Industrial Health 2004, **42**, 41–49 **Original Article**

# The Influence of Work Characteristics on Body Mass Index and Waist to Hip Ratio in Japanese Employees

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*Received February 6, 2003 and accepted November 4, 2003*

**Abstract: A cross-sectional study on 6,676 workers consisting of 4,243 males and 2,433 females aged 20–58 yr in a metal product factory was conducted to elucidate the relationship between work characteristics, e.g. job demand/control/support, sedentary job, overtime work and shift work, and waist to hip ratio (WHR) as well as body mass index (BMI) taking alcohol consumption, smoking, exercise and other psychosocial factors such as education and marital status into account. By a stepwise multiple regression analysis, BMI was associated with shift work, marital status and sedentary job for males, and with exercise but inversely associated with education for females. WHR was also associated with shift work, alcohol consumption, marital status and sedentary job but inversely associated with exercise for males, and with sedentary job, marital status and education but inversely associated with smoking for females. These results suggest that work characteristics such as sedentary job and shift work should also be considered when trying to prevent increases in BMI and WHR.**

**Key words:** Waist to hip ratio, Body mass index, Job stress, Sedentary job, Shift work

## Introduction

The percentage of people over 20 yr of age in Japan showing a body mass index (BMI) ≥25 kg/m$^2$ was 23.8 in 2000. Especially, in younger males the trend toward overweight has markedly increased[1]. Hence, preventing overweight has become an important task from the viewpoint of health promotion. The usefulness of anthropometric measures, such as the ratio of waist to hip (WHR), waist alone and ratio of waist to height, has been recognized in evaluating central adiposity related to hypertension, non-insulin-dependent diabetes and dyslipidmia as cardiovascular risk factors as well as BMI[2,3]. Therefore, elucidating the causes of increasing central adiposity is important to prevent cardiovascular disease.

According to many investigations in several industrial countries, disadvantageous psychosocial factors affect increased WHR. Differences in socioeconomic status (SES) measured by income, education and social class, have been noted to contribute to the differences in WHR. Namely, WHR increased more in the low SES group than in high SES group[4]. Besides, not only work characteristics, e.g. shift work and problems at work, but also psychiatric symptoms, as well as SES, were reported to be associated with WHR[5–9].

The effects of work characteristics on cardiovascular risk

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factors have also been investigated in Japan. Overtime was associated with increased ambulatory blood pressure[10]. With regard to job stress measured by the job demand-control model[11], job demand was related to decreased fibrinolytic activity[12]. Job strain, combined with high demand and low control, and low social support were found to be associated with increased glycosylated haemoglobin A1c[13]. In a case-control study, people with acute ischemic heart disease had high job demand besides hypertension and marked Type A behavior[14]. A U-shaped relationship was found between mean working time and myocardial infarction in another case-control study[15].

Although WHR and ratio of waist to height were also shown to be associated with cardiovascular risk factors among Japanese, only few studies have been available so far on the relationship between psychosocial work environment and WHR in this population, and even on the relationship between work characteristics and BMI, a widely used index of obesity. Our previous study, in which the target subjects in the same factory ranged from 35 to 59 yr of age, demonstrated that sedentary job as a work characteristic was associated with WHR[16]. The objective of this report is to elucidate the relationship between work characteristics including job stress, overtime work and sift work status, and WHR as well as BMI.

## Subjects and Methods

*Study population*

The subjects of the study were the employees aged 20–58 yr in a metal products factory in a rural area, who underwent a medical checkup during the period between April 1996 and March 1997. The study excluded junior employees who worked for less than a year, short-term employees from recruitment agencies, a few directors, and anyone who did not give informed consent to participate in this study, as well as 256 employees who underwent a medical checkup at another medical facility because their anthropometric measurements were not available. Seventy females who experienced delivery between May in 1996 and May in 1997 were also excluded. The participation rate was 88.9% of the 7,509 employees, 90.1% in males and 86.6% in females, based on registration on 1st May in 1996.

*Anthropometric measurements*

The subject's weight, height, and waist and hip circumferences were measured in the factory uniform made of thin cloth. BMI was calculated by dividing weight by height squared. The waist circumference at the umbilicus level and the hip circumference at the widest level were measured by experienced nurses.

*Work characteristics*

Individual work characteristics —job demand, job control and worksite support— were determined by the Japanese version of the Karasek's job demand-control model[17]. Sedentary job, overtime work and shift work as other work characteristics were assessed by a self-administered questionnaire. Job demand, job control and worksite support were classified as nearly as possible into tertiles. Sedentary job was categorized into three groups according to the average sedentary hours per working day in the past year ('< 1 h', '≥ 1 and ≤ 4 h' and '≥ 5 h'). Overtime work was also categorized into four groups according to the sum of overtime working hours during the past month ('< 20 h', '≥ 20 and < 40 h', '≥ 40 and < 60 h' and '≥ 60 h' for males). Categorization of overtime for females was different from that for males, because no females worked overtime excessively ('< 20 h' and '≥ 20 h' for females). Basically the 3-shift workers who worked in the night were categorized as a shift work group (non-shift and shift). No female worker in the factory was engaged in 3-shift work.

*Life style and other social variables*

Smoking habit was classified as 'non-smokers', 'ex-smokers', 'smokers of < 21 cigarettes a day' and 'smokers of ≥ 21 cigarettes a day'. Alcohol consumption was measured in terms of grams of ethanol consumed per week, and was categorized into three groups which were 'less than 25 g/week', '25 g to 174 g/week' and '175 g and more/week' for males. Classification of alcohol consumption in females was not the same since they did not drink as much as males; 'less than 25 g/week' and '25 g and more/week'. Exercise was classified as 'almost no exercise', 'light exercise per week', 'brisk and sweating exercise once or twice per week' and 'brisk and sweating exercise more than three times per week'. In addition to smoking habit, alcohol consumption and exercise, education and marital status were important measurements of social variables. The measure of education was determined by the total years of education, and was classified as '< 11 yr', '11 to 12 yr', '13 to 14 yr' and '≥ 15 yr' of education. Marital status was divided into 'married' and 'not married'.

A questionnaire covering the characteristics of work was administered within a month before or after a person underwent a medical checkup. Other measurements were conducted at the time of the medical checkup.

**Table 1. Means [SD] of body mass index (BMI) & waist hip ratio (WHR) by age**

| Age | | 20–29 | 30–39 | 40–49 | 50–58 |
|---|---|---|---|---|---|
| <Males> | | | | | |
| BMI | n | 864 | 1177 | 1424 | 778 |
| | mean [SD] | 22.35 [2.96] | 23.22 [2.90] | 23.24 [2.77] | 23.44 [2.70] |
| WHR | n | 862 | 1177 | 1418 | 772 |
| | mean [SD] | 0.822 [0.047] | 0.855 [0.050] | 0.869 [0.053] | 0.881 [0.055] |
| <Females> | | | | | |
| BMI | n | 625 | 647 | 805 | 356 |
| | mean [SD] | 20.89 [2.91] | 21.82 [3.25] | 22.79 [3.27] | 22.98 [2.95] |
| WHR | n | 626 | 647 | 805 | 355 |
| | mean [SD] | 0.765 [0.058] | 0.789 [0.069] | 0.795 [0.073] | 0.815 [0.083] |

*Statistical methods*

All statistical analyses were adjusted for age, and data were analyzed separately for males and females using an SAS program package.

Since BMI and WHR are related to smoking habit, alcohol consumption, exercise, education and marital status, we regarded them as covariates[18–24].

Job demand, job control, worksite support, sedentary job, overtime work, shift work, smoking habit, alcohol consumption, exercise, education and marital status were analyzed as categorical data, when BMI adjusted for age and WHR adjusted for age and BMI were compared among various factors using a general linear model method.

The differences in the relationship of various factors to BMI and WHR levels were statistically evaluated by a stepwise multiple regression analysis; job demand, job control, worksite support, sedentary job, overtime work, smoking habit, alcohol consumption, exercise and education were analyzed as order scale. The significance level for the explanatory variables to enter and to stay in these models was p=0.15.

## Results

The overall mean age was 39.2 (SD 10.2) in males and 38.2 (SD 10.5) in females. The mean BMI and WHR were 23.1 (SD 2.9, n=4243) and 0.858 (SD 0.055, n=4229) in males, and 22.1 (SD 3.2, n=2433) and 0.788 (SD 0.072, n=2433) in females. Table 1 shows the mean levels of BMI and WHR by four age groups. With advancing age, BMI and WHR increased in both sexes.

The associations of BMI and WHR after adjustment of BMI with several work and other life style characteristic factors are shown in Table 2 and Table 3. As shown in Table 2, in males, more sedentary job, shift work, no smoking or previous smoking and matrimony were significantly associated with increased BMI. Shift work status, excessive alcohol consumption, smoking habit, less exercise and matrimony were significantly associated with increased WHR. In Table 3 for females, less sedentary job, more exercise and less education were significantly associated with increased BMI. High job control, more sedentary job, less smoking, high education and matrimony were significantly associated with increased WHR.

On the other hand, no significant interactions of job demand and job control with BMI or WHR were found in either sex (results not shown here).

Table 4 shows the results of the final stage analyses of stepwise multiple linear regression in males; the dependent variable was BMI or WHR. Explanatory variables were job control, job demand, worksite support, sedentary job, overtime work and shift work status as work characteristics, tobacco and alcohol consumption and physical activity at non-working time as life style factors, and marital status and education as other psychosocial factors. Increased BMI was shown to be significantly related to older age, shift work, matrimony, more sedentary job and more exercise, and less significantly related to smoking habit. With regard to WHR, BMI, age, less exercise, shift work, excessive alcohol consumption, matrimony and more sedentary job were significant predictors of increased WHR.

Table 5 also shows the results of the same statistical analysis in females. Shift work was excluded from the explanatory variables because no female was working on the night shift. BMI was significantly associated with age, education and exercise: older women with low education and more physical activity showed increased BMI. BMI, age, more sedentary job, matrimony, high education and no smoking status significantly predicted increased WHR.

**Table 2. Means of BMI adjusted for age and of WHR adjusted for both age and BMI in males according to various factors**

| | | [BMI] | | | | [WHR] | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | total | n | mean | p | total | n | mean | p |
| Job control | low | 4030 | 1174 | 23.03 | 0.05 | 4015 | 1169 | 0.858 | 0.93 |
| | middle | | 1353 | 23.00 | | | 1348 | 0.858 | |
| | high | | 1503 | 23.24 | | | 1498 | 0.857 | |
| Job demand | low | 4036 | 1175 | 23.15 | 0.42 | 4022 | 1171 | 0.860 | 0.19 |
| | middle | | 1231 | 23.01 | | | 1227 | 0.857 | |
| | high | | 1630 | 23.12 | | | 1624 | 0.857 | |
| Worksite support | low | 4020 | 1018 | 22.25 | 0.13 | 4005 | 1016 | 0.857 | 0.46 |
| | middle | | 1596 | 23.03 | | | 1592 | 0.859 | |
| | high | | 1406 | 23.06 | | | 1397 | 0.857 | |
| Sedentary jobs | <1 (h) | 4033 | 2147 | 22.95 | ** | 4018 | 2145 | 0.857 | 0.28 |
| (per day in the past year) | 1–4 | | 834 | 23.23 | | | 827 | 0.856 | |
| | ≥5 | | 1052 | 23.28 | | | 1046 | 0.859 | |
| Overtime | <20(h) | 3983 | 2357 | 23.03 | 0.37 | 3969 | 2353 | 0.858 | 0.13 |
| (sum during the past month) | 20–39 | | 1071 | 23.11 | | | 1068 | 0.855 | |
| | 40–59 | | 398 | 23.21 | | | 394 | 0.859 | |
| | ≥60 | | 157 | 23.37 | | | 154 | 0.864 | |
| Shift work | No | 4243 | 3658 | 23.05 | 0.02 | 4228 | 3645 | 0.856 | *** |
| | Yes | | 585 | 23.34 | | | 583 | 0.866 | |
| Alcohol consumption | <25 (g) | 4227 | 1469 | 23.08 | 0.91 | 4214 | 1465 | 0.855 | *** |
| (per week) | 25–174 | | 1755 | 23.07 | | | 1748 | 0.855 | |
| | ≥175 | | 1003 | 23.11 | | | 1001 | 0.865 | |
| Smoking habit | Non | 4243 | 1353 | 23.23 | ** | 4228 | 1350 | 0.856 | ** |
| | Ex | | 458 | 23.35 | | | 456 | 0.857 | |
| | <21 (d) | | 1834 | 22.91 | | | 1825 | 0.858 | |
| | ≥21 (d) | | 598 | 23.11 | | | 597 | 0.863 | |
| Exercise | Non | 4234 | 2686 | 23.03 | 0.28 | 4220 | 2677 | 0.861 | *** |
| (per week) | Light | | 800 | 23.16 | | | 796 | 0.857 | |
| | Brisk (<3 times) | | 521 | 23.25 | | | 521 | 0.848 | |
| | Brisk (≥3 times) | | 227 | 23.22 | | | 226 | 0.846 | |
| Education | –10 (yr) | 4242 | 669 | 22.83 | 0.05 | 4227 | 667 | 0.857 | 0.77 |
| | 11–12 | | 2462 | 23.10 | | | 2457 | 0.857 | |
| | 13–14 | | 241 | 23.02 | | | 240 | 0.860 | |
| | 15– | | 870 | 23.27 | | | 863 | 0.858 | |
| Matrimony | No | 4042 | 1117 | 22.85 | ** | 4027 | 1114 | 0.854 | ** |
| | Yes | | 2925 | 23.18 | | | 2913 | 0.859 | |

**: 0.01>P>0.001, ***: P≤0.001.

## Discussion

The means and standard deviations of BMI levels for this study were very similar to the results of the National Nutrition Survey in Japan conducted in 1996[25]. According to this survey, the means and standard deviations of BMI for males were 23.2 (SD 2.9) for those in their thirties and 23.4 (SD 2.9) for those in their forties. The corresponding levels for females were 21.4 (SD 3.2) and 22.8 (SD 3.2) respectively. The mean WHR levels in this study were lower than those in the other Japanese investigations, probably because the participants in this study were younger than those in the others[26–28].

As for work characteristics related to BMI or WHR, our study showed by stepwise multiple regression analysis that shift work and sedentary job predicted increased BMI and WHR for males, and that sedentary job predicted increased

**Table 3. Means of BMI adjusted for age and of WHR adjusted for both age and BMI in females according to various factors**

| | | *[BMI]* | | | | *[WHR]* | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | total | n | mean | p | total | n | mean | p |
| Job control | low | 2311 | 730 | 22.13 | 0.47 | 2310 | 730 | 0.782 | ** |
| | middle | | 747 | 22.14 | | | 747 | 0.788 | |
| | high | | 834 | 21.97 | | | 833 | 0.793 | |
| Job demand | low | 2332 | 771 | 21.97 | 0.46 | 2331 | 770 | 0.791 | 0.18 |
| | middle | | 745 | 22.16 | | | 745 | 0.785 | |
| | high | | 816 | 22.12 | | | 816 | 0.787 | |
| Worksite support | low | 2308 | 743 | 22.08 | 0.39 | 2307 | 743 | 0.784 | 0.11 |
| | middle | | 487 | 22.23 | | | 486 | 0.789 | |
| | high | | 1078 | 21.99 | | | 1078 | 0.790 | |
| Sedentary jobs | <1 (h) | 2346 | 1365 | 22.24 | 0.02 | 2345 | 1364 | 0.780 | *** |
| (per day in the past year) | 1–4 | | 230 | 21.88 | | | 230 | 0.792 | |
| | ≥5 | | 751 | 21.84 | | | 751 | 0.801 | |
| Overtime | <20 (h) | 2266 | 2106 | 22.06 | 0.69 | 2265 | 2105 | 0.788 | 0.90 |
| (sum during the past month) | ≥20 | | 160 | 22.16 | | | 160 | 0.787 | |
| Alcohol consumption | <25 (g) | 2433 | 2244 | 22.07 | 0.91 | 2431 | 2243 | 0.789 | 0.11 |
| (per week) | ≥25 | | 189 | 22.09 | | | 188 | 0.781 | |
| Smoking habit | Non | 2433 | 2306 | 22.05 | 0.18 | 2431 | 2304 | 0.789 | 0.02 |
| | Ex | | 25 | 21.86 | | | 25 | 0.788 | |
| | <21 (d) | | 102 | 22.63 | | | 102 | 0.770 | |
| Exercise | Non | 2433 | 1872 | 21.90 | *** | 2431 | 1870 | 0.789 | 0.33 |
| (per week) | Light | | 311 | 22.66 | | | 311 | 0.787 | |
| | Brisk (<3 times) | | 208 | 22.48 | | | 208 | 0.791 | |
| | Brisk (≥3 times) | | 42 | 23.21 | | | 42 | 0.771 | |
| Education | –10 (yr) | 2433 | 881 | 22.35 | *** | 2431 | 880 | 0.780 | *** |
| | 11–12 | | 1234 | 22.09 | | | 1233 | 0.788 | |
| | 13–14 | | 276 | 21.28 | | | 276 | 0.809 | |
| | 15– | | 42 | 20.67 | | | 42 | 0.819 | |
| Matrimony | No | 2334 | 652 | 21.98 | 0.40 | 2333 | 652 | 0.783 | 0.03 |
| | Yes | | 1682 | 22.12 | | | 1681 | 0.790 | |

**: 0.01>P>0.001, ***: P≤0.001.

WHR for females. The same results were obtained when we used waist circumference, considered to be another good indicator of abdominal fat accumulation, instead of WHR (analysis not shown here).

It is well known that various life style factors affect BMI and WHR. Increasing physical activity is an important factor in preventing obesity and improving fat distribution of the upper body[21, 22], and this was more consistently true of males than of females in our results. Exercise was positively associated with BMI for both genders. We suggest the following reasons for this; first, BMI for some people who have the habit of regular exercise, for instance athletes and people who perform resistance training, does not decrease but rather increases because of the presence of increased muscle mass. Besides, anthropometric improvement due to exercise is more often observed than reduced body weight[29, 30]. Indeed, the mean WHR in the group of 'brisk and sweating exercise more than twice per week' was the lowest compared to that of the other groups for both males and females in our result. Second, obese people with hypertension, hyperlipidemia and hyperglycemia were repeatedly recommended to implement an exercise program by the health care center in the factory, and so people with increased BMI were very likely to be included in the group of people who do the most exercise. Third, the effect of physical activity on body fat is not always as clear for females as for males[31].

Acute cardiovascular accidents due to overwork with long working hours have been focused on when the health effects

**Table 4. Results of stepwise multiple regression analyses for variables related to BMI and WHR in males**

BMI: dependent variable n=3829, $R^2$=0.03

| | Standardized estimate ($\beta$) | F | p |
|---|---|---|---|
| Age | 0.027 | 25.1 | *** |
| Shift work | 0.506 | 13.5 | *** |
| Matrimony | 0.361 | 8.5 | ** |
| Sedentary job | 0.169 | 7.8 | ** |
| Exercise | 0.112 | 4.7 | 0.03 |
| Smoking habit | –0.089 | 4.2 | 0.04 |
| Worksite support | –0.103 | 2.8 | 0.09 |
| Job control | 0.101 | 2.5 | 0.11 |

WHR: dependent variable n=3817, $R^2$=0.48

| | Standardized estimate ($\beta$) | F | p |
|---|---|---|---|
| BMI | 0.011 | 2370 | *** |
| Age | 0.001 | 329.9 | *** |
| Exercise | –0.006 | 68.8 | *** |
| Shift work | 0.011 | 32.8 | *** |
| Alcohol consumption | 0.005 | 29.1 | *** |
| Matrimony | 0.005 | 8.5 | ** |
| Sedentary job | 0.002 | 6.9 | ** |
| Job demand | -0.001 | 3.4 | 0.07 |

**: 0.01>P>0.001, ***: P≤0.001.

**Table 5. Results of stepwise multiple regression analyses for variables related to BMI and WHR in females**

BMI: dependent variable n=2140, $R^2$=0.01

| | Standardized estimate ($\beta$) | F | p |
|---|---|---|---|
| Age | 0.058 | 51.5 | *** |
| Education | –0.546 | 21.2 | *** |
| Exercise | 0.412 | 19.0 | *** |

WHR: dependent variable n=2140, $R^2$=0.21

| | Standardized estimate ($\beta$) | F | p |
|---|---|---|---|
| BMI | 0.009 | 404 | *** |
| Age | 0.001 | 25.2 | *** |
| Sedentary job | 0.008 | 19.4 | *** |
| Matrimony | 0.013 | 11.9 | *** |
| Education | 0.007 | 7.7 | ** |
| Smoking habit | –0.009 | 7.7 | ** |
| Job control | 0.003 | 2.7 | 0.10 |
| Job demand | –0.002 | 2.2 | 0.14 |

**: 0.01>P>0.001, ***: P≤0.001.

of working conditions in Japan are considered[32]. However, few studies have been conducted yet on the relationship between prolonged working and BMI or WHR affecting cardiovascular risk factors, and the nature of the relationship has been obscure. Our data showed that for males BMI and WHR of the longest overtime group increased more than those of the other groups, but no statistically significant association between overtime and BMI or WHR was found after adjusting for other factors. Maruyama et al reported that working hours was not a contributor to increased obesity in 6,536 intermediate male managers in more than 100 firms[33]. Another 5-year cohort study was conducted on 941 white-collar male workers, of whom about 57% were managers and about 62% were architects/researchers. Long working hours was negatively associated with hypertension, and was not significantly associated with linearly increased BMI[34]. On the other hand, there were significantly positive relationships between total overtime hours and changes in BMI or waist circumference in 230 non-management white-collar male workers in the period of three years[35]. Occupational differences such as working position may contribute to the difference in these results. Another study on laborers in Japan reported that clean-room workers who had changed from working three 8-hour shifts to two 12-hour shifts showed a significant increase in their BMI one year and a half later[36]. But in analyzing these data, two factors, longtime working and shift work, have to be taken into account. Indeed, shift work as a working condition seemed to increase BMI and WHR[5, 6, 37]. Our result also showed that the shift work condition was positively associated with BMI and WHR.

There were significant relationships between sedentary job and BMI for males, and also between sedentary job and WHR for both sexes in our study. This seems to be a reflection of less physical activity[38].

A number of investigations have noted socioeconomic inequalities in health in industrial countries[39, 40]. As one part of the explanation it is implied that people in low SES tend to be more obese than those in high SES[24], and likewise an association between SES and WHR is implied. The present study demonstrated that education as a measure of socioeconomic status was unrelated to increased BMI and WHR for males after taking into account potential confounders. Among females, an inverse association between education and BMI was shown, but contrarily, higher education was a significant contributor to higher WHR. This inconsistency is difficult to explain because of a shortage of information on, for instance, reproductive and menopausal status which seems likely to affect WHR[41]. In our previous study on subjects aged between 35 and 59 yr we reported that after adjusting for confounding factors there was no significant difference in the mean WHR among the different levels of occupational categories for males. The mean WHR of female labourers, however, was higher than that of female engineers and clerks. Although the labourer group was expected to have had lower education in comparison with the engineer and clerk groups, we could not accurately determine the educational backgrounds of the employees in the previous study[16]. Regarding other Japanese studies, WHR of the employees who worked for a computer company was larger for blue-collar than for white-collar workers in both sexes. The author interpreted this result as suggesting that disadvantaged life styles, such as less exercise and more alcohol and smoking consumption, for blue-collar workers might contribute to the differences in WHR[42]. However, others have observed no such association. Among the middle-aged males of the Self-Defense Forces it was demonstrated that military rank as an indicator of socioeconomic status was only weakly associated with BMI, and was not associated with WHR[43]. Another Japanese study conducted on 4,545 workers of various companies demonstrated that BMI was higher in white-collar than in blue-collar workers for males, and that contrarily higher BMI was shown in blue-collar than in white-collar workers for females[44]. Hence, the SES-overweight relationship in Japanese may not be as clear as that seen in other industrial countries.

Moreover, people in low SES generally work in more stressful conditions compared with people in high SES. Björntorp has suggested some stress associated with psychosocial maladjustment elevates WHR because psychosocial disadvantage pressures may cause visceral fat accumulation via acceleration of activity of the hypothalamic-pituitary-adrenal axis[45]. Therefore, his study demonstrated working handicaps such as being out of work and having problems at work were positively associated with WHR[6, 7]. Incidentally, the job demand-control model has been commonly used to evaluate job stress recently. It is not clear, however, whether the job stress promotes a tendency toward overweight or upper body fat distribution[46–48]. A Japanese study showed that BMI of the job strain group was lower compared with that of the others in males, with no significant difference noted in females[49]. In the present study likewise, job stress estimated by a job demand-control model was not significantly associated with BMI or WHR after adjusting for confounding factors in either sex. While a job demand-control model did not show any potent associations with BMI or WHR in our study, we may need to extend our investigation to include other job stress measurements, for instance an effort-reward imbalance model, to clarify the relationship between job stress and obesity and upper body fat distribution.

In the meantime, we measured waist and hip circumferences of the subjects wearing the same factory uniform, and adopted many parameters from self-reported information, so that some of our results might possibly lack accuracy. However, as we studied quite a large population, we may reasonably conclude that shift work and sedentary job were strongly associated with increased BMI and WHR. Besides, the reason coefficients of determination ($R^2$) for BMI by multiple regression analyses were small is that BMI may be more related to other factors such as dietary and genetic ones that we did not examine[50]. We also have to consider that several work-related factors focused on in this study are complicatedly linked to each other. Therefore there is likely to be some criticism for using the stepwise multiple regression analysis to elucidate the relationship between work characteristics and WHR and BMI. In the next step, we will need to unravel these complicated relationships to help develop more effective health promotion activities.

In conclusion, by stepwise multiple regression analyses, BMI was associated with shift work, marital status and sedentary job for males, and with exercise but inversely associated with education for females. WHR was also associated with shift work, alcohol consumption, marital status and sedentary job but inversely associated with exercise for males, and with sedentary job, marital status and education but inversely associated with smoking for females. Because overweight not only aggravates various risk factors of cardiovascular disease but also promotes other health problems such as gallbladder disease, osteoarthritis, back pain and certain types of cancer[51], preventing overweight is important for health. Hence, when we try to prevent increases in BMI and WHR, we should consider work characteristics such as shift work and sedentary job.

## Acknowledgment

This study was supported by a Grant-in-Aid for Scientific Research (C:13670395:2001–2003), from the Japanese Ministry of Education, Culture, Science and Technology.

## References

1) Ministry of Health, Labour and Welfare (2002) The National Nutrition Survey in Japan, 2000, Daiichi, Tokyo (in Japanese).
2) Terry RB, Page WF, Haskell WL (1992) Waist/hip ratio, body mass index and premature cardiovascular disease mortality in US Army veterans during a twenty-three year follow-up study. Int J Obes **16**, 417–23.

3) Prineas RJ, Folsom AR, Kaye SA (1993) Central adiposity and increased risk of coronary artery disease mortality in older women. Ann Epidemiol **3**, 35–41.
4) Brunner E (1996) The social and biological basis of cardiovascular disease in office workers. In: Health and social organization. ed. by Blane D, Brunner E, Wilkinson R, 272–99, Routledge, London and New York.
5) Van Amelsvoort LG, Schouten EG, Kok FJ (1999) Duration of shiftwork related to body mass index and waist to hip ratio. Int J Obes Relat Metab Disord **23** (Suppl), 973–8.
6) Rosmond R, Lapidus L, Björntorp P (1996) The influence of occupational and social factors on obesity and body fat distribution in middle-aged men. Int J Obesity **20**, 599–607.
7) Rosmond R, Björntorp P (1999) Psychosocial and socio-economic factors in women and their relationship to obesity and regional body fat distribution. Int J Obesity **23**, 138–45.
8) Wing RR, Matthews KA, Kuller LH, Meilahn EN, Plantinga P (1991) Waist to hip ratio in middle-aged women: Associations with behavioral and psychosocial factors and with changes in cardiovascular risk factors. Arterioscl Throm **11**, 1250–7.
9) Rosmond R, Lapidus L, Marin P, Björntorp P (1996) Mental distress, obesity and body fat distribution in middle-aged men. Obes Res **4**, 245–52.
10) Hayashi T, Kobayashi Y, Yamaoka K, Yano E (1996) Effect of overtime work on 24-hour ambulatory blood pressure. JOEM **38**, 1007–11.
11) Karasek RA, Baker D, Marxer F, Ahlbom A, Theorell T (1981) Job decision latitude, job demands, and cardiovascular disease: a prospective study of Swedish men. Am J Public Health **71**, 694–705.
12) Ishizaki M, Tsuritani I, Noborisaka Y, Yamada Y, Tabata M, Nakagawa H (1996) Relationship between job stress and plasma fibrinolytic activity in male Japanese workers. Int Arch Environ Health **68**, 315–20.
13) Kawakami N, Akachi K, Shimizu H, Haratani T, Kobayashi F, Ishizaki M, Hayashi T, Fujita O, Aizawa Y, Miyazaki S, Hiro H, Hashimoto S, Araki S (2000) Job strain, social support in the work, and haemoglobin A1c in Japanese men. Occup Environ Med **57**, 805–9.
14) Kayaba K, Yazawa Y, Natsume T, Yaginuma T, Hosaka T, Hosoda S, Tamada T (1990) The relevance of psychosocial factors in acute ischemic heart disease: a case-control study of a Japanese population. Jpn Circ J **54**, 464–71.
15) Sokejima S, Kagamimori S (1998) Working hours as a risk factor for acute myocardial infarction in Japan: case-control study. BMJ **317**, 775–80.
16) Ishizaki M, Yamada Y, Morikawa Y, Noborisaka Y, Ishida M, Miura K, Nakagawa H (1999) The relationship between waist-to-hip ratio and occupational status and life-style factors among middle-aged male and female Japanese workers. Occup Med **49**, 177–82.
17) Kawakami N, Kobayashi F, Araki S, Haratani T, Furui H (1995) Assessment of job stress dimensions based on the job demands-control model of employees of telecommunication and electric power companies in Japan: reliability and validity of the Japanese version of job content questionnaire. Int J Behav Med **2**, 358–75.
18) Shimokata H, Muller DC, Andres R (1989) Studies in the distribution of body fat: III. Effects of cigarette smoking. JAMA **261**, 1169–73.
19) Eliasson B, Attvall S, Taskinen MR, Smith U (1994) The insulin resistance syndrome in smokers is related to smoking habits. Arterioscler Thromb **14**, 1946–50.
20) Laws A, Terry RB, Barrett-Connor E (1990) Behavioral covariates of waist-to-hip ratio in Rancho Bernardo. Am J Public Health **80**, 1358–62.
21) Poston WS 2nd, Foreyt JP (1999) Obesity is an environmental issue. Atherosclerosis **146**, 201–9.
22) Hill JO, Peters JC (1998) Environmental contributions to the obesity epidemic. Science **280**, 1371–4.
23) Colhoun HM, Hemingway H, Poulter NR (1998) Socio-economic status and blood pressure: an overview analysis. J Hum Hypertens **12**, 91–110.
24) Jeffery RW, French SA, Forster JL, Spry VM (1991) Socioeconomic status differences in health behaviors related to obesity: the Healthy Worker Project. Int J Obes **15**, 689–96.
25) Ministry of Health, Labour and Welfare (1998) The National Nutrition Survey in Japan, 1996, Daiichi, Tokyo (in Japanese).
26) Iso H, Kiyama M, Naito Y, Sato S, Kitamura A, Iida M, Konishi M, Sankai T, Shimamoto T, Komachi Y (1991) The relation of body fat distribution and body mass with haemoglobin A1c, blood pressure and blood lipids in urban Japanese men. Int J Epidemiol **20**, 88–94.
27) Ohmura T, Ueda K, Kiyohara Y, Kato I, Iwamoto H, Nakayawa K, Nomiyama K, Ohmori S, Yoshitake T, Shinkawa A, Hasuo Y, Fujishima M (1994) The association of the insulin resistance syndrome with impaired glucose tolerance and NIDDM in the Japanese general population: the Hisayama study. Diabetologia **37**, 897–904.
28) Sakurai Y, Kono S, Shinchi K, Honjo S, Todoroki I,

Wakabayashi K, Imanishi K, Nishikawa H, Ogawa S, Katsurada M (1995) Relation of waist-hip ratio to glucose tolerance, blood pressure, and serum lipids in middle-aged Japanese males. Int J Obes **19**, 632–7.

29) Krotkiewski M (1988) Can body fat patterning be changed? Acta Med Scand **723** (Suppl), 213–23.

30) Friendl KE, Westphal KA, Marchitelli LJ, Patton JF, Chumlea WC, Guo SS (2001) Evaluation of anthropometric equations to assess body-composition changes in young women. Am J Clin Nutr **73**, 268–75.

31) Westerterp KR, Goran MI (1997) Relationship between physical activity related energy expenditure and body composition: a gender difference. Int J Obes **21**, 184–8.

32) Uehata T (1991) Long working hours and occupational stress-related cardiovascular attacks among middle-aged workers in Japan. J Hum Ergol **20**, 147–53.

33) Maruyama S, Morimoto K (1996) Effects of long workhours on life-style, stress and quality of life among intermediate Japanese managers. Scand J Work Environ Health **22**, 353–9.

34) Nakanishi N, Yoshida H, Nagano K, Kawashimo H, Nakamura K, Tatara K (2001) Long working hours and risk for hypertension in Japanese male white collar workers. J Epidemiol Community Health **55**, 316–22.

35) Nakamura K, Shimai S, Kikuchi S, Takahashi H, Tanaka M, Nakano S, Motohashi Y, Nakadaira H, Yamamoto M (1998) Increases in body mass index and waist circumference as outcomes of working overtime. Occup Med **48**, 169–73.

36) Yamada Y, Kameda M, Noborisaka Y, Suzuki H, Honda M, Yamada S (2001) Excessive fatigue and weight gain among cleanroom workers after changing from 8-hour to a 12-hour shift. Scand J Work Environ Health **27**, 318–26.

37) Kawachi I, Colditz GA, Stampfer MJ, Willett WC, Manson JE, Speizer FE, Hennekens CH (1995) Prospective study of shift work and risk of coronary heart disease in women. Circulation **92**, 3178–82.

38) Duncan BB, Chambless LE, Schmidt MI, Szklo M, Folsom AR, Carpenter MA, Crouse JR 3rd (1995) Correlates of body fat distribution: Variation across categories of race, sex, and body mass in the atherosclerosis risk in communities study. Ann Epidemiol **5**, 192–200.

39) Adler NE, Boyce WT, Chesney MA, Folkman S (1993) Socioeconomic inequalities in health: No easy solusion. JAMA **269**, 3140–5.

40) Social Determinants of Health (1999) ed. Marmot M, Wilkinson RG, Oxford University Press, Oxford.

41) Legato MJ (1997) Gender-specific aspects of obesity. Int J Fertil **42**, 184–97.

42) Nakamura S, Nakamura K, Tanaka M (2000) Increased risk of coronary heart disease in Japanese blue-collar workers. Occcup Med **50**, 11–7.

43) Sakurai Y, Umeda T, Shinchi K, Honjo S, Wakabayashi K, Todoroki I, Nishikawa H, Ogawa S, Katsurada M (1997) Relation of total and beverage-specific alcohol intake to body mass index and waist-to-hip ratio: A study of self-defense officials in Japan. Eur J Epidemiol **13**, 893–8.

44) Kikuoka H, Okamoto K, Arako M, Okamura T, Kawaguchi A, Minakata H, Hoso T, Kondou M, Maeda J (1999) The prevalence of obesity found in health check-ups in occupational population: In relation to the occupations and industries. Occup Health J **22**, 34–9 (in Japanese).

45) Björntorp P (1991) Visceral fat accumulation: The missing link between psychosocial factors and cardiovascular disease? J Intern Med **230**, 195–201.

46) Reed DM, Lacroix AZ, Karasek RA, Miller D, Maclean CA (1989) Occupational strain and the incidence of coronary heart disease. Am J Epidemiol **129**, 495–502.

47) Steptoe A, Cropley M, Griffith J, Joekes K (1999) The influence of abdominal obesity and chronic work stress on ambulatory blood pressure in men and women. Int J Obes **23**, 1184–91.

48) Brisson C, Larocque B, Moisan J, Vézina M, Dagenais GR (2000) Psychosocial factors at work, smoking, sedentary behavior, and body mass index: A prevalence study among 6995 white collar workers. JOEM **42**, 40–6.

49) Tsutsumi A, Tsutsumi K, Kayaba K, Theorell T, Nago N, Kario K, Igarashi M (1998) Job strain and biological coronary risk factors: A cross-sectional study of male and female workers in a Japanese rural district. Int J Behav Med **5**, 295–311.

50) World Health Organization (2000) Obesity: Preventing and Managing the Global Epidemic. Part III. Understanding how overweight and obesity develop. WHO Technical Report Series No.894, 100–152, WHO, Geneva.

51) World Health Organization (2000) Obesity: Preventing and Managing the Global Epidemic. Part II. Establishing the true costs of the problem of overweight and obesity. WHO Technical Report Series No.894, 38–68, WHO, Geneva.