Napping improves heart rate variability in older patients with cardiovascular risk factors

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Abstract

Heart rate variability (HRV), especially increased high-frequency (HF) , has been reported to provide clinically useful prognostic information regarding cardiovascular disease. Napping is an excellent sleep management strategy in older adults. This study was conducted to clarify the effect of napping on HRV in older adult patients with cardiovascular risk factors. The patients were divided into two groups: one group of 32 patients who reported napping (nap group) and another group of 45 patients who did not report napping (non-nap group). The HRV was calculated in terms of the HF component over 24 hours during wakefulness, sleep and one hour after sleep onset. The HF in the nap group was significantly higher than that in the non-nap group during all times measured. In addition, napping was a significant predictor of increased HF. This study shows the effectiveness of napping in the daily lives of patients with cardiovascular risk factors.

Keywords

napping, heart rate variability, cardiovascular risk factors, older adult patients

Introduction

Heart rate variability (HRV), especially high frequency (HF) , has been reported to provide clinically useful prognostic information regarding cardiovascular disease regardless of the patient's age (Cygankiewicz et al., 2015). Both a bedside analysis of HRV markers and more sophisticated HRV analyses, including time, frequency domain and nonlinear analyses, have been demonstrated to detect early autonomic involvement in ischemic heart disease and diabetes (Cygankiewicz & Zareba, 2013). Recently, the importance of sleep, especially the effectiveness of naps, has been discussed, but proof of its effectiveness on HRV is not sufficiently adequate (Faraut, Andrillon, Vecchierini, & Leger, 2017).

In previous studies, substantial evidence has suggested that sleep is an important determinant of health and functioning, including cardiovascular disease risk (Cappuccio, Cooper, D'Elia, Strazzullo, & Miller, 2011). In addition, Sofi et al. (2014) showed that difficulties with starting and maintaining sleep were associated with the risk of developing or dying from cardiovascular disease. Gallicchio and Kalesan (2009) indicated that individuals who sleep for both short and long periods were at an increased risk for all-cause mortality. Yang, C. Lai, H. Lai, and Kuo (2002) indicated that the quality of sleep could be measured by HRV. An altered autonomic tone, as measured by a decreased HRV, may represent one pathway through which sleep affects health and functioning (Cappuccio et al., 2011; Gallicchio & Kalesan, 2009). These studies have shown that an appropriate sleep length is important for cardiovascular disease prognosis in patients with cardiovascular risk factors.

Sleep is divided into the following two main sleep stages: (1) nonrapid eye movement (NREM) sleep, which is characterized by reduced global brain activity among other factors, and (2) rapid eye movement (REM) sleep, which is characterized by global brain activity similar to that observed during wakefulness (Chouchou & Desseilles, 2014). HRV analysis results are widely used to explore autonomic modulation and have revealed a higher parasympathetic tone during normal NREM sleep and a shift toward sympathetic predominance during normal REM sleep (Chouchou & Desseilles, 2014). Recently, HRV analyses have been shown to be capable of classifying and distinguishing sleep stages with a high accuracy and sensitivity (Shahrbabaki, Ahmed, Penzel, & Cvetkovic, 2016). A previous study showed that increased HF (0.15-0.4) was related to a better subjective and objective sleep quality (Werner, et al., 2015). In addition, previous studies have shown that sleep disorders, such as sleep pattern alteration and sleep apnea, were risk factors for cardiovascular disease (Machado & Koike, 2014). The activation of the hypothalamic-pituitary adrenal axis and the sympathetic nervous system, which is observed in insomnia, may also increase the risk of hypertension (Bonnet, 2009). Arteriosclerosis associated with aging is inevitable (Ribeiro, Luz, & Aquino, 2015), and sleep disorders have also been reported among older adults (Mander, Winer, & Walker, 2017). For example, older adults show higher indices of fragmentation and instability and fewer and shorter cycles than younger adults (Conte et al., 2014). Therefore, measuring HRV during sleep is meaningful for clinically understanding sleep quality because HRV can estimate patterns such as sympathetic and parasympathetic activities.

Usually, daytime naps are brief, and the frequency of napping increases with age (Yamada, Hara, Shojima, Yamauchi, & Kadowaki, 2015). In Japan, older adults take naps habitually (Furihata, Kaneita, Jike, Ohida, & Uchiyama, 2016). Many studies have reported the benefits of naps on health outcomes (Yamada et al., 2015). Specifically, some studies have shown that napping is correlated with distinct cognitive and health benefits, such as increased cognitive alertness, decreased daytime sleepiness and a decreased risk of myocardial infarction and coronary death (Leng et al., 2014). For older adult patients with cardiovascular risk factors, the management of sleep, including napping, is an important factor in promoting health.

We previously showed that increased daily activity is associated with an increase in the HF power and a decrease in the low frequency (LF)/HF ratio (Nakayama, Negi, Watanabe, & Hirai, 2013). However, there is a limit to the feasible increase in the amount of daily activity. Therefore, we believe that investigating not only the amount of daily activity but also comprehensive life habits, including napping, can assist in developing new methods for maintaining and promoting health.

This study was conducted to clarify the effect of napping on HRV in older adult patients with cardiovascular risk factors.

Materials and Methods

Patients

This nonrandomized study included patients with cardiovascular diseases who visited two primary care doctor offices in Aichi Prefecture between 2013 and 2017. The inclusion criteria were as follows: 1) diagnosed with stable angina pectoris, dyslipidemia, hypertension and/or diabetes mellitus, 2) received only oral treatment at these clinics and 3) did not experience changes in medications and symptoms during the 6 months prior to the start of the study. The exclusion criteria were as follows: 1) pacemakers, 2) taking hypnotics and/or psychotropics, 3) dementia, 4) sleep apnea syndrome and 5) any sleeping habit complaints, such as difficulty falling asleep or frequent waking during the night.

Methods

All patients were able to perform their own activities of daily living and visited the clinic independently. The patients visited the primary care doctor offices at the start of the activity meter measurement, the end of 1 month, start of the 24-hour Holter electrocardiograph measurement and the following day. Considering the influence of HF on the respiration rate, we measured the mean activity level at which the respiration rate increased and clarified the sleeping time at which the respiration rate decreased. The patients were instructed to take internal medications at the same time as usual without taking any internal medications other than ordinary treatment.

Measurements

The patients used activity meters (Active Style Pro HJ-350IT, Omron Colin Co., Ltd.) and measured their mean activity levels for one month. The activity meter contains an algorithm capable of measuring low-intensity activity (Sasai, Hikihara, Okazaki, Nakata, & Oogawara, 2015). Because the patients in this study were elderly, we measured all low-intensity activity using this activity meter. Daily activity was calculated using a ratio of calorie expenditure calculated based on height, weight and time.

In the present study, Holter electrocardiograms (ECGs) were recorded for 24 hours (FM-960; Fukuda Denshi Co., Ltd., Tokyo, Japan). The log reported the times when the patient woke up, took a nap and went to bed. The HRV indices were measured using a Holter ECG registered as a medical device. The authors reviewed all digitized ECG recordings. We eliminated noise and arrhythmias and extracted R-R intervals containing only normal sinus rhythms. A power frequency analysis of 5-minute recordings was sequentially performed using maximum entropy heuristics (MemCalc/Win2; GMS Co., Ltd., Tokyo, Japan). The single component powers were expressed as ms^2. The components in the frequency band from 0.04 to 0.15 Hz were considered LF components. The components in the frequency band from 0.15 to 0.4 Hz were considered HF components, which reflected parasympathetic modulation. In addition, we calculated the LF to HF ratio (LF/HF), which is considered to represent sympathetic modulation (Marek et al., 1996). In the present study, the heart rate (HR), HF power and LF/HF ratio are presented as the mean ± standard deviation after log transformation of the HRV indices. The HR and HRV indices are shown for the following four periods: 1) 24 hours, 2) wakefulness (the time was calculated by subtracting the sleeping times during the night and naps), 3) sleep (the sleeping time during the night) and 4) the first one hour after sleep onset (sleep in the supine position when the HR decreased by 15% or more in combination with the activity log notation of the patient) (Smith, Veale, Pépin, & Lévy, 1998).

Napping

As described in our previous research, we defined daytime napping based on an affirmative answer to the question "Do you have a napping habit?" (Yamada et al., 2015). Additionally, a napping habit was defined according to the patients' self-reports, the activity meter and 24 hour Holter ECGs based on the following criteria: 1) nap duration greater than 15 minutes and less than 60 minutes during the daytime, 2) nap taking occurring 5 times a week or more, 3) a decrease in the amount of activity observed at approximately the same time every day according to the activity meter and 4) an HR decrease greater than 15% during the day according to the Holter ECG (Smith et al., 1998; Stang et al., 2012). In contrast, the absence of a napping habit was determined based on the following criteria: 1) nap duration less than 15 minutes during the day, 2) nap taking occurring once a week or less, 3) no decrease in the amount of activity at approximately the same time daily according to the activity meter and 4) no HR decrease greater than 15% during the day according to the Holter ECG (Smith et al., 1998; Stang et al., 2012).

Statistical Analysis

All statistical analyses were performed using a commercial software package (SPSS version 24.0 J for Windows, IBM, Inc.). For statistical evaluation, comparisons between the two groups were performed using Student's t-test and Chi-square tests. In addition, multivariate logistic regression analysis was used to estimate the odds ratios (ORs) of the strength of the associations between napping and the HF indices. A p-value < 0.05 was considered statistically significant.

Ethical Considerations

All participants in the study received an explanation of the objectives and methods of the study and provided written informed consent prior to enrollment. The present study was approved by the Scientific and Ethics Committee of Chubu University (10-132) and the Nagoya University School of Medicine (2017-0095).

Results

Eighty-nine patients were enrolled in this study, but 12 patients were excluded from the analysis due to unmeasurable or arrhythmic (86.5%) data. The patients were divided into two groups: one group of 32 patients who reported napping (the nap group) and one group of 45 patients who did not report napping (the non-nap group). In the nap group, the mean age was 73.5 ± 6.2 years, and 20 participants were male (62.5%). In the non-nap group, the mean age was 71.5 ± 6.4 years, and 25 participants were male (55.5%). In the nap group, the mean sleep duration was 465.4 ± 106.9 minutes, and the mean daily activity was 0.724 ± 0.290 kcal/minute. In the non-nap group, the mean sleep duration was 447.9 ± 63.6 minutes, and the mean daily activity was 0.738 ± 0.207 kcal/minute. In the nap group, 16 patients had hypertension without angina pectoris, 1 patient had angina pectoris without hypertension, and 15 patients had hypertension and angina pectoris. In the non-nap group, 27 patients had hypertension without angina pectoris, 7 patients had angina pectoris without hypertension, and 11 patients had hypertension and angina pectoris. In the nap group, 4 patients had diabetes mellitus, and 15 patients had hyperlipemia. In the non-nap group, 9 patients had diabetes mellitus, and 25 patients had hyperlipemia. No significant differences were found in the prescriptions of any of the medications used for the treatment of any of these diseases between the nap and non-nap groups (Tables 1 and 2).

Figure 1a and Table 2 show the HR, Log HF and Log LF/HF over a 24-hour period. In the nap group, the Log HF across the 24-hour period was significantly higher than that in the non-nap group (2.25 ± 0.30 vs 2.04 ± 0.26, $p = 0.002$). Figure 1b and Table 2 show the HR, Log HF and Log LF/HF during wakefulness. In the nap group, the Log HF while awake was significantly higher than that in the non-nap group (2.18 ± 0.30 vs 1.95 ± 0.27, $p = 0.001$). Figure 1c and Table 2 show the HR, Log HF and Log LF/HF during sleep. In the nap group, the Log HF during sleep was significantly higher than that in the non-nap group (2.35 ± 0.31 vs 2.16 ± 0.30, $p = 0.010$). Figure 1d and Table 2 show the HR, Log HF and Log LF/HF during the first one hour after sleep onset. In the nap group, the Log HF power during the first hour after sleep onset was significantly higher than that in the non-nap group (2.30 ± 0.37 vs 2.13 ± 0.32, p = 0.031).

Finally, 77 patients were included in the multiple logistic regression analysis. The multivariate logistic regression analysis was performed using the HF power during each period to determine whether napping was a predictor of each HF index. In the multivariate model, napping was associated with an increase in the HF power across the 24-hour period (odds ratio [OR], 1.248; 95% confidence interval [CI], 1.051 - 1.482; p = 0.012), an increase in the HF power during wakefulness (OR, 1.296; 95% CI, 1.086 - 1.546; p = 0.004) and an increase in the HF power during sleep (OR, 1.212; 95% CI, 1.024 - 1.434; p = 0.026) (Table 3).

Discussion

In the present study, compared with the non-napping group, napping increased the mean HF power across the entire 24-hour period and during wakefulness, sleep and the first one hour after sleep onset. The HF power reflects efferent vagal nerve activity in clinical and experimental observations of autonomous manipulation (Marek et al., 1996). In previous studies, healthy adults who took naps exhibited a large HF power and low LF/HF, which were similar to the observations made during their nighttime sleep (Cellini, Whitehurst, McDevitt, & Mednick, 2016). These findings demonstrated an overall decline in cardiovascular output during NREM sleep and the dominance of parasympathetic/vagal activity during both naps and nighttime sleep (Busek, Vanková, Opavský, Salinger, & Nevsímalová, 2005). This pattern provides significant benefits to the cardiovascular system (Trinder, Waloszek, Woods, & Jordan, 2012). These variations in the autonomous profile of the heart associated with sleep and wakefulness can be explained by the combined influences of sleep and circadian rhythms on HR. Additionally, these variations may be partially responsible for the homeostatic regulatory balance correlation between sympathetic and parasympathetic activity, which leads to a reduced risk of cardiovascular disease, diabetes mellitus and all-cause mortality. This phenomenon has led some researchers to describe sleep as a “cardiovascular holiday” (Thayer, Yamamoto, & Brosschot, 2010). Similar to nighttime sleep, napping increases the RR interval and vagal activity, which are indicative of the cardiovascular "rest" ("cardiovascular leave") observed during nighttime sleep (Trinder et al., 2012). The present study suggests that compared to those who do not nap, napping results in cardiovascular rest.

In the present study, an increase in the HF power was confirmed during the first one hour after sleep onset. Campbell, Murphy and Stauble (2005) reported that naps had little effect on nighttime sleep or the duration of sleep and significantly increased the total sleep over a 24-hour period. In addition, improvements in cognitive and psychomotor performance were observed on the day when the individuals took a nap and on the following day. This study showed that the HF power of the nap group was higher than that of the non-nap group even during the first one hour after sleep onset.

In previous studies involving patients with cardiovascular diseases, napping was associated with a worsening prognosis and an increase in all-cause mortality (Liu, Zhang, & Shang, 2015; Yamada et al., 2015; Zhong, Wang, Tao, Ying, & Zhao, 2015). However, in this study, all patients were able to conduct their own living activities and visit the clinic by themselves. In addition, all patients had cardiovascular disease risk factors but were well controlled for hypertension, angina pectoris and diabetes. Therefore, the present study does not support previous results obtained from patients with different backgrounds. In the present study, the HF power in the nap group was higher than that in the non-nap group. The results obtained among patients with risk factors for cardiovascular disease suggest that taking a nap activates HF and does not worsen the cardiovascular disease prognosis compared with those who do not take a nap. These results show that napping is effective in activating parasympathetic nervous system activity.

This study was limited to older adult patients. Because the number of subjects was small, we could not investigate the influence of nap length on patients with cardiovascular risk factors. In addition, we were unable to examine the effect on cardiovascular disease severity in patients with cardiovascular risk factors. Future research should consider the influence of naps on patients of different ages and the influence of cardiovascular disease severity on patients with cardiovascular risk factors.

In the patients with cardiovascular disease risk factors who took naps, the HF power was activated across the 24-hour period and during wakefulness, sleep and the first one hour after sleep onset compared with those individuals who did not take naps. Thus, napping may contribute to prognostic improvement in cardiovascular disease based on its correlation with HRV. This research supports the notion of lifestyle rhythms, including napping, for patients with cardiovascular risk factors. However, the appropriate nap duration needs to be determined.

In summary, the HF power in the nap group was significantly higher than that in the non-nap group during all periods measured. In addition, napping was a significant predictor of increased HF power. This research is clinically important because it identifies the usefulness of napping and demonstrates the effectiveness of managing comprehensive lifestyle habits, such as naps, and rehabilitation activities in the daily lives of cardiovascular patients.

The authors declare that they have no conflicts of interest to disclose.

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Table 1

Baseline characteristics, diagnosis and internal medications of the patients in the nap and non-nap groups (N=77)

	Nap group (n = 32)		Non-nap group (n = 45)		
Characteristics	f	%	f	%	*p-value*
Male sex	20	62.5	25	55.5	0.641
Smoking history	1	3.1	3	6.6	0.637
HT without AP	16	50.0	27	60.0	0.486
AP without HT	1	3.1	7	15.5	0.130
HT and AP	15	46.8	11	24.4	0.052
Diabetes mellitus	4	12.5	9	20.0	0.540
Hyperlipemia	15	46.8	25	55.5	0.494
Medication use					
Angiotensin II receptor antagonist	21	65.6	28	62.2	0.813
Calcium antagonist	18	56.2	29	64.4	0.487
β-blocker	14	43.7	14	31.1	0.337
Coronary vasodilator	7	21.8	3	6.6	0.083

Abbreviations: BMI, Body Mass Index; AP, Angina Pectoris; HT, Hypertension.

Table 2

Continuous heart rate and heart rate variability frequency data among the patients in the nap and non-nap groups (N=77)

	Nap group (n = 32)		Non-nap group (n = 45)		
Continuous and frequency	mean	SD	mean	SD	*p-value*
Age, years	73.5	6.2	71.5	6.4	0.185
BMI, kg/m^2	23.6	4.0	23.2	3.3	0.685
Nap time, min	43.6	19.0	0	0	< 0.0001
Sleep time, min	465.4	106.9	447.9	63.6	0.372
Daily activity, kcal/min	0.724	0.290	0.738	0.207	0.813
Average over 24 hours					
HR, bpm	69	7	68	7	0.537
Log LF/HF	0.27	0.24	0.36	0.25	0.142
During wakefulness					
HR, bpm	73	7	73	8	0.850
Log LF/HF	0.27	0.26	0.39	0.35	0.067
During night sleep					
HR, bpm	61	7	58	6	0.221
Log LF/HF	0.24	0.25	0.24	0.30	0.908
One hour after sleep onset					
HR, bpm	61	8	58	6	0.082
Log LF/HF	0.15	0.35	0.18	0.38	0.737

Abbreviations: BMI, Body Mass Index； HR, Heart Rate; LF, Low Frequency; LF/HF, LF to HF ratio.

Table 3

Multivariate logistic regression analysis of the predictors of an increase in the high frequency index during napping (N=77)

	Odds Ratio	95% Confidence Interval	*p-value*
24 hours	1.248	1.051 - 1.482	0.012*
Wakefulness	1.296	1.086 - 1.546	0.004*
Sleep	1.212	1.024 - 1.434	0.026*

Significant p-values are shown in bold: *$p < 0.05$.