Effect of Working Hours on Biological Functions related to Cardiovascular System among Salesmen in a Machinery Manufacturing Company

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Abstract: A field survey of 71 salesmen (22–60 years) in a machinery manufacturing company was conducted to investigate the effect of working hours on biological functions related to the cardiovascular system. The subjects were divided into four groups by age, and those in each age group were further divided into shorter (SWH) and longer (LWH) working hour subgroups by weekly working hours. Rates of complaints of subjective fatigue for LWH were significantly higher than those for SWH on the whole. Although the mean amplitude of respiratory sinus arrhythmia at rest decreased with age, no significant difference between SWH and LWH was found in this function. Systolic blood pressure for LWH was significantly higher than that for SWH in the 50–60 year group. The serum total cholesterol level for LWH was significantly lower than that for SWH in the 40–49 year group. Comparison of biological functions related to cardiovascular system was also made between fatigue complaint and no-complaint subgroups. Significant differences were found between the two subgroups: systolic blood pressure was higher and the total cholesterol level was lower in the fatigue complaint subgroups. Summarizing our results, it appeared that long working hours might increase systolic blood pressure and lower the total cholesterol level due to fatigue.

Key words: Working hours, Salesman

Introduction

In Japan there is the problem of health hazard with which work overload is associated1,2. Long working hours is one of main factors in work overload, and seems to be able to be readily evaluated and managed by quantity, but, at present, management of working conditions (working hours) and health on long working hours is not adequately provided for. This can be partially attributed to the few reports3–5 analyzing the effect of long working hours on workers’ health by biological indices, which makes it difficult to make an objective appraisal of the effect of long working hours on health. If the characteristics of the effect of long working hours on health are found, it will be possible to minimize the detrimental effect of long working hours. This study was made to find out the effect of working hours on biological functions related to the cardiovascular system (mean amplitude of respiratory sinus arrhythmia, blood pressure and the serum total cholesterol level) and the subjective symptoms of fatigue in salesmen who work in a very competitive business and seem to routinely work for long hours.

Subjects and Method

Subjects

The subjects of this study were 81 salesmen in a machinery
manufacturing company where regular working hours were 8 hours a day (not including lunch time) and 5 days a week. An analytical study was conducted on 71 salesmen (22-60 years of age) except for 10 who took medicines (cold remedy 3, antihypertensive agent 5, drug for hyperlipidemia 3, 2 kinds of drugs 1).

Procedure for field survey
Surveys were made on several working days in Nov. and Dec., 1996. Each subject was examined on one working day during the survey period. The survey consisted of (1) self-report questionnaires (working hours and health conditions, and fatigue), (2) measurement of biological functions (respiratory sinus arrhythmia, blood pressure and urinary catecholamines), and (3) data on serum total cholesterol and BMI (body mass index) determined on the occasion of a regular health check (conducted in Oct., 1996). A questionnaire on working hours and health conditions during the latest full month was filled out on each survey day or the day before the survey day. Investigation by questionnaire on fatigue and measurement of biological functions was conducted on each survey day. A questionnaire on subjective fatigue defined by the Japan Association of Industrial Health6~ was filled out twice on the survey day before and after work (in the morning and in the evening). In this questionnaire, subjective fatigue at the time of writing answers was asked about. Respiratory sinus arrhythmia7~ (RSA) at rest and blood pressure were measured in the evening (around 17:00-19:00) at the office. For the determination of RSA and blood pressure, the salesmen took a rest for 5 min. or more. Then RR interval data were recorded by means of a heart rate monitor LRR-03 (GMS Co. Ltd., Japan) for 3 min. in a sitting position with respiration controlled to once every 5 sec. And analysis of the frequency with MemCalc8 (Suwa Trust Co., Japan) was conducted to obtain power in the range of 0.15-0.30 Hz as POWER_{RSA}. Blood pressure was measured twice with a TM-2541 hemodynamometer (A & D Co. Ltd., Japan) and the mean value was calculated. Few salesmen 20-29 years old had serum total cholesterol included in the regular health check, so that no analysis of the effect on total cholesterol could be made in that group. The analysis of total cholesterol was conducted in the other groups except 3 in the 30-39 year group and 2 in the 50-60 year group whose data were not kept. The results on urinary catecholamines will be reported elsewhere later.

Weekly working hours
The number of weekly working hours was calculated from the working conditions during the latest full month in the answers to the questionnaire. Working hours in this study was defined as follows: Working hours = (hours at the office) + (one-way commuting time). SWH (LWH) in the overall group is the sum of SWH (LWH) in each group by age. The vertical lines indicate standard errors.

Other information
The difference between the mean values for the two groups was found by t-test (p<0.05).
This study was carried out under permission of the Ethics Committee of our institute.

Results
Weekly working hours and other demographic characteristics
Data on weekly working hours surveyed in this study are
Working hours and cardiovascular system

Table 1. Weekly working hours of shorter (SWH) and longer (LWH) working hour subgroups

<table>
<thead>
<tr>
<th>Group by age (years)</th>
<th>Working hours (sum of A+B) (hr/week)</th>
<th>(A) Hours at the office*1 (hr/week)</th>
<th>(B) One-way commuting time (hr/week)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total*2</td>
<td>SWH 0</td>
<td>LWH*3</td>
</tr>
<tr>
<td>20–29</td>
<td>59.9 ± 4.1</td>
<td>56.7 ± 3.1</td>
<td>63.0 ± 2.1</td>
</tr>
<tr>
<td>30–39</td>
<td>62.2 ± 5.1</td>
<td>57.8 ± 2.7</td>
<td>66.6 ± 2.4</td>
</tr>
<tr>
<td>40–49</td>
<td>62.9 ± 6.8</td>
<td>58.0 ± 3.6</td>
<td>68.7 ± 4.6</td>
</tr>
<tr>
<td>50–60</td>
<td>58.7 ± 3.2</td>
<td>56.5 ± 2.5</td>
<td>61.3 ± 1.4</td>
</tr>
<tr>
<td>Overall</td>
<td>60.7 ± 4.9</td>
<td>57.2 ± 2.9</td>
<td>64.5 ± 3.8</td>
</tr>
</tbody>
</table>

Values are the mean ± SD except (0–3). *1: Defined as hours from arrival at to leaving the office or hours from start to finish of business in a day. *2: The total is the sum of SWH and LWH. *3: SWH (LWH) in the overall group is the sum of SWH (LWH) in each group by age.

Table 2. Basic information on shorter (SWH) and longer (LWH) working hour subgroups

<table>
<thead>
<tr>
<th>Group by age (years)</th>
<th>n*4</th>
<th>Age (year)</th>
<th>BMI (kg/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total*2</td>
<td>SWH</td>
<td>LWH*3</td>
</tr>
<tr>
<td>20–29</td>
<td>18</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>30–39</td>
<td>18</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>40–49</td>
<td>13</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>50–60</td>
<td>22</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>Overall</td>
<td>71</td>
<td>37</td>
<td>34</td>
</tr>
</tbody>
</table>

Age and BMI are shown as the mean ± SD. *4: Number of subjects in each group. *5: The total is the sum of SWH and LWH. *6: SWH (LWH) in the overall group is the sum of SWH (LWH) in each group by age. *7: Significant difference (p<0.05) between the values for SWH and LWH.

shown in Fig. 1 and Table 1 (numbers of subjects are shown in Table 2). Working hours in the overall group was 60.7 hr/week (shown under “Total” in Table 1). In the comparison of different groups by age, salesmen 40–49 years of age had the longest working hours (62.9 hr/week), followed by the salesmen aged 30–39 years (62.2 hr/week). Salesmen 50–60 years old spent the shortest time as working hours (58.7 hr/week). In the comparison of (SWH) and longer (LWH) working hours subgroups, the difference in working hours (0–3) was 7.3 hr/week in the overall group. The salesmen aged 40–49 years showed the largest difference: LWH spent 10.7 hr/week longer than the SWH. The difference in the 50–60 year group was 4.8 hr/week, the smallest. One-way commuting time in the overall group was 6.2 hr/week (shown under “Total” in Table 1). The differences between SWH and LWH in one-way commuting time were relatively small, from -0.7 hr/week (20–29 years) to 1.8 hr/week (30–39). The number, age and BMI of subjects in each group are shown in Table 2. No significant difference between SWH and LWH in age and BMI was found except BMI in the 30–39 year group.

Working hours and subjective fatigue

Fig. 2 shows the subjective symptoms of fatigue of SWH and LWH in the overall group. Subjective symptoms of fatigue were divided into 3 categories: fatigue I (drowsiness...
and dullness), II (difficulty in concentrating attention) and III (feeling of local physical abnormality). A comparison showed that the complaint rate for fatigue I (drowsiness and dullness) was the highest. There was a large difference between SWH and LWH in the complaint rate for fatigue I (drowsiness and dullness). In contrast with this, it was found that there was only a little difference between SWH and LWH in the complaint rate for fatigue III (feeling of local physical abnormality).

Working hours and biological functions

Although the mean amplitude of RSA at rest decreased with the increase in age, no significant difference between SWH and LWH in any age group was found in RSA amplitude (Fig. 3). Systolic blood pressure (SBP) increased with age (Fig. 4). Though there was little difference between SWH and LWH in the salesmen aged 20–29, 30–39 and 40–49 years, SBP of the LWH in the 50–60 year group was significantly higher than that of the SWH. As to the total cholesterol level (Fig. 5), data for the 20–29 year group could not be obtained, and the results shown are for the over 30 year groups. It was found that there was little difference between SWH and LWH in the salesmen 30–39 and 50–60 years old, but that LWH in the salesmen aged 40–49 showed a significantly lower level of total cholesterol than the SWH.

Subjective fatigue and biological functions

An analysis was made of the relationship between complaints of fatigue I (drowsiness and dullness) before or after work and 3 functions of respiratory sinus arrhythmia (RSA) at rest, systolic blood pressure (SBP) and the total cholesterol (TC) level. The questionnaire on complaints of each fatigue group is composed of 10 questions requiring a “Yes” or “No” answer. Subjects were divided into two subgroups, no-complaint and one or more complaints (Complaints) by the number of “Yes” answers for fatigue I (drowsiness and dullness). RSA amplitude, SBP and TC level received from the two subgroups, No-complaint and Complaints before or after work were compared. The results of the analysis of fatigue I after work and RSA amplitude are shown in Fig. 6. Although there was a large difference between the numbers of subjects in the fatigue subgroups in the 20–29 year group, the difference was small in the
groups over 30 years old. Therefore, the comparison of RSA in the fatigue subgroups in the overall group was made in the 30–60 year group in order to make the age difference smallest between the fatigue subgroups (as in the case of SBP). It was found that there was little difference between the fatigue subgroups in RSA amplitude in the 20–29 year group, but RSA amplitudes in the No-complaint subgroups were greater than those in the Complaints subgroups in the over 30 year groups. There was a significant difference between the fatigue subgroups in RSA amplitude in the 30–60 year group. As for SBP in relation to fatigue I after work (Fig. 7) and the TC level in relation to fatigue I before work (Fig. 8), we obtained tendencies similar to those for RSA (although high/low is different in SBP). There were significant differences between the fatigue subgroups in the 30–60 year group in the SBP and TC levels: SBP was higher and the TC level was lower in the Complaints subgroups. In the case of the TC level there was also a significant difference between the fatigue subgroups in the 50–60 year group. Relationships of fatigue I before or after work to functions related to cardiovascular system in the 30–60 year group are summarized in Fig. 9. Significant relationships were found in three cases: RSA amplitude and SBP with fatigue I after work, and the TC level with fatigue I before work. The results for the SBP and TC levels with fatigue I before work have the same tendency as those after work, but the results for RSA amplitude with fatigue I before work had a different tendency from that after work. There was no significant difference between No-complaint (N) and Complaint (C) subgroups in the 30–60 year group in age or BMI (Table 3).

**Discussion**

Working hours defined in this study includes both “hours at the office” and “one-way commuting time”. It is not yet clear whether commuting time should be included in working hours in the field of industrial health. From the viewpoint of workload, we considered that the commuting load was equivalent to half the actual business load. Because the differences between SWH and LWH in one-way commuting time were small, it was thought that the differences between SWH and LWH working hours were mostly attributable to those in “hours at the office” in this study. The working hours differences between SWH and LWH were 4.8–10.7...
hr/week, and were thought to be not so large, but it was found that there were large differences between SWH and LWH in the overall group in complaints of the subjective symptoms of fatigue, particularly in fatigue I (drowsiness and dullness). Therefore, it can be thought that working hours might have any effect on functions related to the cardiovascular system in the salesmen surveyed in this study. It is suggested that the mean amplitude of respiratory sinus arrhythmia (RSA) at rest is associated with the function of cardiac parasympathetic nerves, and it has been pointed out that the deterioration of its function is related to the development of the cardiovascular diseases. Although the mean RSA amplitude at rest decreased with the increase in age, there were no significant differences between SWH and LWH. In contrast with this, Kageyama et al. reported recently that long commuting time and extensive overtime decreased RSA amplitude in white-collar workers. It is desirable to extensively study the effect of working time on RSA amplitude because it is conceivable that RSA is strongly affected by factors other than working hours (for example, exercise). Systolic blood pressure (SBP) for LWH was significantly higher than that for SWH in the 50–60 year group. Uehata et al. reported that long working hours have an effect on new onset and development of hypertension. SBP may be one of the major functions which is readily affected by the length of working hours. The total cholesterol (TC) level for LWH was significantly lower than that for SWH in the 40–49 year group. Tanaka et al. suggested that long hour workers tended to have a lower level of TC, according to the analysis of the data on physical examinations at another manufacturing company. It has recently been indicated that an extreme decrease in TC is a risk factor for the development of cerebral hemorrhage. The TC level may also be one of the important indices for health management of long hour workers.

Significant relations were found in this study both between working hours and fatigue complaints and between fatigue complaints and the level of SBP and TC. These results

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**Fig. 9. Biological functions related to the cardiovascular system and complaints of fatigue I (drowsiness and dullness) in the 30–60 year group**

RSA: respiratory sinus arrhythmia; SBP: systolic blood pressure; TC: total cholesterol. The numbers of subjects in each subgroup are shown in each bar. The vertical lines indicate standard errors. *: p<0.05.

**Table 3. Basic information on “no fatigue complaint subgroup” (N) and “one or more fatigue complaints subgroup” (C) in the 30–60 year group**

<table>
<thead>
<tr>
<th>Subject of analysis</th>
<th>n*</th>
<th>Age (year)</th>
<th>BMI (kg/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>C</td>
<td>N</td>
</tr>
<tr>
<td>RSA - BP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before work</td>
<td>24</td>
<td>29</td>
<td>46.3 ± 9.5</td>
</tr>
<tr>
<td>After work</td>
<td>28</td>
<td>25</td>
<td>44.6 ± 9.9</td>
</tr>
<tr>
<td>TC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before work</td>
<td>22</td>
<td>27</td>
<td>46.6 ± 9.5</td>
</tr>
<tr>
<td>After work</td>
<td>25</td>
<td>24</td>
<td>45.3 ± 9.8</td>
</tr>
</tbody>
</table>

*Number of subjects in each subgroup.

Age and BMI are shown as the mean ± SD. *: Number of subjects in each subgroup.
suggest that long working hours may raise the SBP level and lower the TC level through fatigue. This suggestion is partially supported by the results obtained in this study on the relations between working hours and the levels of SBP and TC. The relation between fatigue and RSA at rest has to be studied further because the results obtained on fatigue before work are different from those on after work.

This study was made on a limited number of subjects and it cannot be denied our results may be only accidental. It is desirable to conduct another survey on a larger population to confirm our results.

References