Nursing Faculty Publications

College of Nursing

9-2012

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Abstract

Objective—The objectives for the present study were to: 1) examine within-person variability of nap duration and 2) assess how variability in nap duration is related to the number of health conditions in a sample of older adults. For highly variable behaviors such as sleep, it is important to consider fluctuations within the person instead of solely comparing averages of behaviors across persons.

Methods—Data were drawn from a previous study examining sleep in 103 community-dwelling older adults. Subjective estimates of napping behavior were obtained from sleep diaries and objective estimates of napping behavior were obtained using actigraphy. Both measures were collected for 14 consecutive days. The sampled data were aggregated in terms of: 1) average daily time spent napping and 2) average within-person fluctuations in daily nap duration. The health measure consisted of the number of self-reported health conditions.

Results—Both the objective and subjective measures revealed that there was considerable day-to-day fluctuation in nap duration and that variability in nap duration, not mean duration, uniquely predicted the number of health conditions, [b=.03, b^*=.26, t(100)= 2.71, p = .01].

Conclusions—Duration of napping in the elderly is a highly variable behavior, fluctuating as much within- as between-person. Further, variability in nap duration from day-to-day is predictive of greater medical morbidity, suggesting that clinicians should assess for inconsistencies in nap behavior in addition to duration, frequency, and timing.

Keywords

nap; health; older adults; variability; sleep

Both daytime napping and the number of health conditions become increasingly prevalent with age. While the increase in frequency of napping is likely due to a broad range of biopsychosocial factors, one line of thought is that reduced sleep quality and quantity at night prompts the individual to take naps during the day. That is, with aging there is a tendency for the individual to spend more time in lighter sleep (i.e., more Stage 1 and Stage

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2 sleep and less slow wave sleep), to obtain less total sleep time, and to experience longer sleep onsets and more awakenings (Ohayon, Carskadon, Guilleminault, & Vitiello, 2004).[1] This tendency, in turn, corresponds to an increase in daytime napping, with one in four older adults engaging in a daily nap (Ancoli-Israel & Martin, 2006; Foley, 1995) and 54% reporting napping over the prior month (Picarsic, et al., 2008). In addition to changes in sleep, older adults (i.e., age 60 and older) experience higher rates of chronic health conditions (Federal Interagency Forum on Aging-Related Statistics, 2008).

To date, these age-related trends have been evaluated in a categorical way with the incidence of napping having been found to be associated with short- and long-term severe mental and physical health problems including cognitive decline (Blackwell, et al., 2006), dementia, increased susceptibility to cardiovascular problems, increased falls, reduced social interaction, reduced work productivity, and higher morbidity (Bursztyn, Ginsberg, Hammerman-Rozenberg, & Stessman, 1999; Foley, et al., 2007; Hays, Blazer, & Foley, 1996). What has not been evaluated is the extent to which 1) the two phenomena covary and 2) day-to-day variability in nap duration is predictive of poorer health (cumulative medical burden). While examining the association between mean frequencies represents a standard approach, the latter proposition (to assess within-person variability's association with health) may be more informative. This is true for essentially two reasons. First, characterizing a highly variable behavior like nap duration with a measure of central tendency may simply fail to represent the true nature of the behavior (i.e., that the behavior is more variable than stable. Second, at a lesser level of abstraction, it follows that day-to-day variability in nap duration may negatively or positively covary with medical morbidities. For example, nap durations may covary with symptom and/or illness severity, and this may be more evident in older adults with more health complaints.

Given that little is known about the day-to-day variability of napping behavior in older individuals and still less is known about the association of nap duration with medical morbidity, the present archival analyses was undertaken to address these issues.

Methods

Participants

As noted above, the present analysis is an archival analysis of data conducted from an earlier study on the sleep patterns of community dwelling older adults (McCrae, et al., 2005). Of the 116 individuals who initially responded to recruitment materials, thirteen people were ineligible to participate in the study due to age, dementia, medication, and sleep apnea diagnosis. The mean age of the participants was 72.90 years ($SD = 6.86$). The majority of participants were white Non-Hispanic (96.1%), female (64.1%), college educated ($M = 16.16$ years, $SD = 3.02$), and married (70.9%). All of the participants lived in their own homes during the study.

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[1]The sample ages in all reviewed literature are similar to the study sample (i.e., age 60 or older) except for one younger sample (minimum age of 55; Foley, et al., 2007).

Individuals were excluded from the parent study on the basis of six criteria: 1) age younger than 60 years; 2) self-report of sleep disorder diagnoses other than insomnia (e.g., sleep apnea or narcolepsy); 3) self-report of sleep symptoms indicative of sleep diagnoses other than insomnia (e.g., heavy snoring, gasping for breath, leg jerks, daytime sleep attacks); 4) presence of severe psychiatric disorders (e.g., thought disorders or depression) as ascertained through self- report of previous diagnosis and/or treatment, and in the case of depression, via the Beck Depression Inventory-Second Edition (Beck, Steer, & Garbin, 1996); 5) cognitive impairment (e.g., as ascertained with a neurobehavioral cognitive status exam; Mueller, Kiernan, & Langston, 2001); 6) use of psychotropic or other medications known to alter sleep (e.g., beta-blockers, regular hypnotic use, and antihistamines); and 7) medical conditions or treatments that impair independent daily functioning requiring weekly care by a health professional, such as end-stage renal disease.

Procedure

Participants were recruited for the parent study from the North Florida area using a variety of recruitment techniques including media advertisements, community groups, and flyers. Participants were compensated \$30 USD for their participation. All participants deemed eligible via preliminary screening and who continued to express interest in the study underwent an initial 1- 1½ hour interview. During this interview, participants read and signed an informed consent form approved by the University of Florida Institutional Review Board. Once consent was obtained, the neurobehavioral cognitive status exam was administered (Cognistat; Mueller et al., 2001) along with a questionnaire assessing participant demographics, health status, and behaviors. Following the administration of these instruments, participants were provided with both the actiwatch and daily sleep diaries. The participants were advised to complete the sleep diaries each morning for 14 days and to wear the actiwatch continuously during this time period (except for bathing/swimming). Data were collected from the participants at three points during the study: baseline, end of first week, and end of second week.

Measures

Objective napping—Napping was measured objectively using actigraphy. Actigraphy is a motion detection method that allows for the identification and quantification of sleep. That is, the detection of movement and the absence of movement are used to infer when an individual is awake or asleep; the inference being that during wakefulness, there is a substantial amount of movement and that during sleep, movement occurs only sporadically. Actigraphy is accomplished by monitoring movement in the extremities (usually the non-dominant arm) using a small motion detector on the wrist. Users can specify the length of time, or *epoch*, for which data is collected.

In the parent study, participants wore a Mini Mitter Actiwatch-L® actiwatch with an integrated ambient light sensor for 14 consecutive 24-hr periods. Actiware-Sleep Software version 3.3 (Mini Mitter Co., 2001) was used to identify nap periods. This software uses a validated algorithm to identify the activity of each epoch as wake or sleep (Oakley, 1997). Finally, it should be noted that, when usuing a high sensitivity setting (as done in the present study), actigraphy provides high correlations with PSG measured total sleep time (.95) for

healthy older adults (Colling, 2000), and for total sleep time (.73) and sleep onset latency (.93) for people with insomnia (Cook, 2004). Additionally, actigraphy has high criterion-validity when compared to PSG (.80) and high test-retest reliability (0.92; Ancoli-Israel, et al., 2003).

In addition to the standard application of the actigraphy hardware and software, several accommodations were made during the application of the analysis to increase actigraphy's sensitivity to distinguish between inactivity due to napping and inactivity due to resting or the removal of the watch (for a more detailed description see Dautovich, et al., 2008). First, participant narratives within the sleep diaries were examined for evidence that inactivity was related to behavioral considerations or watch removal (e.g. "was watching a movie from 2-4pm" "removed watch from 6-8 p.m."). Second, the epoch data were evaluated using "Webster's rules" (Webster, 1982). In brief, this procedure involves rescoring small wake periods surrounded by sleep periods as 'sleep' and rescoring small sleep periods surrounded by wake periods as 'wake'. Third, the epoch data were re-reviewed and rescored using a maximum gain setting (i.e., effectively lowers the threshold for the amount of activity that is identified as "wakefulness") and noting which periods are still identified as naps at this setting. Fourth, in keeping with previous research (see Dautovich et al., 2008), a period of inactivity during the diurnal phase of the day was scored as a napping episode if it was of a minimum of 5 minutes duration and less than 180 minutes.

Subjective napping—Subjective estimates of napping behavior were obtained using a sleep diary. Sleep diaries have been shown to provide a reliable and valid index of sleeping behavior (Lichstein, Riedel, & Means, 1999), with a Cronbach's alpha internal consistency estimate across seven nights of assessment of 0.91 (Currie, Malhotra, & Clark, 2004). The 'nap' section of the sleep diary provides a place for a person to record the total number of minutes spent napping prior to bedtime for each day. The nap variable "subjective mean nap duration" (total amount of time spent napping during the day on average) was derived from the sleep diary data.

Demographics and health survey—This survey consists of 13 items collecting information on demographics, sleep disorder symptoms, physical health, and mental health (Lichstein et al., 2004). Self-report sleep questions on the survey contained information on whether the participant had a sleep problem and if they or a bed partner noticed heavy snoring, difficulty breathing or gasping for breath, frequent leg jerks, restlessness before sleep onset, sleep attacks during the day, or paralysis at sleep onset. Health conditions were assessed as a yes/no response to questions regarding the current presence of the following conditions: heart attack, other heart problems, cancer, AIDS, hypertension, neurological disorder (seizures, Parkinson's), breathing disorder (asthma, emphysema, allergies), urinary problems (kidney disease, prostate problems), diabetes, pain (arthritis, back pain, migraines), and gastrointestinal disorders (stomach ulcers, irritable bowel syndrome, gastric reflux). The 'number of health conditions' variable consisted of a sum total of all the classes of health conditions each participant reported. For example, if a participant was experiencing two different breathing disorders, they would be considered to have one health condition (problems with breathing).

Analysis

In order to investigate the association between nap duration variability and the number of health conditions, three analytic steps were undertaken. First, the nap duration data for each individual were detrended. Second, metrics were created to represent within-person, between-person, and total variability. Third, bivariate correlations, independent *t* tests, and hierarchical regression analyses were conducted to formally test the association between the variables of interest.

For Step 1, within-person variability was calculated for both objective and subjective daily nap duration. Within-person variability refers to the extent that a person's repeated scores fluctuate around their own mean (i.e., a standard-deviation within the individual). The first step was to detrend the nap variables. Detrending is required to eliminate effects that occur with the simple passage of time. Detrending for time effects within the present context allows for the distinction between fluctuations that may be time-dependent (e.g., adaptation or homeostasis) and fluctuations that are randomly ordered in time, that are of interest in the present study (random variations in a person's behavior; Ram & Gerstorf, 2009). Detrending consisted of calculating regressions for all nap variables for all participants with time (linear, quadratic, and cubic functions) as the independent variable, and nap as the dependent variable. As a result, the unstandardized residuals resulting from the regressions consisted of time-independent values (the possible impact of linear, quadratic, and cubic functions were removed from all the nap variables).

For Step 2, estimates of within-person and between-person variability were calculated. This was accomplished by deriving the standard-deviation for each person's nap variables (an intra-individual standard deviation). Additionally, mean-level values for each of the nap variables were calculated. In order to provide a point of comparison for the amount of within-person variability, the amount of between-person variability for each of variables was also derived by calculating the overall sample standard deviation for each variable. The total amount of variability to be explained in a variable can be divided between variability due to within-person fluctuations and variability due to between-person fluctuations, culminating in a total of 100% variability. Consequently, comparing the amount of within to between-person variability provides a measure of the proportion that each type of variability contributes to the overall amount of variability to be explained.

For Step 3, bivariate correlation analyses between age, the objective and subjective nap variables of mean nap duration and nap duration variability, and the number of health conditions were calculated. An independent samples *t* test was run to differentiate between the number of health conditions reported by males and females. A one-way ANOVA was run to determine how marital status predicted number of health conditions. Finally, only the variables that were significantly associated with the number of health conditions were entered into multiple hierarchical regression analyses.

Missing Data Transformations and Statistical Power

The amount of missing data was minimal. For the subjective nap variable, less than 2.5% of the data was missing. For the objective nap variable, there was no missing data. Similarly,

data was complete for the number of health conditions. Means and within-person standard deviations were calculated using available values. Results of evaluation of the assumptions led to a transformation of the health variable to reduce kurtosis. A square root transformation was performed on the health variable and was successful in normalizing the distribution. However, using the transformed health variable did not substantially change the results so untransformed values were used in the analyses. With regard to power, calculations showed that for a hierarchical multiple regression analysis with three predictors, predicting an R^2 of at least 0.15, at an alpha level of .05, a sample size of 103 participants would yield a power of approximately 0.95.

Results

Sample

Descriptive statistics (age, gender, education, marital status, ethnicity, health conditions, and sleep classification) are presented in Table 1.

Amount of Within-person Variability

For objective nap duration, the amount of variability due to fluctuations within individuals was 49.18% of the total amount of variability (this compares to 50.82% of the variability due to between-person fluctuations). For subjective nap duration, 44.30% of the variability was due to fluctuations occurring within persons (this compares to 55.70% of the variability due to between-person variations). The finding suggests that 1) the day-to-day variance in nap duration within older subjects is very high (i.e., within-person variability is usually a fraction of between-person variability), and 2) such variability has the potential to be associated with other variable domains of interest (in this case, cumulative medical morbidity).

Association of Demographic Variables with Number of Health Conditions

Bivariate correlations showed that age ($r = .29$, $p = .003$) was significantly positively correlated with the number of health conditions (see Table 2). An independent samples t test showed that gender was not significantly associated with the number of health conditions, ($t[98] = -0.44$, $p = 0.66$). A one-way ANOVA showed a significant main effect for marital status predicting the number of health conditions, ($F [3, 79] = 3.94$, $p = .01$). Hochberg's post hoc comparisons indicated that widowed participants ($M = 2.91$, 95% CI[2.18, 3.64]) had a significantly higher number of health conditions compared to married participants ($M = 1.61$, 95% CI [1.29, 1.93]), $p = .01$.

Association of Nap Duration with Number of Health Conditions

Bivariate correlations showed that: 1) objectively measured mean nap duration, and nap duration variability were not significantly associated with the number of health conditions although objective mean nap duration approached significance ($p = 0.06$); 2) subjectively measured mean nap duration ($r = .23$, $p = .02$) and nap duration variability ($r = .27$, $p = .01$) were significantly positively correlated with the number of health conditions (see Table 2).

In step one of the first multiple regression model, age and marital status were entered and accounted for 9% of the variance in health conditions, $R^2 = 0.09$, $F(2, 83) = 5.36$, $p = 0.006$. Age (not marital status) was a significant predictor of the number of health conditions. In step two, mean nap and nap duration variability were entered and accounted for 15% of the variance in health conditions, $R^2 = 0.15$, $R^2 = 0.06$, $F(4, 81) = 5.57$, $p = 0.001$. Based on the non-significant contribution of mean nap duration and marital status for predicting health conditions, a second model was run with only age and nap duration variability as the predictors. There was no significant change in R^2 from the first to the second model, suggesting that the elimination of mean nap duration and marital status did not significantly reduce the predictive utility of the model. A final model was run with age and mean nap to confirm that mean nap did not significantly predict the number of health conditions. Mean nap was found to not significantly predict the number of health conditions even with the removal of nap duration variability from the model. Only the variables that were significantly associated with the number of health conditions in the bivariate analyses above were entered into the regression equation (i.e., age, marital status, subjective mean nap duration, and nap duration variability). (See table 3).

In summary, according to the model that best predicted the number of health conditions, being older and having more variability in the duration of napping was associated with a higher number of health conditions.

Discussion

This study demonstrated that a substantial proportion of the total variability in nap duration in older adults was attributable to variations within the individual. This indicates that 1) although older adults may report engaging in regular napping behavior (e.g., daily afternoon naps), the *length* of these naps vary considerably from day-to-day, and 2) the nap behavior of a given individual was as likely to resemble the nap behavior of another person as it was to resemble their own nap behavior on another day. Further, it was found that variability in nap duration, not mean nap duration, was significantly associated with cumulative medical morbidity and that this finding occurred primarily with the subjective as opposed to the objective measures.

While it is not surprising that older adults exhibit a high degree of day-to-day variability in napping behavior and that this is associated with health, it is somewhat surprising that this relationship was more evident for the subjective measure of nap duration variability. Before speculating on what other factors may be at play, it should be noted that it is a common finding in sleep research that subjective and objective measures often produce relatively discordant estimates. For example, it is a common and well established finding that good sleepers often overestimate, and poor sleepers often underestimate, total sleep time relative to objective measures (actigraphy and/or polysomnography [e.g., See citations in Perlis, Giles, Mendelson, Bootzin & Wyatt, 1997]). Some have ascribed this to the necessary limitations of human estimates, the over precision of objective devices, and/or to psychological factors regarding the need to present in a manner, or perceive in a manner, that is consistent with (or biased to) one's view of themselves. Still others have suggested that the objective measures (especially with disease and aging) are less precise at demarking

what the individual rightly perceives and/or remembers as sleepiness and sleep (Perlis et al.). In the present case, it may be that the subjective measure is a stronger predictor precisely because it more closely captures the individual's experience of napping. Alternatively (or perhaps additionally), the subjective measure may be affected by other factors that are related to health. One possible candidate is related to memory difficulties that occur with aging. Thus, some of the observed shared variance may be based on the good correlation between what amounts to two health variables (memory affected by aging and health affected by aging) as opposed to what is being remembered – sleep duration.

The present study is somewhat limited with respect to generalizability given that the sample was primarily white Non-Hispanic, female, and college-educated. Also, the cross-sectional study design did not enable causal inferences or specify the direction of the relationship between variability in napping and the number of health conditions. While age could be controlled in the analyses, the lack of socioeconomic status (SES) data in the study prevented this variable from being included in the analyses. It is possible that SES could be a third variable influencing the relationship between nap behavior and health conditions (e.g., perhaps persons of lower SES may vary their nap duration due to economic demands and have a higher number of health conditions). Finally, the use of a self-report measure of health assessing the presence/absence of a health condition limits the generalizability of the results. The health variable is a global, distal assessment of health that was related to daily measures of napping. The use of more proximal, specific measures of health on a daily basis may have more accurately captured this relationship.

Finally, as with any correlational and/or cross-sectional study design, the directionality of the observed association cannot be ascertained.. For example, the introduction suggested that nap duration may be associated with cumulative morbidity based on the possibility that nap duration was varying with day-to-day fluctuations in symptom severity (e.g., more physical discomfort may lead older subjects to seek out "escape" from that discomfort by napping). This said, it is entirely possible that napping itself (and napping variability even more so) may lead to adverse changes in the circadian regulation of one or more physiological processes (e.g., hormone secretions, blood pressure, and body temperature) and that this, in turn, leads to worse health. Thus, it is left to future studies to disentangle how and why napping, duration of napping, and/or variability of the timing and duration of napping are associated with poorer health.

The theoretical importance of the present findings (which include and extend beyond the sleep field) is that within-person variability may be as, or more important, when profiling clinical populations than incidence or mean data. This is also true at the clinical level. For example, having a person report a given behavior over a single day may provide an estimate that is not representative of how the behavior fluctuates over time. Similarly, having a person report a given behavior over many days and then representing such data in terms of central tendency (as a mean) may also provide an estimate that is not representative of how the behavior fluctuates over time. Accordingly, treatment recommendations based on one-point of measurement or averages may not best meet the actual needs of the individual.

Additional investigations are needed to examine the association between variability in napping and health by using measures of medical morbidity that extend beyond occurrence by also taking into account chronicity, severity, and day-to-day symptom variation. With respect to the last of these, such data would allow for two types of demonstrations, both of which would strengthen the case for there being a necessary link between napping and health. The first demonstration would amount to between person correlations using detrended standard deviation data from both domains [nap variability and symptom variability (for one or more illnesses or clusters of related illnesses)]. The second demonstration would amount to within person correlations to assess how nap duration correlates on a day-to-day basis with symptom variability (for one or more illnesses or clusters of related illnesses). This latter effort would provide the strongest data possible for a causal relationship outside of direct experimental manipulations: temporal covariation.

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Table 1

Participant Demographics and Characteristics (N = 103)

	M (SD)	**%**
Age	72.90 (6.86)	
Gender (% female)		64.10
Education (years)	16.16 (3.02)	
Marital Status		
Single		5.80
Married		70.90
Widowed		14.00
Divorced		9.30
Ethnicity		
White Non-Hispanic		96.10
African American		2.90
Other		1.00
Health Conditions[1]	2.00 (1.59) (range = 0-8)	
Objective Nap Duration	12.59 (11.15)	
Subjective Nap Duration	17.87 (21.74)	
Sleep Classification		
Good Sleepers		58.30
Poor Sleepers[2]		41.70

[1] Total number of classes of health conditions from the following list: heart problems, cancer, hypertension, neurological disorder, breathing disorder, urinary problems, diabetes, pain, gastrointestinal disorders, mental health disorder, and other.

[2] Participants were classified as poor sleepers if they reported 31 minutes or more of unwanted awake time during the night (sleep onset latency or wake after sleep onset) 3 nights or more per week on their sleep diaries.

Table 2

Bivariate Correlations Between Age, Objective and Subjective Nap Variables, and the Number of Health Conditions (N = 103)

		health conditions	*p*
age		0.29	0.003
objective			
	mean nap duration	0.19	0.06
	nap duration variability	0.16	0.10
subjective			
	mean nap duration	0.23	0.02
	nap duration variability	0.27	0.01

Table 3

Hierarchical Multiple Regression Analyses Predicting Number of Health Conditions by Age, Subjective Mean Nap Duration, and Subjective Nap Duration Variability (N = 103)

Variable	R^2	R^2	b	$SE\ b$	b^*	T	df	p	CI
Model 1									
Step 1	.09								
age			.07	.02	.29	3.09	83	.003	[.02, .11]
marital status			.40	.24	.17	1.64	83	.11	[−.08, .85]
Step 2	.15	.06							
age			.06	.02	.25	2.24	81	.03	[.01, .11]
marital status			.41	.23	.18	1.82	81	.07	[−.04, .86]
subjective mean nap duration			−.003	.01	−.04	−0.24	81	.81	[−.02, .02]
subjective nap duration variability			.05	.02	.35	2.52	81	.01	[.01, .08]
Model 2	.15	.00							
age			.06	.02	.24	2.49	100	.01	[.01, .10]
subjective nap duration variability			.03	.01	.26	2.71	100	.01	[.01, .06]
Model 3	.11	−.04							
age			.05	.02	.22	2.14	100	.03	[.004, .10]
subjective mean nap duration			.01	.01	.17	1.65	100	.10	[−.003, .03]

Note. *b* refers to unstandardized regression coefficients and *b** refers to standardized regression coefficients.

[1]Total number of classes of health conditions from the following list: heart problems, cancer, hypertension, neurological disorder, breathing disorder, urinary problems, diabetes, pain, gastrointestinal disorders, mental health disorder, and other.