Overtime work, insufficient sleep, and risk of non-fatal acute myocardial infarction in Japanese men

Y Liu, H Tanaka, The Fukuoka Heart Study Group

OBJECTIVE: To examine the relation between working hours and hours of sleep and the risk of acute myocardial infarction (AMI), with special reference to the joint effect of these two factors.

METHOD: Case-control study in Japan. Cases were 260 men aged 40–79 admitted to hospitals with AMI during 1996–8. Controls were 445 men free from AMI matched for age and residence who were recruited from the resident registers. Odds ratios of AMI relative to mean weekly working hours and daily hours of sleep in the past year or in the recent past were calculated.

RESULTS: Weekly working hours were related to progressively increased odds ratios of AMI in the past year as well as in the past month, with a twofold increased risk for overtime work (weekly working hours >61) compared with working hours ≤40. Short time sleep [daily hours of sleep ≤5] and frequent lack of sleep [2 or more days/week with <5 hours of sleep] were also associated with a two to threefold increased risk. Frequent lack of sleep and few days off in the recent past showed greater odds ratios than those in the past year.

CONCLUSIONS: Overtime work and insufficient sleep may be related to increased risk of AMI.

METHODS

Subjects

Eligible cases were patients aged 40–79 who were admitted to 22 collaborating hospitals for a first AMI occurring during the period from September 1996 to September 1998 who survived to receive rehabilitation and who were within a month after the onset of AMI. Thirteen hospitals were selected to cover the patients in Fukuoka City at the time when the study was started, and nine hospitals subsequently joined the study from June 1997 to recruit the patients in adjacent municipalities. These collaborating hospitals had one or more expert cardiologists and the facilities for treating AMI.

Research nurses checked all admissions with a diagnosis of AMI or suspected AMI, and asked eligible patients to participate in the study. Collaborator cardiologists were responsible for the diagnosis of AMI, which was based on an electrocardiogram, ischaemic cardiac pain lasting at least 30 minutes, and enzyme change. A total of 756 potentially eligible patients were identified, and 660 patients (87%) participated in the study; participation rates in men and women were both 87%.

At most two controls for each case, matched by sex, age (within 2 years), and residence, were recruited from the resident registers, which list residents in order of house numbers; eligible residents listed subsequently to the case were selected. Two potential control subjects who lived nearest to a case were firstly invited to participate in the study. If one or two refused, then a third one was chosen and so on till at least one control was recruited. From September 1996 to March 1999, a total of 2613 control candidates were first approached by post. Two further letters were sent to non-respondents, then they were contacted by telephone if telephone numbers were available. Finally, 1277 participated in the study. The information about non-participants was as follows: non-resident or emigration 2613, contact refused 889, death 22, undelivered mail 53, no response to mail 267. Thus the net participation rate was estimated to be 52% (1277/2433):
participation rates in men and women were 56% and 45%, respectively. No control was recruited for one case, only one control was recruited for in cases matched, and two controls were recruited for each of the remaining cases.

Because working women were few, the present study included working men only. After exclusion of all women (181 cases and 346 controls) and men without a job (171 cases and 293 controls), 308 cases and 638 controls remained. Also, men with incomplete information on working hours (nine cases and 16 controls) were deleted. We further excluded cases without a matched control and controls without a matched case (39 and 177, respectively). Finally, 260 cases and 445 individually matched controls remained in the analysis.

#### Risk factors

A questionnaire based interview elicited details of work related factors, lifestyle factors, and medical and family history before AMI in cases and before interview in controls.

The subjects were asked about their mean working hours each week, number of days off a year, hours of sleep a day on working days and on days off separately, and days each week with less than 5 hours sleep in the past year. Weekly working hours and number of days off in the past month and days of sleeping less than 5 hours in the past week were also recorded. We then grouped weekly working hours, monthly days off, and daily hours of sleep into three arbitrary categories (<40, 41–60, and ≥61; <2, 2–7, and ≥8; and ≤5, 6–8, and ≥9 respectively).

Weekly working hours ≥61, monthly days off <2, daily hours of sleep ≤5, and 2 or more days a week with less than 5 hours sleep were defined as overtime work, few days off, short sleep time, and frequent lack of sleep, respectively.

Exposure to cigarette smoking was expressed by cigarette-years, the number of cigarettes smoked a day multiplied by years of smoking, which was categorised into 0, 1–399, 400–799, and ≥800 cigarette-years. The average amount of alcohol consumed a day was calculated for current alcohol drinkers, and alcohol use was categorised into never, past, and current use with a consumption of <50 or ≥50 ml of alcohol a day. History of diseases related to AMI (hypertension, hyperlipidaemia, and diabetes mellitus) was defined as positive if subjects had ever been prescribed medication, special diet, or exercise for these conditions. Height and body weight were also recorded, and a body mass index (kg/m²) of 25 or greater was defined as overweight. Job titles were coded according to the classification used in the national census. They were grouped into white collar jobs (professional, managerial, clerical, and sales work) and blue collar jobs (craft, labouring, and service work). Shift work was defined if subjects had rotating work. Subjects self rated their occupational physical activity as mostly sedentary, moderately active, quite active, or having a job related to sport. The last three categories were combined as non-sedentary. Job strain was assessed in accordance with the Karasek model. The detailed procedures have been described elsewhere. In brief, job demand and control scores were determined on the basis of two and five questions, respectively. These scores were dichotomised at the median values, and high job strain was defined as a combination of low control and high demand.

To examine the characteristics of control candidates who did not participate in the present study, we posted an abbreviated questionnaire containing 13 questions to 456 such people until December 1997. Of these, 217 responded to the questionnaire, and unanswered questions were completed by telephone interview. Subjects who reported a history of myocardial infarction (n=4) were excluded from participating as control subjects. Among the remaining 213 subjects, 72 men with a job were used in the analysis. In this survey, questions about mean weekly working hours, monthly days off, and daily hours of sleep on work days in the past year were included.

#### Statistical analysis

Analysis of variance (ANOVA) and analysis of covariance (ANCOVA) were used to compare the means of working hours, days off, and hours of sleep among groups. Conditional logistic regression analysis was used to obtain ORs of AMI relative to working hours, numbers of days off, and hours of sleep; 95% confidence intervals (95% CIs) were calculated with standard errors of the logistic regression coefficients. The interaction was assessed by the likelihood ratio test. Covariates included in the multivariate models were hypertension, diabetes mellitus, hyperlipidaemia, overweight, cigarette smoking, alcohol intake, parental CHD (angina pectoris and myocardial infarction), job type (blue collar job and white collar job), and sedentary job. They were treated as categorical variables with indicator variables representing the categories. All computations were performed with the SAS software package version 6.04 (SAS Institute, Cary, NC, USA).

#### RESULTS

There was no material difference between the surveyed controls and non-participant control candidates for weekly working hours (44.1 versus 45.7) and monthly numbers of days off (1.8 versus 1.7) in the past year, but participants took slightly shorter sleep than non-participants (7.0 versus 7.3 hours).

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Case (working h/week)</th>
<th>Control (working h/week)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;40 n=86</td>
<td>41–60 n=131</td>
<td>≥61 n=43</td>
</tr>
<tr>
<td>Age [y, mean]</td>
<td>60.3 ± 6.1</td>
<td>54.0 ± 5.9</td>
<td>0.0001*</td>
</tr>
<tr>
<td>Current smoking</td>
<td>59.3 ± 7.2</td>
<td>76.6 ± 6.9</td>
<td>0.09</td>
</tr>
<tr>
<td>Current weekly alcohol use</td>
<td>50.0 ± 5.3</td>
<td>44.2 ± 4.7</td>
<td>0.57</td>
</tr>
<tr>
<td>Parental CHD</td>
<td>19.3 ± 2.2</td>
<td>18.6 ± 2.0</td>
<td>0.79</td>
</tr>
<tr>
<td>Hypertension</td>
<td>24.4 ± 1.6</td>
<td>18.6 ± 1.2</td>
<td>0.02</td>
</tr>
<tr>
<td>Hyperlipidaemia</td>
<td>20.9 ± 1.0</td>
<td>16.3 ± 1.6</td>
<td>0.63</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>15.1 ± 1.9</td>
<td>14.0 ± 1.5</td>
<td>0.49</td>
</tr>
<tr>
<td>Overweight</td>
<td>22.4 ± 3.1</td>
<td>32.6 ± 3.2</td>
<td>0.13</td>
</tr>
<tr>
<td>Days off/month</td>
<td>11.7 ± 2.8</td>
<td>9.0 ± 2.9</td>
<td>0.0001</td>
</tr>
<tr>
<td>Workday sleeping hours</td>
<td>5.8 ± 2.0</td>
<td>6.0 ± 2.0</td>
<td>0.05</td>
</tr>
<tr>
<td>Days/week of &lt;5 h sleep*</td>
<td>0.7 ± 0.8</td>
<td>1.4 ± 0.9</td>
<td>0.006</td>
</tr>
<tr>
<td>Shift work</td>
<td>9.3 ± 1.9</td>
<td>18.6 ± 1.6</td>
<td>0.23</td>
</tr>
<tr>
<td>Sedentary job‡</td>
<td>70.9 ± 2.6</td>
<td>60.5 ± 1.6</td>
<td>0.36</td>
</tr>
<tr>
<td>Blue collar job</td>
<td>22.4 ± 4.5</td>
<td>44.2 ± 4.2</td>
<td>0.002</td>
</tr>
<tr>
<td>Job strain</td>
<td>23.2 ± 3.6</td>
<td>31.0 ± 3.4</td>
<td>0.12</td>
</tr>
</tbody>
</table>
The past month (table 4) were related to progressively change the results. Significant adjustment for several known risk factors did not controls. Numbers of days a month off and hours of sleep on sleep in cases and controls. Cases worked longer and slept less.

Cases worked longest were more likely to have high job strain. In workers in both cases and controls. Those controls who worked shortest were oldest, were more likely to have a sedentary job, and tended to be white collar disease, job type, and sedentary job.

Table 2 gives means of working hours and numbers of days off in the past year as well as in the past month and hours of sleep in cases and controls. Cases worked longer and slept less. Mean working hours and hours of sleep on working days were significantly longer, and the number of days with less than 5 hours sleep was significantly greater among cases than among controls. Numbers of days a month off and hours of sleep on days off were slightly less in cases, but the differences were not significant. Adjustment for several known risk factors did not change the results.

Weekly working hours in the past year (table 3) as well as in the past month (table 4) were related to progressively increased ORs of AMI. Although the number of days off in the past year was unrelated to the risk of infarction (table 3), a moderate increase in the OR was found among men with less than 2 days off in the past month (table 4). Men who had slept for 5 hours or less each working day on average in the past year had a twofold increased risk. Men with short sleep time on days off also had an increased risk, but the increase did not reach significance (table 3). The number of days with less than 5 hours sleep was also positively associated with the risk of AMI; the frequent lack of sleep in the past week was more noticeably associated with an increased risk. Adjustment for the coronary risk factors did not change the results much except for a significantly increased OR associated with few days off in the past month.

Table 2 and 3 show the interaction between working hours and sleep or number of days off relative to the risk of AMI in the past year and in the recent past, respectively. For ease of presentation, each intermediate level was combined as the referent category because ORs for the intermediate levels were not much greater than unity. The categories of longer work and less days off or short sleep time generally showed the greatest increase in the OR, none of the tests for the interaction were significant.

**DISCUSSION**

The present study showed that working long hours was associated positively with the risk of AMI, independent of the other coronary risk factors. Short sleep time or frequent lack of sleep, especially very recently, was also related to an increased risk of AMI; the frequent lack of sleep in the past week was more noticeably associated with an increased risk. Adjustment for the coronary risk factors did not change the results much except for a significantly increased OR associated with few days off in the past month.

**Table 2** Means (SE) of working time, sleeping time, and numbers of days off of cases and controls

<table>
<thead>
<tr>
<th>Variable</th>
<th>Reference period</th>
<th>Crude</th>
<th>Adjusted*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working h/week:</td>
<td></td>
<td>Case Control</td>
<td>p Value†</td>
</tr>
<tr>
<td>≤40</td>
<td>Past year</td>
<td>48.8 (1.0)</td>
<td>45.1 (0.7)</td>
</tr>
<tr>
<td>41–60</td>
<td></td>
<td>47.7 (1.0)</td>
<td>44.6 (0.8)</td>
</tr>
<tr>
<td>≥61</td>
<td></td>
<td>9.0 (0.3)</td>
<td>9.1 (0.2)</td>
</tr>
<tr>
<td>Days off/month:</td>
<td></td>
<td>Case Control</td>
<td>p Value‡</td>
</tr>
<tr>
<td>≥8</td>
<td>Past year</td>
<td>8.2 (0.3)</td>
<td>8.4 (0.3)</td>
</tr>
<tr>
<td>2–7</td>
<td></td>
<td>6.8 (0.1)</td>
<td>6.9 (0.1)</td>
</tr>
<tr>
<td>&lt;2</td>
<td></td>
<td>7.6 (0.1)</td>
<td>7.7 (0.1)</td>
</tr>
<tr>
<td>Workday sleeping (h)</td>
<td>Past year</td>
<td>0.84 (0.1)</td>
<td>0.55 (0.1)</td>
</tr>
<tr>
<td>Days/week of &lt;5 h sleep</td>
<td>Past year</td>
<td>0.95 (0.1)</td>
<td>0.52 (0.1)</td>
</tr>
</tbody>
</table>

*Period before the onset of acute myocardial infarction in cases and before the interview in controls; †p values are based on ANOVA; ‡p values are based on ANCOVA adjusting for cigarette-year, alcohol drinking, overweight, hypertension, diabetes mellitus, hyperlipidaemia, parental coronary heart disease, job type, and sedentary job.
among those working 7 hours a day or less.

were selected from among community residents, and thus were healthy workers. It was thus possible that cases had shortened working hours because of routine medical examinations at the workplace; it was thus unlikely that the increased risk of AMI associated with overtime work was due to this factor.

The present study did not consider quality of sleep. It has been suggested that poor quality of sleep may increase the risk of AMI. However, a cross sectional study and a prospective study indicated that increased risk of CHD associated with short sleep time was independent of sleep quality. As the participation rate in controls was not sufficiently high, the selection bias needs to be considered carefully. It could be anticipated that men working longer were more likely to be reluctant to participate in the study. However, the pilot investigation found no material difference between the participant controls and non-participant control candidates for working hours and days off but non-participants slept longer than participants. It is thus unlikely that the increased risks of AMI associated with overtime work, short sleep time, frequent lack of sleep, and few days off were overestimated. It is possible that having an AMI may have influenced patients’ perception or recall of work and sleep before the onset of AMI. Generalisation of the present findings is thus limited. The present study was based only on non-fatal AMI, and therefore, caution needs to be exercised in interpreting the results.

Table 6 The ORs (95% CIs) of acute myocardial infarction relative to few days off, and insufficient sleep according to weekly working hours in the recent past

<table>
<thead>
<tr>
<th>Days off or sleep</th>
<th>Weekly working hours in the past month</th>
<th>p Value for interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days off in the past month:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥2</td>
<td>1.0 (referent)</td>
<td>1.3 (0.8 to 2.4)</td>
</tr>
<tr>
<td>&lt;2</td>
<td>1.5 (0.3 to 7.1)</td>
<td>3.6 (0.7 to 19.0)</td>
</tr>
<tr>
<td>Working day sleep [h]:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥6</td>
<td>1.0 (referent)</td>
<td>1.4 (0.8 to 2.5)</td>
</tr>
<tr>
<td>≤5</td>
<td>2.2 (0.9 to 5.2)</td>
<td>4.8 (0.9 to 26.4)</td>
</tr>
<tr>
<td>Day off sleep [h]:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥6</td>
<td>1.0 (referent)</td>
<td>1.5 (0.9 to 2.6)</td>
</tr>
<tr>
<td>≤5</td>
<td>1.6 (0.5 to 4.8)</td>
<td>3.3 (0.3 to 33.6)</td>
</tr>
<tr>
<td>Days/week of &lt;5 h sleep:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤1</td>
<td>1.0 (referent)</td>
<td>1.5 (0.9 to 2.8)</td>
</tr>
<tr>
<td>≥2</td>
<td>2.5 (0.9 to 6.4)</td>
<td>1.5 (0.4 to 5.9)</td>
</tr>
</tbody>
</table>

Adjusted for cigarette-year, alcohol drinking, overweight, hypertension, diabetes mellitus, hyperlipidaemia, parental coronary heart disease, job type, and sedentary job; p values are based on the likelihood ratio test.

Main messages

- Longer working hours were related to progressively increased risks of AMI.
- Insufficient sleep was also associated with an increased risk of AMI.
- Long working hours and insufficient sleep in the recent past were more strongly related to an increased risk of AMI.

Policy implications

- Restricting working hours to 40 or less a week is desirable.
- Those working for a prolonged time should take sufficient sleep or take at least 2 days rest a month.

and negatively with hours of sleep, but the associations were rather weak (data not shown). Shift work is another risk factor for AMI, which may exert its influence through poor or short sleep time. Among controls, mean hours of sleep on working days in the past year were 6.8 in the shift workers and 7.0 in non-shift workers. Additional adjustment for high job demand and shift work did not alter the reported results.

Overtime work deprives people of sleep time and holidays. However, insufficient sleep itself might be part of the syndrome of vital exhaustion. The present study did not consider quality of sleep. It has been suggested that poor quality of sleep may increase the risk of AMI. However, a cross sectional study and a prospective study indicated that increased risk of CHD associated with short sleep time was independent of sleep quality. As the participation rate in controls was not sufficiently high, the selection bias needs to be considered carefully. It could be anticipated that men working longer were more likely to be reluctant to participate in the study. However, the pilot investigation found no material difference between the participant controls and non-participant control candidates for working hours and days off but non-participants slept longer than participants. It is thus unlikely that the increased risks of AMI associated with overtime work, short sleep time, frequent lack of sleep, and few days off were overestimated. It is possible that having an AMI may have influenced patients’ perception or recall of work and sleep before the onset of the AMI. Therefore, caution needs to be exercised in interpretation. The present study was based only on non-fatal AMI, and cannot consider the effect of working hours and duration of sleep on the occurrence of fatal AMI. Generalisation of the present findings is thus limited.

Several biological explanations are possible for the increased risk of AMI associated with overtime work. Overtime work...
work is known to increase blood pressure and heart rate,24–27 and induces cardiac or psychological symptoms—such as chest pain, depression, and fatigue.24 Chronic stress or fatigue related to overtime work may increase sympathetic nervous system activity to such a critical level as to induce the onset of AMI.28 It is also known that lack of sleep increases activity in the sympathetic nervous system, leading to an increase in blood pressure and heart rate.20,22 Furthermore, people with sleep deprivation were shown to be more likely to develop malignant hypertension than those without.11 The combined effect of overtime work and insufficient sleep may increase sympathetic nervous system activity to such a critical level as to induce the onset of an AMI.

In summary, overtime work and insufficient sleep in the past year were each related to an increased risk of AMI, and insufficient sleep and few days off in the very recent past were associated with a profound increase in the risk. These findings suggest that chronic overwork and sleep deprivation confer increased risk of AMI, and that recent lack of rest and sleep deprivation may further enhance the risk of infarction.

ACKNOWLEDGEMENTS

We acknowledge the following medical associations for their valuable support: Fukuoka City Medical Association, Division of Internal Medicine of the Fukuoka City Medical Association, Chikushu Medical Association, Ishiyama Medical Association, Kasuya Medical Association, and Musakata Medical Association. Dr Tetsuji Yokoyama made a great contribution in the analysis. The study was supported by a grant from Sankyo, Japan.

APPENDIX: MEMBERS OF THE FUKUOKA HEART STUDY GROUP LISTED IN ALPHABETICAL ORDER AT EACHAFFILIATION

Hiroko Kodama, Suminori Kono, Ying Liu, Yoshio Miyake, Shizuka Sasaki, Keitaro Tanaka, Shoji Tokunaga, Kosumi Yohishi, Masafumi Takebe, Yoshio Wshio (Department of Preventive Medicine, Graduate School of Medical Sciences, Kyushu University; these are also the members of the working group); Masahiro Mohri, Akira Takeshita (Department of Cardiovascular Medicine, Graduate School of Medical Sciences, Kyushu University); Kikuo Arakawa, Munehito Sato (Department of Preventive Medicine, School of Medicine, Fukuoka University); Koichi Handa, Keichi Tanaka (Department of Emergency and Critical Care Medicine, School of Medicine, Fukuoka University); Hidekazu Arai (Tokushukai Fukuoka Hospital); Yoshibei Doi, Tomoki Kawano, Osamu Nakagaki, Kazuyuki Takada (Saiseikai Fukuoka General Hospital), and Yasushi Sasaki (Udo Ishihara Cardiovascular Disease Hospital); Yasushi Ishihara (Odo Ishihara Hospital); Tetsuji Inoue (Fukuoka Red Cross Hospital); Fumio Oshima (Fukuoka Medical Association Hospital); Tomoki Homma, Samon Koyanagi (National Kyushu Medical Center Hospital); Yasuo Hayashi, Yuji Taira (Hara San-shin General Hospital); Yuji Maruoka (Hamanomachi Hospital); Ken Abe (Chibaya Hospital); Shunjii Maka, Sueguru Mori, Shinjiya Oda (Hakujuki Hospital); Ryuji Kagamishita, Ichiro Ohmura (National Sanatorium Fukukahigashi Hospital); Tadayuki Hiroki, Ryochirou Miyawaki (Fukuoka University Ichikushiki Hospital); Juzaburo Inoue (Sagasagi Hospital); Shinichiro Itou, Kazuyuki Saito (Fukuoka Seishukai Hospital); Terutoshi Tanioka (Munakata Suikoki Hospital); Kohejo Iino (Ishimoto Cardiovascular Medical Association Hospital); Yasuyuki Mera (Munakata Medical Association Hospital); Yasuhiko Orita (Fukuoka Kameyamadai Hospital); Yohsuke Katsuta, Hideko Nakazono (Saiseikai Futsukashi Hospital); Naotaka Hama (Department of Clinical Chemistry and Laboratory Medicine, Graduate School of Medical Sciences, Kyushu University); Hitomi Hayabuchi (Fukuoka Women's University); Sumie Jingu, Ryoko Hayashi, Masako Sakamoto (Fukuoka City Office); Yohshi Egashira, Tadashi Enomoto, Masanori Fujino, Keisuke Fukuda, Masakazu Gondo, Shouhei Hata, Satoshi Hiratsuka, Takashi Ichiki, Nariaki Ikeda, Yasuo Iwanaga, Hisashi Kanaya, Yoshiko Kato, Masaki Kohara, Nobuo Masuda, Hideyo Matsuguchi, Eiichi Murayama, Masatsugu Ohga, Hideaki Ogushi, Nobuo Ouchi, Hiroshi Sakai, Teizo Sata, Kuninori Soejima, Hiroshi Takamiyake, Shinshuke Takei, Masafumi Tanaka, Noritami Tashiro, Takehiko Yamada, Tetsuomi Yoshimoto, Masato Yoshida (general practitioners in Fukuoka City).

*Principal investigator; †Co-principal investigator.

REFERENCES


Authors’ affiliations

Y Liu, Graduate student of Department of Preventive Medicine, Graduate School of Medical Sciences, Kyushu University, Fukuoka 812-8582, Japan
H Tanaka, Department of Epidemiology, Medical Research Institute, Tokyo Medical and Dental University, Tokyo 101-0062, Japan
Overtime work, insufficient sleep, and risk of non-fatal acute myocardial infarction in Japanese men

Y Liu and H Tanaka

*Occup Environ Med* 2002 59: 447-451
doi: 10.1136/oem.59.7.447

Updated information and services can be found at:
http://oem.bmj.com/content/59/7/447

These include:

**References**

This article cites 30 articles, 6 of which you can access for free at:
http://oem.bmj.com/content/59/7/447#BIBL

**Email alerting service**

Receive free email alerts when new articles cite this article. Sign up in the box at the top right corner of the online article.

**Notes**

To request permissions go to:
http://group.bmj.com/group/rights-licensing/permissions

To order reprints go to:
http://journals.bmj.com/cgi/reprintform

To subscribe to BMJ go to:
http://group.bmj.com/subscribe/