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Relation between Sleep Quality and Daily Physical Activity in Hemodialysis Outpatients

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The purpose of this study was to examine the correlations among objective sleep variables, sleep–wake cycle parameters, and daily physical activity in hemodialysis patients and controls.

Twenty-four hemodialysis patients (HD group) were compared with a control group consisting of 24 healthy participants matched for age, height, and weight. Sleep variables (total sleep time [TST], sleep efficiency [SE], sleep latency [SL], and waking after sleep onset [WASO]), sleep–wake cycle parameters (the sleep–wake cycle period and the peak of sleep–wake cycle variance), and daily physical activity (steps per day) for each participant were assessed by objective methods for two weeks.

While there was no difference in TST between the two groups, the HD group showed a significantly increased SL (HD: 0:29 ± 0:20 vs control: 0:16 ± 0:13, $p < 0.05$) and WASO (HD: 2:21 ± 1:00 vs control: 1:35 ± 0:41, $p < 0.05$) and decreased SE (HD: 67.1 ± 13.6% vs control: 77.5 ± 9.7%, $p < 0.01$) compared to the control group.

There was no significant difference in sleep–wake cycle period between the HD and control groups. However, the peak of sleep–wake cycle variance in the HD group (0.050 ± 0.028) was significantly lower ($t = 2.49$, $p < 0.05$) than in the control group (0.068 ± 0.019). The number of daily steps taken in the HD group (4,774 ± 2,845 steps) was also significantly lower than in the control group (8,696 ± 3,047). The peak of sleep–wake cycle variance was significantly correlated with SE ($r = 0.532$, $p < 0.01$), SL ($r = -0.501$, $p < 0.01$), and WASO ($r = -0.436$, $p < 0.01$), whereas the number of steps showed a weak correlation only with WASO ($r = -0.308$, $p < 0.05$) among the objective sleep parameters.

Our results suggest that sleep quality in HD patients may be more effectively improved by maintaining the regular 24-hour sleep–wake cycle rather than by increasing the amount of daily physical activity, indicating that intervention such as measures to prevent napping during hemodialysis sessions may prove effective in improving the quality of sleep in HD patients.

Sleep disorders are prevalent in HD patients (10), with nearly 60% of patients suffering from disturbed sleep (20). In fact, studies have shown that sleep quality is compromised subjectively (18,19) as well as objectively (19) in maintenance HD patients receiving dialysis on tri-weekly basis. The factors common to sleep disorders in HD patients include physical factors such as itching or restless legs syndrome (RLS); physiological factors such as excessive napping during hemodialysis sessions; psychological factors such as anxiety over daily living; psychiatric factors such as depression; and pharmacological factors such as antihypertensive drugs.

One of the objectives of dialysis nursing is the maintenance of a regular pattern of daily life in HD patients, in other words, to maintain and enhance their daily physical activity and quality of life (QOL). In comparison with the general population, the daily activity patterns of HD patients differ substantially in that their physical activity is restricted by being attached to a dialysis machine on tri-weekly basis for 4–5 hours at a time. In fact, previous studies assessing the daily physical activity of HD patients indicated that the number of daily steps taken by these patients was significantly fewer compared to the general population (3,4,21), and it is plausible that the reduced level of physical activity may affect the biological rhythm of HD patients in such a way as to compromise their sleep quality. However, there have been few studies conducted to date which examine the correlations between sleep quality and daily activity in HD patients using objective parameters.

This study, therefore, was conducted to clarify the relationship between sleep quality and daily physical activity in HD patients using objective parameters.

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METHODS

Subjects

All subjects for this study were recruited following authorization by the Ethics Committees of Kobe University Graduate School of Health Sciences. The following were the criteria for the inclusion of HD patients in this study: maintenance HD patients who had undergone hemodialysis treatments for ≥6 months, who had no serious cardiac, neurologic, or orthopedic diseases or dementia, and with a dialysis efficiency of Kt/V >1.2.

The group of 24 HD outpatients (13 men, 11 women; mean age: 66.0 ± 8.2 y) who consented to enroll in this study were designated as the HD group. These subjects had a ≥1 to <34 year history of maintenance HD (mean: 10.4 ± 9.1 y); and the underlying diseases included primary glomerular diseases 16 (67%)(chronic glomerulonephritis 12 patients, rapidly progressive glomerulonephritis 1 patient, IgA nephritis 1 patient), diabetic nephropathy 5 patients (21%), nephrosclerosis 1 patient (4%), unkown 4 patients (17%). The rate of primary glomerular diseases were higher compared with ordinary Japanese hemodialysis patients. A group of 24 healthy adults (14 men, 10 women; mean age: 70.3 ± 6.8 y) matched for age, height and weight were designated as the control group for comparison. Ten subjects in HD outpatients and two in the control took sleep medications several times per week. Subjects were informed of the purposes and methods of this study and gave written consent to participate in the investigation.

Procedures

All subjects were asked to wear a lifestyle recording device (Lifecorder GS, Suzuken) around the waist for 2 weeks, at all times except during bath time, and to record their morning rising times and bedtimes. The number of steps taken was employed as a quantitative parameter for daily activity, and the mean number of steps taken from rising time to bedtime was computed. The sleep–wake cycle period and the peak of sleep–wake cycle variance, which represents the intensity of periodicity, were employed as the qualitative parameters of daily activity. Sleep-Sign-Act (KISSEI COMTEC) analysis software was used to conduct periodogram analyses of the activity data obtained over 2 weeks from the Lifecorder GS, in order to calculate sleep–wake cycle period and peak values of variance. The sleep–wake cycle period represents the circadian rhythm extrapolated from sleeping and physical activity. The more periodic elements there are, the higher the variance values (y-axis) become; therefore the value for peak variance was assigned as a parameter representing the intensity of periodicity (see Fig. 1).

Sleep-Sign-Act software was then used to analyze the activity data obtained from Lifecorder GS together with rising times and bedtimes to calculate the following sleep parameters: total sleep time (TST), the sum of sleep stages 1–4 and REM; sleep latency (SL), bedtime to the first epoch of stage 1 sleep; hours of waking after sleep onset (WASO); and sleep efficiency (SE), the ratio of TST/time in bed [6]. The validation in the accuracy and convenience of this method has been previously described [6].

Analysis

All the data are shown as mean values ± SD. An unpaired t-test was used to compare the data between the groups, and the Cochran–Cox method was used to analyze data having unequal population variances. The correlation between 2 variables was determined using Pearson correlation coefficients, and the level of significance was 5% in each case.

RESULTS

Sleep parameters

Table I shows a comparison of the sleep parameters in the HD and control groups. There was no difference in TST between the two groups (HD: 7:03 ± 1:33 vs. control: 7:04 ± 0:59); however, SL (0:29 ± 0:20) and WASO (2:21 ± 1:00) in the HD group were significantly prolonged ($p < 0.05$) compared to the control group (SL: 0:16 ± 0:13, WASO: 1:35 ± 0:41); and SE was significantly lower in the HD group (HD: 67.1 ± 13.6 vs. control: 77.5 ± 9.7) ($p < 0.01$). Moreover, inefficient sleep (IS), defined as sleep efficiency of less than 70%, was calculated in both groups as described in a previous study (Unruh et al. 2008). The results show that the percentage of subjects manifesting IS was 29% and 50% in the control and HD groups, respectively.

Table I. Sleep variables in the HD and control groups

Sleep variables	HD (n = 24)	Control (n = 24)	P-value
TST (h:min)	7:03±1:33	7:04±0:59	NS
SL (h:min)	0:29±0:20	0:16±0:13	0.017
WASO (h:min)	2:21±1:00	1:35±0:41	0.047
SE (%)	67.1±13.6	77.5±9.7	0.004

TST, total sleep time; SL, sleep latency; SE, sleep efficiency; WASO, waking after sleep onset

Sleep–wake cycle

Figure 1 shows the typical pattern of periodogram analysis in one subject from each group. In these examples, the variance peaked at 24:00 in both subjects, while the peak value of variance was lower in the HD patient than in the control subject. When the mean values of the sleep–wake cycle period in the two groups were compared, no significant difference was found between the HD (24:06 ± 0:27) and control (24:00 ± 0:03) groups ($t = 1.02$, NS). However, the peak value of variance, which represents the intensity of periodicity, was significantly lower in the HD group (0.050 ± 0.028) than in the control group (0.068 ± 0.019) ($t = 2.49$, $p < 0.05$). Although there was no difference in sleep–wake cycle period between the two groups, the periodicity in HD group was found to be significantly weaker (Fig. 2).

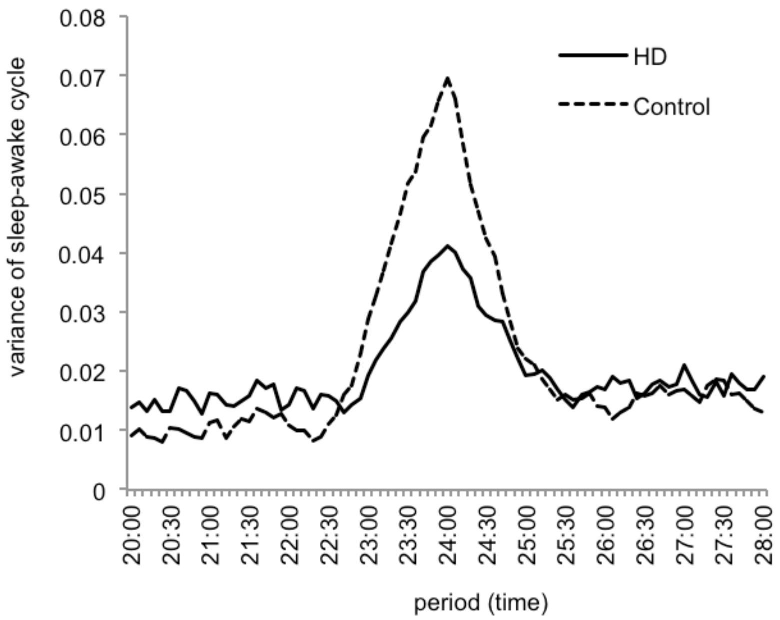
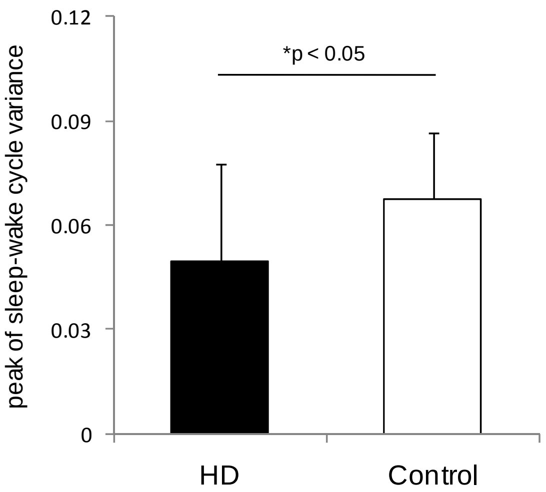


Figure 1.
Typical patterns of periodogram analysis from each group
HD: female patient, 70 years (solid line), Control: healthy female, 71years (dashed line)



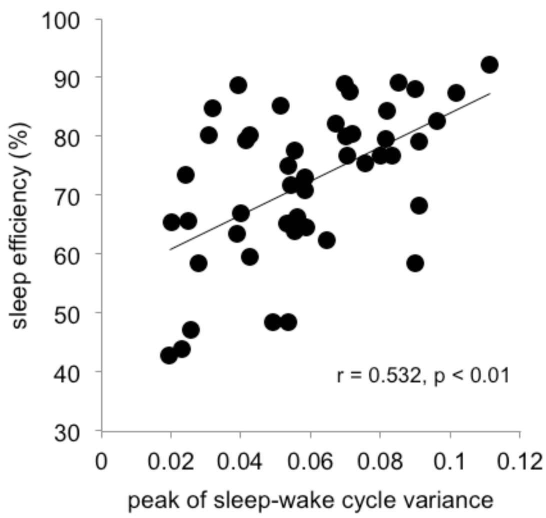


Figure 2. Comparison of the peak of sleep–wake cycle variance in both groups

Figure 3. Relationship between the peak of sleep–wake cycle variance and sleep efficiency (n=48)

Correlations between daily physical activity and each sleep parameter

As shown in Figure 3, there was a significant positive correlation between the peak of sleep–wake cycle variance and SE ($r = 0.532$, $p < 0.01$). Moreover, the peak of sleep–wake cycle variance showed significant negative correlations with SL ($r = -0.501$, $p < 0.01$) and WASO ($r = -0.436$, $p < 0.01$). The number of steps taken in the HD group (4,774 ± 2,845 steps) was significantly lower than in the control group (8,696 ± 3,047 steps) (t = 4.61, p < 0.01). In addition, the number of steps taken during dialysis treatment days was significantly lower (3,860 ± 2,333 steps) than on non-dialysis treatment days (5,645 ± 2,917 steps) in the HD group (t = 4.41, p < 0.01). There was no correlation between the number of steps taken and SE (r = 0.230, NS) or SL (r= −0.253, NS). The number of steps taken showed only a weak negative correlation to WASO (r= −0.308, p < 0.05).

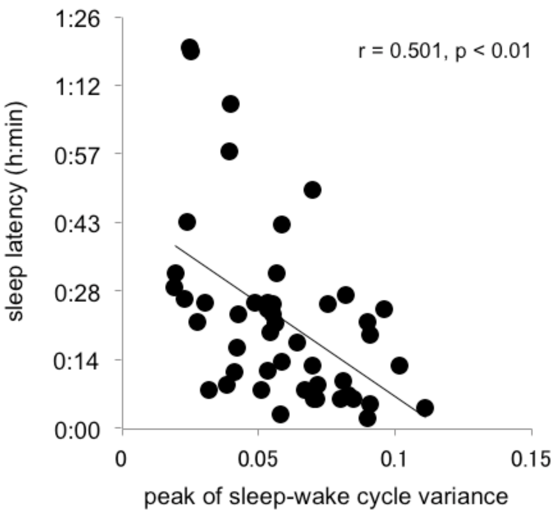


Figure 4. Relationship between the peak of sleep–wake cycle variance and sleep latency (n=48)

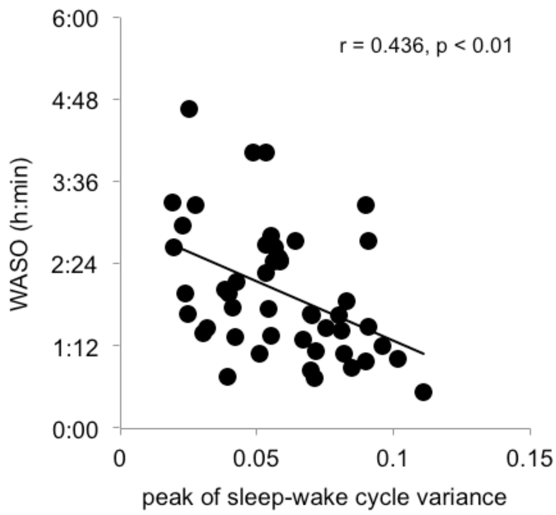


Figure 5. Relationship between the peak of sleep–wake cycle variance and WASO (n=48)

DISCUSSION

This study revealed that the values of the objective parameters (SL, WASO, and SE), which represent sleep quality, were significantly worsened in the HD group. Moreover, the peak of sleep–wake cycle variance, which represents the intensity of periodicity, and the number of steps taken, a quantitative parameter of physical activity, were significantly lower in the HD group than in the control group. In addition, significant correlations were only obtained between the peak of sleep–wake cycle variance and each sleep parameter.

HD patients, including those with end-stage renal failure, are known to often suffer from sleep disorders [(10)]. Unruh et al. [(19)] conducted a study with 46 HD patients and a control group of 137 healthy participants, matched for age, sex, BMI, and race, to calculate the rates of IS (SE < 70%) by performing a large scale polysomnographic analysis, a standard sleep diagnostic tool. The rate of IS in HD patients was reported to be 50%, significantly higher than the rate of 34% seen in the control group. The percentage of patients with SE below 70% in the present study was 29% and 50% in the control group and the HD group, respectively; these values consistent with those in the previous study. Although there are various factors causing poor sleep quality in HD patients, an important factor might be the issue related to the physical activity. Because it was considered plausible that the low volume of physical activity could impact biological rhythm and thereby compromise sleep quality, particularly as the physical activity of HD patients is restricted by 4–5 hours at a time during hemodialysis treatment. Sabbagh et al. [(15)] investigated the relationship between physical function and sleep quality in 46 maintenance HD patients, and reported that those having low activity scores (adjusted activity score) and high levels of C-creatinine protein (CRP) scored low on the Pittsburgh Sleep Quality Index questionnaire and were more likely to suffer from sleep disorders. The results obtained in this study also show that the amount of physical activity (the number of steps taken) and the values of the objective sleep parameters in the HD group were significantly lower than those in the control group. These results suggest that maintenance of or increase in physical activity may favorably affect the sleep quality of HD patients, and that daily physical activity may play a vital role in the maintenance and improvement of QOL.

However, although the number of steps, a quantitative parameter of physical activity, showed a weak correlation with WASO, no significant correlations were found with SE or SL in this study. On the other hand, the peak of sleep–wake cycle variance, which represented the intensity of periodicity showed significant correlations with all of the sleep parameters. To our best knowledge, this finding might be the first report and has clinical importance, because it suggests that increasing activity that would intensify the periodicity of the 24-hour rhythm of life, rather than simply increasing the volume of daily activity, may contribute to improving the quality of sleep. In fact, in HD patients, symptoms such as malaise and fatigue, the cause of which cannot be identified solely by data obtained from laboratory tests, have become associated with the desynchronization of circadian rhythms such as the sleep–wake and body temperature cycles [8]. Many HD patients have a tendency to sleep or nap during HD treatments [13], and it is likely that this long napping during the day may lead to interference with the daily rhythm of HD patients and worsen the quality of nighttime sleep. It is therefore necessary to make sure that HD patients obtain enough daytime physical activity, and it is particularly important to intervene in terms of how the time is passed during treatment sessions; the implementation of physical exercise programs as one of such interventions is considered to be promising. A recent study on the effect of implementing exercise programs during HD treatments on restless legs syndrome (RLS), one of the factors in sleep disorders, showed that implementing 16–24 weeks of aerobic exercise regimens during HD treatment sessions significantly reduced the severity of RLS symptoms (International RLS study group rating scale) by 42–58%, and the objective quality of sleep reported in questionnaires also showed improvements [7, 16]. Furthermore, the implementation of exercise during HD sessions was effective in improving not only sleep quality, but also the following factors: improvements in HD efficiency (spKt/V) [5, 14]; improvements in clinical conditions such as reduced serum creatinine level [1] and inflammatory reactions (hs-CRP) [1, 2] and reduced serum phosphorus and potassium levels [11]; improvements in physical activity such as increased maximum oxygen uptake, an index for aerobic capacity [12], and increased 6-minute walk distance [5, 9, 14]; and improvements in psychological factors such as a reduction in depression and improved Life Satisfaction Index and Quality of Life Index scores [12]. Thus the implementation of exercise during HD sessions is considered to contribute not only to improvement in clinical conditions, physical functions, and psychological factors but also to defining the daily rhythm so as to improve the quality of sleep.

In Japan, the proportion of elderly individuals in chronic HD patients was 54% in 2002 and increased to 69% by 2012 [17]. The high proportion of elderly patients makes it difficult for all HD patients to achieve a certain level of high-volume physical activity. However, the results obtained in this study provide evidence that intensification of periodicity in the sleep–wake cycle (the peak of sleep–wake cycle variance) might contribute to improving sleep quality; this suggests that intervention measures to prevent HD patients from napping, by implementing a light exercise program such as stretching during HD sessions, may clarify the sleep–wake cycle and help promote an improvement in sleep quality.

Our study has several limitations. The jobs influence the daily life style and are important factor for our study. However, we did not analyze about the jobs in detail. Therefore, further studies are needed.

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