stiffness and is a marker of early-stage atherosclerosis, and elevated PWV is associated with development of atherosclerotic diseases (Asmar, Benetos, Topouchian, Laurent, Pannier, Brisac et al., 1995; Laurent, Boutouyrie, Asmar, Gautier, Laloux, Guize et al., 2001). In Japan, although there has been no prospective study on elevated PWV and incidence of CVD, elevated PWV has been significantly related to future death due to cardiovascular disease in Japanese-Americans living in Hawaii (Shokawa, Imazu, Yamamoto, Toyofuku, Tasaki, Okimoto et al., 2005). A simple non-invasive automatic method for measurement of brachial-ankle PWV (baPWV) has recently been developed (Tomiyama, Yamashina, Arai, Hirose, Koji, Chikamori et al., 2003; Yamashina, Tomiyama, Takeda, Tsuda, Arai, Hirose et al., 2002). The technical simplicity and short sampling time of the new method makes it more feasible for use in screening a large population than previous methods such as carotid-femoral PWV. In early-stage atherosclerosis, a relationship between the socioeconomic gradient and carotid atherosclerosis has been reported (Diez-Roux, Nieto, Tyroler, Crum, & Szklo, 1995; Lynch, Kaplan, Salonen, Cohen, & Salonen, 1995; Rosvall, Ostergren, Hedblad, Isacsson, Janzon, & Berglund, 2000, 2002, 2006). However, there have been no reports concerning the influence of socioeconomic status on PWV as an early marker of atherosclerosis. Elucidating the effect of the socioeconomic gradient on early stage atherosclerosis and new cardiovascular disease markers such as CRP and baPWV could facilitate the effort to develop better preventive measures.

Because of their practicality and risk predictive performance, CRP and baPWV, should be increasingly be used for population screening. The aim of this study was to investigate whether lower educational level and employment grade were associated with increased CRP levels and arterial stiffness (based on baPWV values) among Japanese urban civil servants.

Methods

Subjects

The subjects were local government employees (8229 men and 2194 women) at Sapporo City, aged 35 to 60 years, who underwent their annual health check-up between April 2003 and March 2004. We used a self-administered questionnaire, which included items on clinical history, family history, smoking, alcohol consumption, frequency of exercise, educational status, occupation, job ranking, menopausal status and hormone-replacement therapy. The questionnaire was distributed to the subjects before their annual health check-up and was collected during the check-up. Answers to the questionnaire and written informed consent to view health check-up data were obtained from 3907 men and 1044 women (response rate: men 47.5%, women 47.6%). A total of 685 subjects (495 men, 190 women) were excluded for the following reasons: past history of coronary disease or stroke (n = 136; 124 men, 12 women), low ankle/brachial pressure index (<0.9; n = 12, 11 men, 1 woman; the baPWV values in the subjects with peripheral artery disease cannot be evaluated accurately), PWV not measured (n = 600; 416 men, 184 women) or blood samples not analysed (n = 3; all women). The final study group thus comprised 3412 men (41.5%) and 854 women (38.9%).

This study was conducted with the written informed consent of all subjects and was approved by the institutional ethical board for epidemiological studies of Hokkaido University Graduate School of Medicine.

Data collection

Socioeconomic status

Socioeconomic status classification was performed as done in a previous Japanese civil servant study (Nishi et al., 2004). Educational attainment was categorised into ‘junior high school’, ‘high school’ or ‘university (including junior and graduate college)’. Employment grade was categorized into ‘higher-level non-manual’, ‘lower-level non-manual’ or ‘manual’. ‘Non-manual’ workers included clerical workers, professional workers (e.g. physicians, nurses, public health nurses, pharmacists, radiographers, dieticians, researchers and technicians) and fire fighters. ‘Higher-level non-manual’ workers included non-manual workers whose rank was department director or section chief for men, and department director, section chief or chief clerk for women. ‘Lower-level non-manual’ workers included non-manual workers whose rank was chief clerk or who were in a non-managerial position for men, and a non-managerial position for women. Regardless of rank, ‘manual’ workers included drivers, conductors, sanitation workers, cooks and janitors.

Women who reported that they were in the postmenopausal stage were accordingly defined, depending on whether it was natural or surgically induced.

Covariates

Subjects were asked about the number of cigarettes they currently smoked every day, and the smoking habit was categorized into 'non-smoker' (never smoked), 'ex-smoker' or 'current smoker'. Alcohol consumption was categorized into 'rarely or never', '1–5 times/week' or '6–7 times/week'. The frequency of leisure time exercise (with perspiration) (was categorised into either 'rarely or never' or '$\geq$1 per week'.

Occupational stress was assessed using the effort–reward imbalance (ERI) model and the demand–control model (DCM). The Japanese version of the ERI model (Tsutsumi, Ishitake, Peter, Siegrist, & Matoba, 2001) consists of six questions on effort invested (demands, obligations) and eleven questions on rewards received (money, esteem, career opportunities, career and security). The subjects were asked to rate on the basis of severity from 'not at all distressed' (1 point) to 'very distressed' (4 points). To examine the joint effect of unfavourable distribution of effort and reward, a ratio was computed between the two scales using the formula effort/(reward × 6/11) (Fahlen, Knutsson, Peter, Akerstedt, Nordin, Alfredsson et al., 2006). In this formula, 6/11 is a correction factor for the difference in the number of items in the numerator and denominator. In addition to these two variables, Siegrist proposed an additional index called ‘overcommitment’ (Siegrist, Starke, Chandola, Godin, Marmot, Niedhammer et al., 2004). This term is assessed using 6 items reflecting preoccupation with work and an inability to switch off, e.g. ‘As soon as I get up in the morning, I start thinking about work problems’, and ‘People close to me say I sacrifice myself too much for my job’. Ratings were summed up so that higher scores indicate greater overcommitment (range 6–24). Cronbach’s alpha coefficients were 0.79 in men and 0.80 in women for effort, 0.82 in men and 0.80 in women for reward and 0.77 in men and 0.78 in women for overcommitment.

The Japanese version of the DCM (Sugisawa, Uehata, Pin, Sekiya, Chida, Ishihara et al., 1993) consists of five questions on psychological demands (job demands, time pressures and conflicting demands) and six questions on decision latitude (influence or control over work, job variety and the possibilities for learning new skills). Each question has four frequency-based response categories ranging from ‘never’ (1 point) to ‘always’ (4 points). Job strain was defined as the ratio of demands to job control (Tsutsumi, Kayaba, Tsutsumi, & Igarashi, 2001). Cronbach’s alpha coefficients were 0.65 in men and 0.61 in women for job control, and 0.74 in men and 0.74 in women for job demand.

Anthropometric measures (height, body weight, and waist and hip circumferences) were recorded using a standardised protocol. The body mass index (BMI) was calculated as weight (kg)/height (m^2).

Blood samples were drawn from the antecubital vein of the seated subject with minimal tourniquet use after a 12-h fast. Specimens were collected in siliconised glass vacuum tubes containing sodium fluoride for blood glucose.

Total cholesterol (TC) levels were measured using an enzymatic method (Wako, Osaka, Japan). The triglyceride (TG) levels were measured using an enzymatic method (Daiichi Pure Chemicals, Tokyo, Japan), the high-density lipoprotein cholesterol level by a direct method (Daiichi Pure Chemicals), and blood glucose by an amperometric method (Arkray, Kyoto, Japan).

Outcomes

CRP was measured through nephelometry with a latex particle-enhanced immunoassay (N

Latex CRP II; Dade Behring, Tokyo, Japan). The assay could detect 0.004 mg/dL of CRP. Undetectable CRP values were recorded as 0.002 mg/dl.

All blood variables except CRP were measured at Daiichi Clinical Laboratories, Inc. (Sapporo, Japan), a commercial haematology laboratory, where the measurements of TC and HDL cholesterol were all standardized by the Lipid Standardization Program of the Centre for Disease Control and Prevention, Atlanta, Georgia. CRP was measured at Mitsubishi Kagaku Bio-Clinical Laboratories, Inc. (Tokyo, Japan), a commercial haematology laboratory.

A volume-plethysmographic apparatus was used for measuring baPWV (Form PWV/AVI; model BP-203RPEII, Colin Co., Komaki, Japan) (Tomiyama et al., 2003; Yamashina et al., 2002). This device records the phonocardiogram, electrocardiogram, and volume pulse form and arterial blood pressure at the left and right brachia and bilateral ankles. A time-phase analysis between right brachial and volume waveforms at both ankles was used for calculating baPWV. Blood pressure, heart rate (HR) and the ankle brachial index (ABI) were measured using a pulse-wave velocimeter concurrently with PWV measurement. ABI is the ratio of ankle systolic blood pressure to brachial systolic blood pressure, and right and left ABIs were measured simultaneously. In all the studies, baPWV was obtained after at least 5 min of rest.

Statistical analysis

All analyses were performed separately for men and women. The data are presented as the mean ± SD or median values (and interquartile range) for variables with a skewed distribution or percentages. The risk factors, CRP, occupational stress (job strain, effort/reward ratio and overcommitment) and PWV were compared according to educational level and employment grade, using general linear model (GLM) univariate analyses adjusted for age. Because of their skewed distribution, the log-transferred CRP and TG were compared and the back-transformed means and the 95% confidence intervals (CI) of log-transferred CRP and TG are shown in the results and tables. Multiple repression analyses were used to evaluate whether cigarette smoking, alcohol consumption and physical activity were associated with log CRP and baPWV after age adjustment. Age-adjusted logistic regression analyses were used to evaluate whether the socioeconomic gradient was associated with cigarette smoking (current smoker), alcohol consumption (6–7 times/week) and physical inactivity (rare or never).

Next, the mean values of log-transferred CRP and baPWV were compared according to educational level and employment grade after adjustment of possible confounders using GLM univariate analyses as follows: Model 1—adjusted for age; BMI; smoking; alcohol consumption; exercise; medication for hypertension, hyperlipidemia and diabetes and menopausal status of women; Model 2—adjusted for model 1 variables plus heart rate, systolic blood pressure, TC, log TG, HDL, FBS and log CRP for baPWV analyses; Model 3—model 2 variables plus job strain, effort–reward imbalance, overcommitment. In addition, post hoc tests were performed with Bonferroni correction for multiple comparisons. To examine the linearity of the variables, the significance test for linearity (p for trend test) was performed.

P-values <0.05 were considered to be statistically significant. All analyses were conducted using the SPSS software package version 15 for Windows (SPSS Inc., Chicago, IL).

Results

Characteristics of the male and female subjects are presented in Table 1. The mean ages of the male and female subjects were 48.4 (SD 6.8) and 46.8 (SD 7.2) years, respectively. The medians of CRP for the male and female subjects were 0.045 (interquartile range: 0.023–0.089) and 0.025 (interquartile range: 0.012–0.052) mg/dl, respectively. The means of baPWV in the male and female subjects were 1369 (SD 200) and 1250 (SD 180) cm/s, respectively. The number of women with a university education was higher than that of men.

The relationship between educational level and employment grade is shown in Table 2. Males and females with higher educational levels had higher employment grades.

The age-adjusted means of variables were compared according to educational level (Table 3). In men, educational level was significantly related to systolic blood pressure, total cholesterol, HDL cholesterol, CRP, baPWV, job strain, and overcommitment. In women, educational level was significantly related to systolic blood pressure, triglycerides and job strain, but was not related to CRP and baPWV.

The age-adjusted means of variables were compared according to employment grade (Table 4). In men, employment grade was significantly related to systolic blood pressure, CRP, baPWV, job strain, effort/reward ratio and overcommitment. In women, employment grade was significantly related to triglycerides, job strain, effort/reward ratio and overcommitment, but was not related to

CRP and baPWV.

Table 5 shows the relationship of smoking, alcohol consumption and physical activity to CRP and baPWV in age-adjusted multiple linear regression analyses. In men, smoking status and physical activity were significantly related to log CRP, and alcohol consumption and physical activity were significantly related to baPWV. In women, alcohol consumption and physical activity were significantly related to baPWV.

Table 6 shows the relationships of educational level and employment grade with smoking, alcohol consumption and physical inactivity. Lower educational levels and employment grades were significantly associated with cigarette smoking among both genders. However, neither educational level nor employment grade was associated with alcohol consumption. With regards to physical inactivity, lower-level non-manual work was negatively associated in men, whereas lower employment grade was positively associated in women.

Next, multivariate adjusted geometric mean concentrations of CRP were compared according to educational level and employment grade (Table 7). Educational level and employment grade had no significant relationship with the CRP levels after multivariate adjustments in both genders.

Then, multivariate adjusted mean values of baPWV were compared according to educational level and employment grade (Table 8). Lower educational levels were consistently associated with higher baPWV values in all models in men. As for employment grade in men, higher-level non-manual work was significantly associated with a higher baPWV value in model 1. However, in models 2 and 3, the significance of higher-level non-manual worker disappeared, and the association of lower-level non-manual work with higher baPWV value was found in models 2 and 3. In women, neither educational level nor employment grade was related to the baPWV value.

Discussion

In men, educational level was significantly associated with the baPWV value even after multivariate adjustment, and employment grade was partially associated with the baPWV value. However, in women, neither educational level nor employment grade was associated with the baPWV value. After adjustment for age, both educational level and employment grade were negatively related to the CRP levels in men, but were not related to those in women. Furthermore, after multivariate adjustment, the significant relationship in men disappeared. However, we believe that early lifestyle education on cardiovascular disease prevention should be provided actively, although we found positive results only concerning baPWV in men.

There have been few reports investigating the relationship between the socioeconomic gradient and early-stage atherosclerosis, and most of these studies involved subjects with carotid atherosclerosis (Diez-Roux et al., 1995; Lynch et al., 1995; Rosvall et al., 2000, 2002, 2006). To our knowledge, there has been no report about the relationship between the socioeconomic gradient and PWV as a marker of early-stage atherosclerosis after adjustment for conventional risk factors and occupational stress.

Among the men in our study, educational level had a consistently significant relationship with the PWV value. However, the trend significance of employment grade disappeared in models 2 and 3, although lower-level non-manual workers had significantly lower PWV values compared with manual workers in these models. In Japan, a positive relationship between socioeconomic status and cardiovascular risk factors has been reported (Ishizaki et al., 2000; Morikawa et al., 1997; Nakamura et al., 2000; Nishi et al., 2004). However, in a rural study, Ishizaki et al. (2000) reported that the highest waist-to-hip ratio was found in female labourers as well as male managers, and Martikainene et al. (2001) reported that higher employment grades demonstrated higher BMI, waist-to-hip ratios and lower HDL cholesterol levels, and that the educational level displayed a similar trend. Nishi et al. (2004) pointed out that the socioeconomic gradient effect was different between rural and urban areas in Japan. Since our subjects lived in an urban area (resident population of about 190 million people), the baPWV findings were compatible with those of previous Japanese studies.

To measure socioeconomic status, educational level is commonly used in the USA, whereas occupational gradient is used more frequently in the UK (Cox et al., 2006). Differences in social structure affect each measure of socioeconomic status to health status. In a study that examined employees from three countries, the influence of employment grade on physical function among Japanese workers was smaller and less systematic than that observed among Finnish or British workers (Martikainen, Lahelma, Marmot, Sekine, Nishi, & Kagamimori, 2004). Our study involved urban civil servants, not the general population, and all our subjects were guaranteed lifetime employment and were provided equal benefits. These factors probably reduced the employment grade effect.

Many aspects of lifestyle such as smoking are established before starting employment. The stronger association of baPWV values with educational level than with employment grade that persisted after multivariate adjustments may reflect early and late inappropriate lifestyle characteristics, which usually cannot be evaluated.

Among the women in our study, neither educational level nor employment grade were significantly related to the baPWV value. Similar to the other study on Japanese civil servants (Nishi et al., 2004), a small percentage of women were working high-level non-manual jobs compared to men. For this reason, we included the job of non-manual chief clerk in the category of 'higher-level non-manual' because the number of women holding the positions of department director and section chief was smaller than that of men. It was speculated that analyses of the socioeconomic gradient in women's health in Japan may be better conducted using household-based measures of socioeconomic status because wage differences between men and women are large and there is a strong dependence on family responsibility in welfare provision geared around the well-earning male 'bread-winner' (Martikainen et al., 2004).

The baPWV values of women were smaller than those of men in our study. Another Japanese study showed that gender deference of baPWA value exists in 25- to 59-year-old subjects but disappears in subjects aged 60 years or older (Tomiyama et al., 2003). Estrogen plays an important role in protecting the vascular system, i.e. enhancing endothelial function and vasodilatation, inhibiting vascular smooth muscle cell proliferation, and improving HDL and LDL cholesterol levels (Farhat, Lavigne, & Ramwell, 1996; Gruber, Tschugguel, Schneeberger, & Huber, 2002). This may attenuate the socioeconomic gradient effect in adolescence. Moreover, a smaller sample size and lower mean value of baPWV in women can reduce the statistical power of this finding.

Many studies have reported increased CRP levels in smokers (Haverkate, Thompson, Pyke, Gallimore, & Pepys, 1997; Koenig et al., 1999). Among the male subjects in our study, the smoking status was significantly related to log CRP in age-adjusted multiple linear regression analysis. This could attenuate the relationship between two socioeconomic status indicators and CRP levels in the multiple adjusted models. On the other hand, among the female subjects in our study, the smoking status was not significantly related to log CRP in multiple linear regression analysis. In the other Japanese population-based studies, a significant relationship between smoking and CRP levels was found in males, but not in females (Saito, Sato, Nakamura, Kokubo, Mannami, Adachi et al., 2007; Yamada et al., 2001). It has been speculated that the lower prevalence rate of smoking might attenuate the smoking effect on CRP levels, but the reason for the sex difference concerning the smoking effect on CRP levels is not entirely clear. Moreover, among both the male and female subjects in our study, smoking status was not significantly related to baPWV values in multiple linear regression analysis. Therefore, the significance of baPWV was not greatly attenuated in the multiple adjustment models.

Most epidemiological studies reported a CRP lowering effect with moderate alcohol intake (Albert, Glynn, & Ridker, 2003; Levitan, Ridker, Manson, Stampfer, Buring, Cook et al., 2005; Pai, Hankinson, Thadhani, Rifai, Pischon, & Rimm, 2006; Volpato, Pahor, Ferrucci, Simonsick, Guralnik, Kritchevsky et al., 2004). However, among both the male and female subjects in our study, alcohol consumption was not significantly related to log CRP in multiple linear regression analysis. On the other hand, a significant relationship between alcohol consumption and baPWV values was found in both males and females. A longitudinal study in Japanese men suggested that alcohol is an important risk factor for increased PWV (Nakanishi, Kawashimo, Nakamura, Suzuki, Yoshida, Uzura et al., 2001). Furthermore, a J-shaped association between alcohol consumption and PWV was reported in European studies (Sierksma, Lebrun, van der Schouw, Grobbee, Lamberts, Hendriks et al., 2004; Sierksma, Muller, van der Schouw, Grobbee, Hendriks, & Bots, 2004). Thus, CRP is a marker that is more vulnerable to smoking, whereas baPWV is more vulnerable to drinking. Therefore, the effect of socioeconomic status on CRP was attenuated by adjustment for smoking, which was significantly related to socioeconomic status; however, the effect of socioeconomic status on baPWV was not greatly attenuated by adjustment for drinking, which was not significantly related to socioeconomic status.

The socioeconomic gradient, especially educational level, was related to cigarette smoking in both men and women in our study. As Nishi et al. (2004) have noted, it is natural that smoking is more strongly related to educational level, because lifestyle factors such as smoking take root during adolescence.

Employment grade was positively related to alcohol consumption among both genders in a British study on civil servants (Ferrie, Shipley, Davey Smith, Stansfeld, & Marmot, 2002) and among women in a Japanese study on civil servants (Nishi et al., 2004). The authors of the latter study speculated that a greater level of responsibility associated with a higher employment grade leads to frequent drinking. However, in the Japanese survey, women in the lowest quintile for household income had a significant but weak odds ratio (OR 1.28) for alcohol consumption, whereas men had no significant association (Fukuda, Nakamura, & Takano, 2005). Population specificity may lead to such contradictory results. Moreover, Japanese often have a low tolerance for alcohol as compared to Westerners (Higuchi, Matsushita, Muramatsu, Murayama, & Hayashida, 1996).

Lower-level non-manual work had significantly lower OR for physical inactivity in men; however, in women, lower-level non-manual and manual work had significantly higher ORs. Japanese, US and European studies have reported that the socioeconomic gradient is negatively related to physical inactivity (Fukuda et al., 2005; Laaksonen, Talala, Martelin, Rahkonen, Roos, Helakorpi et al., 2007; Lantz, House, Lepkowski, Williams, Mero, & Chen, 1998; Schrijvers, Stronks, van de Mheen, & Mackenbach, 1999). Another study on Japanese civil servants revealed that high school education in men had a significantly lower OR for physical inactivity, and that both socioeconomic indicators are not significantly related. Population specificity may have caused the equivocal results in the studies on Japanese civil servants.

A statement for healthcare professionals made by the Centre for Disease Control and Prevention and the American Heart Association classifies a CRP value of >0.3 mg/dl as high cardiovascular risk (Pearson, Mensah, Alexander, Anderson, Cannon, Criqui et al., 2003). However, because Japanese have relatively lower CRP values, the CRP cut-off point of 0.065 mg/dl was recommended based on Japanese-population-based studies (Oda, 2007).

One of the hypertension management guidelines of the Arterial Hypertension of the European Society of Hypertension and the European Society of Cardiology classifies a carotid-femoral PWV >1200 cm/s as subclinical organ damage (Mancia, De Backer, Dominiczak, Cifkova, Fagard, Germano et al., 2007). Concerning baPWV, one study suggested a 1400 cm/s cut-off point (Yambe, Tomiyama, Yamada, Koji, Motobe, Shiina et al., 2007); however, an authorized cut-off point has not been established.

Japanese have the longest life expectancy in the world and the life expectancies at birth were estimated to be 79 years for male and 86 years for females in 2004 (WHO; World Health report 2006). In previous Japanese civil servants studies, the effects of social inequity on health were smaller among women compared to men (Nishi et al., 2004; Sekine, Chandola, Martikainen, Marmot, & Kagamimori, 2006). And the effects among Japanese women were smaller compared to European women (Martikainen et al., 2004). The smaller effects among Japanese women in public sectors are favourable for their health, and further studies are needed to elucidate the social inequity effects on health among other recent Japanese female workers. Additionally, Japanese women had lower CRP level compared to Japanese men and Westerners (Saijo et al., 2004; Yamada et al., 2001), which may be also desirable for Japanese women's health.

There were some noteworthy limitations in our study. First, the possibility of selection bias needs to be considered when generalizing the present findings, because only about 47.0% of the participants volunteered for the study. If the unhealthy and low socioeconomic status workers hesitated to participate in this study, the socioeconomic gradient effects would be attenuated. Second, our subjects were restricted to civil servants. Civil servants are relatively 'healthy workers' compared with community samples (Nishi et al., 2004). The results may underestimate the socioeconomic gradient of the general population. And only 20 percent of woman had higher than 0.065 mg/dl CRP level which was recommended cut-off point among Japanese (Oda, 2007), though 34.1% of men had. This also suggested that women of our study were relatively "healthy workers", and this may attenuate the relationships among women. Third, we could not obtain information on the subjects' incomes. As previously mentioned, analyses of the socioeconomic gradient in women's health may be better conducted using household-based measures of socioeconomic status. Fourth, the number of female subjects was somewhat small. A further study involving a larger number of women along with data on their household income is thus required. Finally, inappropriate classification of employment grade may attenuate the statistical significance. However, employment grade classification was performed as in a previous Japanese civil servant study (Nishi et al., 2004), which had a significant relationship with coronary risk factors, self-rated health status and psychological well-being. Therefore, we believed that our classification had acceptable validity.

In summary, socioeconomic gradient, especially educational level, was significantly related to the baPWV value in men. In women, the socioeconomic gradient was not related to the PWV value. Although the socioeconomic gradient showed a significant relationship with CRP levels in men after adjustment for age, the significance disappeared after multivariate adjustment. In women, the socioeconomic gradient showed no significant relationship with CRP levels. Because educational level may reflect the adolescent environment, early health education should be provided to prevent an unfavourable lifestyle and atherosclerotic diseases in later life.

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Table 1 Characteristics of male and female subjects

	Men (n = 3412)			Women (n = 854)		
Age (y)	48.4	±	6.8	46.8	±	7.2
BMI (kg/m^2)	23.8	±	2.9	21.8	±	3.4
SBP (mmHg)	122.8	±	15.3	114.6	±	15.7
DBP (mmHg)	77.9	±	10.9	69.3	±	10.3
Heart rate (bpm)	60.6	±	9.5	59.6	±	8.2
Total cholesterol (mg/dl)	207.3	±	33.4	208.3	±	32.2
Triglyceride (mg/dl)	105		(75–152)	67		(50–91)
HDL cholesterol (mg/dl)	56.7	±	14.4	69.7	±	15.0
Fasting glucose (mg/dl)	95.8	±	21.0	88.8	±	14.8
CRP (mg/dl)	0.045		(0.023–0.089)	0.025		(0.012–0.052)
PWV (cm/s)	1369	±	200	1250	±	181
Smoking status						
Non-smoker	808		(23.7%)	570		(66.4%)
Ex-smoker	908		(49.7%)	77		(9.0%)
Current smoker	1696		(26.6%)	207		(24.2%)
Alcohol consumption						
Rarely or never	929		(27.2%)	405		(47.4%)
1–5 times/week	1400		(41.0%)	296		(34.7%)
6–7 times/week	1083		(31.7%)	153		(17.9%)
Frequency of exercise						
Rarely or never	1861		(54.5%)	575		(67.3%)
≥1 time/week	1551		(45.5%)	279		(32.7%)
Postmenopausal state				336		(39.3%)
Medication for						
Hypertension	318		(9.3%)	37		(4.3%)
Hyperlipidemia	171		(5.0%)	40		(4.7%)
Diabetes	79		(2.3%)	8		(0.9%)
Job stress						
Job strain	0.728	±	0.179	0.796	±	0.202
Effort/reward	0.381	±	0.197	0.470	±	0.231
Overcommitment	12.8	±	2.9	13.5	±	3.0
Education						
University	1456		(42.7%)	479		(56.1%)
High school	1737		(50.9%)	324		(37.9%)
Junior high school	219		(6.4%)	51		(6.0%)
Employment grade						
Higher-level non-manual	342		(10.0%)	107		(12.5%)
Lower-level non-manual	2063		(60.5%)	466		(54.6%)
Manual	1007		(29.5%)	281		(32.9%)

Variables are presented as mean ± SD, median (interquartile range) for skewed variables, or number (percentage).

Table 2 Relationship between educational level and employment grade

		Employment grade		
		Higher-level non-manual	Lower-level non-manual	Manual
Gender	Education			
Male	University	291	1004	161
	High school	50	1017	670
	Junior high school	1	42	176
Female	University	93	351	35
	High school	14	110	200
	Junior high school	0	5	46

Table 3 Age-adjusted mean of variables by sex according to educational level

Variables	University				High school				Junior high school				P for trend
	Mean	95% CI			Mean	95% CI			Mean	95% CI			
Men													
BMI (kg/m^2)	23.6	23.4	to	23.7	24.0	23.8	to	24.1	24.2	23.8	to	24.6	0.009
SBP (mmHg)	121.9	121.1	to	122.6	123.3	122.6	to	124.0	125.1	123.1	to	127.2	0.004
DBP (mmHg)	77.6	77.1	to	78.2	78.1	77.6	to	78.6	77.9	76.4	to	79.3	0.756
Heart rate (bpm)	61.1	60.6	to	61.6	60.3	59.8	to	60.7	60.5	59.2	to	61.8	0.416
Total cholesterol (mg/dl)	209.4	207.7	to	211.1	206.3	204.8	to	207.9	201.8	197.2	to	206.4	0.003
Triglycerides (mg/dl)*	106.9	104.1	to	109.8	109.7	107.1	to	112.5	102.4	95.3	to	110	0.275
HDL cholesterol (mg/dl)	57.8	57.1	to	58.6	56.0	55.3	to	56.7	54.9	53.0	to	56.9	0.008
Fasting glucose (mg/dl)	94.5	94.4	to	96.5	95.8	94.9	to	96.8	98.5	95.7	to	101.3	0.050
CRP (mg/dl)*	0.043	0.041	to	0.046	0.051	0.049	to	0.054	0.053	0.045	to	0.062	0.019
PWV (cm/s)	1362	1353	to	1371	1367	1358	to	1375	1427	1401	to	1452	<0.0001
Job strain	0.714	0.705	to	0.723	0.728	0.720	to	0.736	0.824	0.800	to	0.748	<0.0001
Effort/reward ratio	0.387	0.376	to	0.397	0.376	0.367	to	0.385	0.388	0.361	to	0.415	0.920
Overcommitment	13.1	13.0	to	13.3	12.5	12.4	to	12.7	12.2	11.8	to	12.6	<0.0001
Women													
BMI (kg/m^2)	21.9	21.6	to	22.2	21.7	21.4	to	22.1	22.3	21.4	to	23.2	0.391
SBP (mmHg)	114.6	113.2	to	115.9	113.8	112.1	to	115.4	119.3	115.2	to	123.4	0.036
DBP (mmHg)	69.5	68.6	to	70.5	68.6	67.5	to	69.7	71.2	68.4	to	74.0	0.275
Heart rate (bpm)	60.1	59.3	to	60.8	58.7	57.8	to	59.6	60.9	58.6	to	63.2	0.498
Total cholesterol (mg/dl)	206.8	204.1	to	209.5	210.8	207.5	to	214.1	207.4	199.2	to	215.6	0.895
Triglycerides (mg/dl)*	67.1	64.2	to	70.1	73.2	69.4	to	77.2	78.2	68.4	to	89.4	0.036
HDL cholesterol (mg/dl)	69.9	68.5	to	71.3	69.9	68.2	to	71.6	66.4	62.3	to	70.6	0.125
Fasting glucose (mg/dl)	89.5	88.2	to	90.8	87.4	85.8	to	89.1	90.4	86.4	to	94.5	0.681
CRP (mg/dl)*	0.027	0.024	to	0.030	0.029	0.025	to	0.033	0.035	0.025	to	0.049	0.137
PWV (cm/s)	1247	1232	to	1262	1249	1231	to	1267	1286	1241	to	1332	0.116

Job strain	0.771	0.752	to	0.789	0.826	0.804	to	0.849	0.838	0.782	to	0.895	0.027
Effort/reward ratio	0.495	0.473	to	0.516	0.438	0.412	to	0.463	0.436	0.372	to	0.500	0.094
Overcommitment	13.7	13.4	to	14.0	13.3	12.9	to	13.6	13.1	12.2	to	13.9	0.155

*log-transformed data were analysed, and adjusted means (95% CI) were back-transformed

Table 4 Age-adjusted mean of variables by sex according to employment grade

Variables	Higher-level non-manual				Lower-level non-manual				Manual				P for trend
	Mean	95% CI			Mean	95% CI			Mean	95% CI			
Men													
BMI (kg/m^2)	23.5	23.2	to	23.8	23.9	23.8	to	24.0	23.9	23.6	to	24.0	0.084
SBP (mmHg)	120.6	118.9	to	122.2	122.9	122.3	to	123.6	123.3	122.4	to	124.2	0.004
DBP (mmHg)	77.0	75.9	to	78.2	78.1	77.6	to	78.5	77.7	77.1	to	78.4	0.292
Heart rate (bpm)	60.7	59.6	to	61.7	60.9	60.5	to	61.3	60.0	59.5	to	60.6	0.310
Total cholesterol (mg/dl)	209.5	205.8	to	213.1	207.2	205.8	to	208.7	206.9	204.8	to	208.9	0.220
Triglycerides (mg/dl)*	109.6	103.5	to	116.0	108.3	105.8	to	110.8	107.1	103.6	to	110.6	0.488
HDL cholesterol (mg/dl)	57.7	56.1	to	59.3	56.8	56.1	to	57.4	56.2	55.3	to	57.1	0.109
Fasting glucose (mg/dl)	93.2	90.9	to	95.4	96.4	95.5	to	97.3	95.5	94.2	to	96.8	0.071
CRP (mg/dl)*	0.042	0.037	to	0.048	0.048	0.046	to	0.051	0.049	0.045	to	0.052	0.044
PWV (cm/s)	1348	1328	to	1368	1367	1359	to	1375	1379	1369	to	1391	0.008
Job strain	0.675	0.656	to	0.695	0.725	0.717	to	0.733	0.752	0.741	to	0.763	<0.0001
Effort/reward ratio	0.349	0.327	to	0.370	0.387	0.378	to	0.396	0.380	0.368	to	0.393	0.011
Overcommitment	13.1	12.7	to	13.4	13.1	12.9	to	13.2	12.1	11.9	to	12.3	<0.0001
Women													
BMI (kg/m^2)	21.8	21.1	to	22.4	21.8	21.4	to	22.1	22.0	21.6	to	22.4	0.508
SBP (mmHg)	114.8	112.0	to	117.6	114.3	112.9	to	115.7	114.9	113.1	to	116.7	0.947
DBP (mmHg)	69.7	67.8	to	71.6	69.5	68.6	to	70.4	68.8	67.6	to	70.0	0.410
Heart rate (bpm)	60.0	58.4	to	61.6	60.0	59.1	to	60.7	58.9	57.9	to	59.9	0.251
Total cholesterol (mg/dl)	205.3	199.7	to	210.9	207.5	204.7	to	210.3	210.9	207.4	to	214.5	0.089
Triglycerides (mg/dl)*	63.8	58.3	to	69.9	67.4	64.4	to	70.5	77.2	72.9	to	81.7	<0.001
HDL cholesterol (mg/dl)	72.2	69.3	to	75.0	69.3	67.9	to	70.7	69.5	67.7	to	71.3	0.107
Fasting glucose (mg/dl)	89.3	86.6	to	92.1	89.0	87.6	to	90.4	88.2	86.4	to	89.9	0.482
CRP (mg/dl)*	0.027	0.021	to	0.034	0.027	0.024	to	0.031	0.029	0.025	to	0.034	0.498
PWV (cm/s)	1243	1213	to	1274	1247	1232	to	1262	1257	1238	to	1277	0.467

Job strain	0.746	0.708	to	0.784	0.776	0.757	to	0.794	0.848	0.824	to	0.872	<0.0001
Effort/reward ratio	0.513	0.469	to	0.557	0.472	0.450	to	0.494	0.449	0.421	to	0.476	0.013
Overcommitment	14.1	13.5	to	14.7	13.7	13.4	to	14.0	13.0	12.6	to	13.4	0.001

*log-transformed data were analysed, and adjusted means (95% CI) were back-transformed.

Table 5 Age-adjusted regression coefficient of smoking, alcohol consumption and physical activity to CRP and baPWV

	Log CRP				baPWV			
	Partial regression coefficient	95%CI	β	p value	Partial regression coefficient	95%CI	β	p value
Males								
Smoking status								
Ex-smoker (vs. non-smoker)	0.07	0.02 to 0.11	0.058	0.006	4.134	-13.32 to 21.59	0.009	0.642
Current smoker (vs. non-smoker)	0.17	0.13 to 0.21	0.167	<0.0001	-0.88	-16.28 to 14.52	-0.002	0.911
Alcohol consumption								
1-5 times/ week (vs. rarely or never)	0.00	-0.02 to 0.02	0.005	0.818	26.65	11.48 to 41.82	0.066	0.001
6-7 times/ week (vs. rarely or never)	0.01	-0.01 to 0.03	0.016	0.750	52.11	36.08 to 66.13	0.122	<0.0001
Frequency of exercise								
≥1week (vs. rarely or never)	-0.06	-0.09 to -0.03	-0.61	<0.0001	-30.01	-42.37 to -17.66	-0.075	<0.0001
Females								
Smoking status								
Ex-smoker (vs. non-smoker)	-0.04	-0.16 to 0.09	-0.020	0.555	4.62	-33.74 to 42.98	0.007	0.813
Current smoker (vs. non-smoker)	-0.02	-0.10 to 0.06	-0.018	0.608	3.69	-21.94 to 29.32	0.009	0.778
Alcohol consumption								
1-5 times/ week (vs. rarely or never)	0.00	-0.08 to 0.08	0.001	0.976	-3.62	-27.85 to 20.62	-0.010	0.770
6-7 times/ week (vs. rarely or never)	-0.04	-0.14 to 0.06	-0.028	0.429	33.747	3.69 to 63.80	0.072	0.028
Frequency of exercise								
≥1week (vs. rarely or never)	-0.07	-0.15 to 0.00	-0.065	0.057	-24.04	-47.26 to -0.083	-0.062	0.042

β indicates standardized regression coefficient

Table 6 Age-adjusted odds ratio for smoking, alcohol consumption and physical inactivity according to educational level and employment grade

	Cigarette smoking					Alcohol consumption					Physical inactivity				
	OR*	95% CI			p for trend	OR*	95% CI			p for trend	OR*	95% CI			p for trend
Men															
Education					<0.0001					0.888					0.135
University	reference					reference					reference				
High school	1.82	1.58	to	2.09		0.96	0.83	to	1.12		1.09	0.95	to	1.26	
Junior high school	1.67	1.24	to	2.25		1.13	0.83	to	1.53		1.19	0.89	to	1.60	
Employment grade					0.017					0.431					0.358
Higher-level non-manual	reference					reference					reference				
Lower-level non-manual	1.15	0.91	to	1.47		0.85	0.66	to	1.09		0.65	0.51	to	0.83	
Manual	1.32	1.02	to	1.69		0.96	0.77	to	1.29		0.87	0.68	to	1.12	
Women															
Education					<0.0001					0.789					0.341
University	reference					reference					reference				
High school	1.80	1.26	to	2.57		0.88	0.59	to	1.31		1.10	0.80	to	1.52	
Junior high school	4.52	2.40	to	8.50		1.10	0.50	to	2.42		1.33	0.72	to	2.46	
Employment grade					<0.0001					0.251					0.093
Higher-level non-manual	reference					reference					reference				
Lower-level non-manual	1.32	0.74	to	2.37		0.92	0.51	to	1.67		1.71	1.04	to	2.81	
Manual	2.54	1.43	to	4.51		1.25	0.69	to	2.28		1.70	1.03	to	2.79	

* Age-adjusted odds ratio

Educational level and employment grade were separately analysed in the model

Table 7 Adjusted CRP levels by gender according to educational level and employment grade

	Model 1				Model 2				Model 3			
	Mean	95% CI			Mean	95% CI			Mean	95% CI		
Men												
Education												
University	0.046	0.043	to	0.048	0.046	0.043	to	0.048	0.046	0.043	to	0.048
High school	0.050	0.047	to	0.052	0.050	0.047	to	0.052	0.050	0.047	to	0.052
Junior high school	0.050	0.043	to	0.058	0.049	0.043	to	0.057	0.049	0.042	to	0.057
p value (p for trend)	0.073 (0.285)				0.071 (0.307)				0.104 (0.422)			
Employment grade												
Higher-level non-manual	0.045	0.040	to	0.051	0.045	0.040	to	0.050	0.045	0.040	to	0.051
Lower-level non-manual	0.048	0.046	to	0.050	0.048	0.046	to	0.050	0.048	0.046	to	0.051
Manual	0.048	0.045	to	0.052	0.048	0.045	to	0.052	0.048	0.045	to	0.051
p value (p for trend)	0.511 (0.257)				0.495 (0.247)				0.597 (0.370)			
Women												
Education												
University	0.026	0.024	to	0.029	0.026	0.024	to	0.029	0.026	0.024	to	0.029
High school	0.029	0.026	to	0.033	0.029	0.026	to	0.033	0.030	0.026	to	0.033
Junior high school	0.032	0.023	to	0.044	0.030	0.022	to	0.042	0.031	0.022	to	0.042
p value (p for trend)	0.366 (0.284)				0.406 (0.417)				0.372 (0.378)			
Employment grade												
Higher-level non-manual	0.027	0.022	to	0.033	0.028	0.022	to	0.034	0.027	0.022	to	0.034
Lower-level non-manual	0.028	0.025	to	0.031	0.028	0.025	to	0.031	0.027	0.025	to	0.031
Manual	0.028	0.025	to	0.033	0.028	0.025	to	0.032	0.029	0.025	to	0.033
p value (p for trend)	0.884 (0.632)				0.970 (0.857)				0.894 (0.709)			

*log-transformed data were analysed, and adjusted means (95% CI) were back-transformed
Model 1: adjusted for age; BMI; smoking; alcohol consumption; exercise; medication for hypertension, hyperlipidemia and diabetes and menopausal status of women; Model 2: adjusted for model 1 variables plus heart rate, systolic blood pressure, TC, log TG, HDL and FBS; Model 3: model 2 variables plus job strain, effort–reward imbalance and overcommitment.

Table 8 Adjusted baPWV value by gender according to education level and employment grade

	Model 1					Model 2					Model 3				
	Mean	95% CI				Mean	95% CI				Mean	95% CI			
Men															
Education															
University	1360	1231	to	1260	a	1366	1360	to	1373	a	1367	1360	to	1373	a
High school	1369	1234	to	1269	a	1365	1359	to	1371	a	1365	1359	to	1371	a
Junior high school	1420	1233	to	1323		1410	1392	to	1427		1409	1391	to	1427	
p value (p for trend)	<0.0001 (<0.0001)					<0.0001 (<0.0001)					<0.0001 (<0.0001)				
Employment grade															
Higher-level non-manual	1350	1330	to	1369	b	1366	1352	to	1380		1367	1353	to	1381	
Lower-level non-manual	1365	1358	to	1373		1364	1358	to	1370	b	1364	1358	to	1370	b
Manual	1382	1371	to	1393		1379	1370	to	1387		1377	1369	to	1385	
p value (p for trend)	0.006 (0.004)					0.016 (0.139)					0.035 (0.219)				
Women															
Education															
University	1246	1232	to	1261		1248	1237	to	1258		1248	1238	to	1259	
High school	1252	1235	to	1270		1255	1243	to	1268		1254	1242	to	1267	
Junior high school	1274	1229	to	1319		1241	1209	to	1273		1240	1208	to	1273	
p value (p for trend)	0.512 (0.256)					0.554 (0.704)					0.613 (0.642)				
Employment grade															
Higher-level non-manual	1243	1213	to	1273		1244	1222	to	1265		1245	1223	to	1267	
Lower-level non-manual	1249	1234	to	1263		1249	1239	to	1260		1249	1239	to	1260	
Manual	1256	1237	to	1275		1254	1241	to	1268		1253	1239	to	1268	
p value (p for trend)	0.742 (0.475)					0.691 (0.411)					0.797 (0.512)				

[a] $p < 0.001$: vs. junior high school

[b] $p < 0.05$: vs. manual

Model 1: age; BMI; smoking; alcohol consumption; exercise; medication for hypertension, hyperlipidemia and diabetes and menopausal status of women; Model 2: adjusted for model 1 variables plus heart rate, systolic blood pressure, TC, log TG, HDL, FBS and log CRP; Model 3: model 2 variables plus job strain, effort–reward imbalance and overcommitment.