Physical Activity, Energy Expenditure and Work Intensity of Care-Workers on Shift Work in a Special Nursing Home for the Elderly

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Abstract: Physical Activity, Energy Expenditure and Work Intensity of Care-Workers on Shift Work in a Special Nursing Home for the Elderly: Tadaaki WAKUI, et al. Department of Wellness and Welfare, Ube College—To evaluate the workload of care-workers on shift work in special nursing homes for the elderly (SNHs), physical activity, energy expenditure and work intensity were measured. Nine healthy female care-workers volunteered to participate in our study; 3 subjects worked the day shift, 3 subjects worked the night shift, and 3 subjects worked both shifts. Time spent in actual care, heart rate, number of walking steps, energy expenditure, work intensity and time spent in different postures was determined for the day shift and night shifts. The time on duty, work and break (recess) times were significantly greater for the night shift than for the day shift. The percent care time was significantly greater for the day shift than the night shift, and the percent break time was significantly greater for the night shift than the day shift. Individual care of residents accounted for the greatest percent of work time. Minimum and mean heart rates were significantly greater for the day shift than for the night shift, and minimum heart rate in relation to estimated maximum heart rate was significantly greater for the day shift than for the night shift. Although total walking steps for the night shift was significantly greater than that for the day shift, the number of steps per h did not differ between shifts. Energy expenditure (kcal) for the night shift was significantly greater than for the day shift, but the difference between the two shifts in work intensity (kcal/kg/min) was not significant. Standing (posture) accounted for the largest percentage of work time in relation to other work postures regardless of shift. Physical activity, energy expenditure and work intensity of the SNH care-workers for both shifts appear to be higher than those reported for nursery school teachers and hospital nurses. We agree with other investigators that appropriate countermeasures are needed to reduce the workload of such care-workers. (J Occup Health 2002; 44: 8–14)

Key words: Special nursing home for the elderly, Care-worker, Care work, Shift work, Physical activity, Energy expenditure, Work intensity, Posture

Over the past 50 yr, the average life span in Japan has increased remarkably, and the life span of both men and women ranks first in the world. Consequently, the aged population is increasing rapidly, and the number of bedridden and senile persons is increasing accordingly. Demands for health care, medical care and welfare services by this growing population are also increasing. Adequate facilities and numbers of workers providing long-term care services for the elderly are therefore important concerns today in Japan.

Care of the elderly often requires manual lifting and postures that place a severe burden on the lower back. Low back pain is prevalent among care-workers with many years in the field. The increasing numbers of elderly and severely disabled nursing home residents will increase the workload of care-workers in the near future. We have two primary concerns: one is the health status of the care-workers; the other is the quality of care given to residents of special nursing homes for the elderly (SNHs).

There have been many reports on the physical activity, energy expenditure and work intensity characteristic of various occupations, but studies of this kind concerning SNH care-workers are very few. Matsumoto et al. reported the physical and mental fatigue of SNH...
care-workers engaged in shift-work to be quite high. The physical activity and energy expenditure of such shift workers are probably higher than the outputs of other types of workers. Yokozeki et al. reported high energy expenditure and work intensity associated with day shift work; we reported a heavy workload associated with both day and night shifts, concluding that countermeasures such as increasing the number of care workers and decreasing shift hours are needed.

Energy expenditure in our study was estimated from the relative metabolic rate (RMR) over time. This measurement method tends to underestimate actual energy expenditure. Yokozeki et al. measured energy expenditure by the heart rate-oxygen uptake method, but night-shift energy expenditure was not included in their study. We therefore examined physical activity, energy expenditure and work intensity by the heart rate-oxygen uptake method in both day and night shift care-workers in an SNH to further clarify health problems faced by these care-workers.

Methods

Subjects

Nine healthy female care-workers employed at an SNH in Yamaguchi prefecture, Japan, volunteered to participate in our study; 3 subjects worked the day shift, 3 subjects worked the night shift, and 3 subjects worked both shifts. Prior to their participation, they were apprised of the purpose and methods of the study, and each gave consent. As care-workers aged 40 yr or more are common at SNHs in Japan, the 9 subjects were selected from 16 care-workers aged 40 yr or older among 19 full-time care-workers employed at the SNH. One care-worker aged 40 yr or more was excluded from the subjects, because she was a chief of staff.

SNH population

The study of day-shift work was conducted in August 1994. The number of residents in the SNH at the time was 80, including 2 residents temporarily hospitalized. The mean age of the residents was 83 yr (range 65–98). Total or partial care was required for 27.5% of residents, for excretion in 70.0%, for bathing in 87.5%, for movement in 77.5% and for dressing in 77.5%. Of 78 residents evaluated, 54 (69.2%) were judged to have senile dementia.

The study of night-shift work was conducted in August 1996. The number of SNH residents at this time was 80, and their mean age was 82 yr (range 67–100). Total or partial care was required for feeding in 40.0% of residents, for excretion in 62.5%, for bathing in 87.5%, for movement in 88.8% and for dressing in 68.8%. Fifty-one of these residents (63.8%) were judged to have senile dementia.

Shift system

The SNH care-workers were organized into two shifts: a day shift and a night shift. The standard day shift began at 08:30 and ended at 17:30; overlapping shifts were also scheduled: 07:00–16:00 and 09:30–18:30. The night shift began at 17:00 and ended at 09:00. The day shift generally comprised 13 workers; the night shift comprised 3. Measurement for the day shift in this study was carried out on days with bathing care, which was twice a week (Monday and Thursday). The work schedule for the night shift did not differ with the day of the week.

Measurement of working time, posture, heart rate and number of steps

After height, weight and percent body fat of each subject were measured, a portable heart rate device (VAMI-001, VINE, Japan) and counter (Calorie Counter α, SUZUKEN, Japan) were attached to the subject’s waist belt during the shift work. Weights of the apparatuses were 150 g and 42 g, respectively. %body fat was estimated according to the method of Brozek et al., with body density calculated from skinfold thickness (at the triceps and the subscapula) with calipers (Eiyoken-type, YAGAMI, Japan).

Each work activity required and the time spent working in different postures (sitting, standing, walking and running) were determined by the time-study method. Work activities were classified according to the first level code developed by the National Council of Social Welfare in Japan. Heart rate was measured continuously, though that during break (recess) time was excluded from the data used in the analysis. Minimum, maximum and mean heart rate were calculated for each subject. Heart rates were compared with the estimated maximal heart rate for each subject calculated by the formula adopted by the American Heart Association (maximal heart rate equal to 220 minus age [years] beats per minute) and expressed as a percentage. Walking steps were measured with the calorie counter α; walking steps during break time were not included in the analysis.

Measurement of energy expenditure

To measure energy expenditure during working time, a heart rate-oxygen uptake regression equation was calculated for each subject based on the heart rate and oxygen uptake when sitting, when standing and during submaximal exercise. Measurement of heart rate and oxygen uptake for the sitting and standing were performed during 10 min periods, respectively. The heart rate and oxygen uptake were evaluated for the last 5 min and the data were expressed as 1 min values. Submaximal exercise was carried out on a bicycle ergometer. Beginning at a work load of 0 watt, work load was increased by 20 watts every 4 min until a heart rate of about 150 beats per min. Heart rate and oxygen uptake...
were measured during the last 1 min of each work load. A portable device (VAM4-064, VINE, Japan) was used to measure oxygen uptake. A statistically significant correlation between the heart rate and oxygen uptake for each subject was confirmed (n=5, r=0.964–0.999, p=0.008–<0.001). Oxygen uptake was calculated for each subject by inputting the heart rate measured during care work into the heart rate-oxygen uptake regression equation obtained from the above; energy expenditure was obtained by converting 1 l of oxygen to 5 kcal. Workload in this study was defined both as the percentage of maximal heart rate (%HRmax) and work intensity (kcal/kg/min). The latter was calculated by dividing the energy expenditure by the subject’s weight and time spent performing each task.

Statistical analysis

Values are expressed as the mean ± standard deviation (SD) for each shift. Variables for the day and night shifts were compared by means of the non-paired t-test. If a significant difference was found in a variance, t-test with Welch’s correction was used for the statistical analysis. For analysis of the three subjects participating in both the day and night shift studies, the paired t-test was used. Differences were considered statistically significant at p<0.05.

Results

The general characteristics of subjects are shown in Table 1. Age and %body fat were significantly greater in the night shift workers than in the day shift workers. The %body fat of the three subjects participating in both studies was greater at the time of the night shift study (mean 31.5%) than at the time of the day shift study (mean 24.7%) (p=0.001).

The time spent working, break time, and their values relative to the total time on duty are shown in Table 2. Duty work time (p<0.001), break time (p<0.001), and total time on duty (p<0.001) were significantly greater for the night shift than for the day shift. The percent work time for the day shift was significantly greater than the percent work time for the night shift, and the percent break time for the night shift was significantly greater than the percent break time for the day shift. The percent work time and break time for the three subjects participating in both the day and night shift studies were similar to those shown in Table 2. The five most time-consuming tasks for each shift are shown in Table 3. The amount of time spent per task and the times relative to total working time are also shown. The most time-consuming task for both shifts was individual care of residents, and the time spent on individual care on the night shift was significantly greater than that on the day shift (p<0.001). The percent administration time was significantly greater on the day shift than on the night shift (p=0.010). Time spent in actual care on both the day and night shifts was roughly similar, 86.8% and 87.5%, respectively. For the three subjects participating in both studies, only the amount of time spent in individual care differed significantly, being greater at night (mean 498 min) than during the day (mean 301 min) (p=0.017).

Table 4 shows the mean heart rates and their percentages relative to estimated maximum heart rate. Maximum heart rate was similar for the two shifts, but minimum and mean heart rates for the day shift were significantly greater than the respective heart rates for the night shift (p=0.001, p=0.020). Minimum heart rate in relation to estimated maximum heart rate was significantly greater for the day shift than for the night shift. For the three subjects participating in both studies,
mean heart rates and their percentages relative to estimated maximal heart rate were significantly greater for the day shift (mean 97 beats/min, 55.7%) than for the night shift (mean 89 beats/min, 51.7%) (p=0.005, p=0.003, respectively).

As shown in Table 5, the total walking steps for the night shift was significantly greater than the total walking steps for the day shift (p<0.001), but the number of steps per hour was similar for the two shifts. For the three dual-study workers, the total number of steps for the night shift (mean 19,494 steps) significantly exceeded that for the day shift (mean 11,088 steps) (p=0.022).

The total energy expenditure for the night shift was significantly greater than that for the day shift (p=0.001), but work intensity (kcal/kg/min) was similar for the two shifts (Table 6). Energy expenditure of the three dual-study subjects matched that of subjects in the separate studies (mean 0.0460 kcal/kg/min, 0.0500 kcal/kg/min).

Time spent in the various working postures was similar for both shifts, as shown in Table 7; time spent standing and percent standing time were greatest, followed by time spent and percent times for walking and sitting. Standing and walking accounted for 90.7% of the work time in the day shift and 83.4% of the work time in the night shift. Sitting accounted for a significantly greater amount of work time on the night shift than on the day shift (p<0.001). For the three dual-study workers, the amount of time spent standing for the night shift (mean 448 min) was significantly greater than that for the day shift (mean 280 min) (p=0.036).
In our study examining physical activity, energy expenditure and work intensity for day shift vs. night shift care performed by SNH workers, we observed that the amount of time spent working and on breaks for the night shift were significantly greater than the respective times for the day shift. Nevertheless, the percent working time for the day shift was significantly greater than that for the night shift, and the percent break time for the night shift was significantly greater than that for the day shift. The most time-consuming task on both shifts in our study was individual care, and the percentages of time spent working were roughly the same for the two shifts (60.6 ± 5.6% and 61.3 ± 1.8%, respectively). Our data differ from those of Wakui 14) who reported the percentages of time spent in individual care for day and night shifts at 71.4 ± 15.4% and 52.3 ± 5.5%, respectively. Furthermore, Wakui 14) reported the percent time spent on individual care for the day shift to be significantly greater than that for the night shift. The disparity between the studies may be due to the relatively lower ADL of the residents in the present study.

Mean heart rate in our care-workers was roughly the same as rates reported previously 12–14). The lower heart rate for the night shift could be due to the longer time spent by workers waiting in wards during the night. For the three subjects participating in both studies, those trends were ascertained. This may also explain why the minimum heart rate and its percentage relative to estimated maximum heart rate were significantly lower for the night shift than for the day shift.

Shimaoka et al. 19) reported a mean heart rate in nursery school teachers (age 29.0 ± 6.1 yr) of 90 ± 6 beats/min. Fujiwara 20) reported a mean heart rate in hospital nurses (age 21.5 ± 2.3 yr) for day, evening and night shifts of 93.6 ± 9.5, 82.5 ± 15.0 and 80.1 ± 6.1 beats/min, respectively. Our mean heart rates of workers for both shifts were slightly higher than those reported for nursery school teachers 19) and hospital nurses 20). The percentages of estimated maximal heart rate were about 10% higher in care worker than in prior studies when adjustments were made for age. In comparison, the mean heart rate of women market workers is reported to be 90 beats/min, of female mechanics, 89 beats/min, and those planting rice by hand, 119 beats/min 9). The maximum permissible mean heart rate for a standard 8 h of work in women aged 30 to 49 was approximately at 110 beats/min 21). The mean heart rates in our study subjects were approximately 88% and 81% of this permissible level for day and night shifts, respectively. Furthermore, the mean heart rate of care-workers in our study approached the maximum permissible level more closely than did the mean heart rate in the studies by Shimaoka et al. 19) and Fujiwara 20), both of which recommended reductions in work time, reconsideration of the daily schedule and improved working conditions.

### Table 6. Energy expenditure and work intensity

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>kcal</th>
<th>P value</th>
<th>kcal/kg/min</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day shift</td>
<td>6</td>
<td>1,239 ± 89</td>
<td>0.001</td>
<td>0.0473 ± 0.0047</td>
<td>0.493</td>
</tr>
<tr>
<td>Night shift</td>
<td>6</td>
<td>2,218 ± 306</td>
<td></td>
<td>0.0497 ± 0.0068</td>
<td></td>
</tr>
</tbody>
</table>

n=number of subjects. Values shown are the mean ± SD.

### Table 7. Time spent in different working postures and percentages of total working time

<table>
<thead>
<tr>
<th></th>
<th>n min</th>
<th>P value</th>
<th>% P value</th>
<th>min</th>
<th>P value</th>
<th>% P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting</td>
<td>Day shift</td>
<td>6</td>
<td>44 ± 10</td>
<td>&lt;0.001</td>
<td>9.0 ± 2.1</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Night shift</td>
<td>6</td>
<td>134 ± 28</td>
<td></td>
<td>16.4 ± 3.4</td>
<td></td>
</tr>
<tr>
<td>Standing</td>
<td>Day shift</td>
<td>6</td>
<td>270 ± 31</td>
<td>&lt;0.001</td>
<td>55.8 ± 6.4</td>
<td>0.183</td>
</tr>
<tr>
<td></td>
<td>Night shift</td>
<td>6</td>
<td>417 ± 38</td>
<td></td>
<td>51.2 ± 6.4</td>
<td></td>
</tr>
<tr>
<td>Walking</td>
<td>Day shift</td>
<td>6</td>
<td>168 ± 30</td>
<td>&lt;0.001</td>
<td>34.9 ± 6.1</td>
<td>0.365</td>
</tr>
<tr>
<td></td>
<td>Night shift</td>
<td>6</td>
<td>263 ± 22</td>
<td></td>
<td>32.2 ± 2.8</td>
<td></td>
</tr>
<tr>
<td>Running</td>
<td>Day shift</td>
<td>6</td>
<td>1 ± 3</td>
<td>0.512</td>
<td>0.3 ± 0.5</td>
<td>0.659</td>
</tr>
<tr>
<td></td>
<td>Night shift</td>
<td>6</td>
<td>2 ± 2</td>
<td></td>
<td>0.2 ± 0.2</td>
<td></td>
</tr>
</tbody>
</table>

n=number of subjects. Values shown are the mean ± SD.
The number of total walking steps of care workers was significantly greater for the night shift than for the day shift, but the numbers of steps per hour were similar. This can be explained by the longer night shift period. Waku et al. reported numbers approximately 20% greater than ours. We consider it likely that differences in resident schedules, differences in types of care, and differences even in ADL of residents, care work and facility layout account for the disparity. Furthermore, the total walking steps of our care-workers for each shift was greater than the totals for nursery school teachers and hospital nurses. For comparison with the hospital nurses; we calculated the total walking steps in evening and night shifts, since nurses usually work in a three-shift system, each 8 h in length.

Waku et al. reported energy expenditures of care-workers for day and night shifts to be 1,041 ± 249 and 1,663 ± 355 kcal, respectively. These values are approximately 20% below ours. This may be mainly explained by the difference in the measurement methods. The RMR method has been shown to underestimate actual energy expenditure. Furthermore, the difference between the two studies in the ADL of the residents may also be an explanation.

Energy expenditure in the Yokozeki et al. study, based on the method we used, was greater than energy expenditure in our study, but the age of subjects, ADL of residents, worker tasks and facility layout could account for the difference. The average ages of our day shift and night shift workers were about 13 yr and 19 yr greater, respectively, than the average age of the Yokozeki et al. subjects.

The total energy expenditure of our care-workers doing night-shift work was significantly greater than that of day-shift workers, but the difference between the two shifts in work intensity (kcal/kg/min) was not significant. These findings imply that care work with a work intensity similar to that of the day shift was performed and spent over a longer time in night shifts. Furthermore, the total energy expenditure of care-workers for each shift was greater than that of nursery school teachers and hospital nurses.

Working posture is one of the major contributors to low back pain among SNH care-workers. In our study, the longest working time and highest percentage of the total time on duty in each shift went to standing. The percentages of times spent in working postures including standing, walking and running accounted for 91.0% and 83.6% of the total working time for the day and night shifts, respectively. The former was greater than the latter, explained by the longer waiting periods at night.

Physical activity, energy expenditure and work intensity of SNH care-workers appears to be high. The workload was not low even though it was during the night shift, in which physiological activities must decrease. We agree with other investigators that appropriate countermeasures are needed to reduce the workload of such care-workers.

There are some limitations in this study, such as the small number size of subjects, indirect method for measuring oxygen uptake during care work, and lack of evaluation of musculo-skeletal strain. To clarify the impact of the workload on the health status of SNH workers, further studies considering these problems are needed in future.

References

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