Exploring the interplay between socioeconomic status and sleep quality on general cognitive status among Taiwanese older adults

Significance

As population aging worldwide, late-life cognitive impairment has become of growing attention to health research and social policy. Cognitive impairment does not meet the clinical criteria for dementia; however, it is suggested as a precursor of dementia development. Recent research has examined individual differences in cognitive impairment and decline; these studies have found that high socioeconomic status (SES) plays a *protective* role in delaying cognitive impairment (Karp et al., 2004; Peters et al., 2009; Scazufca et al., 2008).

Insights provided by the social ecological theory (Bronfenbrenner, 1979; McLeroy, Bibeau, & Steckler, 1988) underscored the complex interplay between the nested social and behavioral factors that envelop older adults and the individuals in their immediate lifestyle factors with regards to their influence on health (Bronfenbrenner, 1979). The theory emphasizes that individuals are embedded within a context and to an extent their lifestyles practices are the result of various social influences. We thus hypothesized that older adults with poor cognitive status are more likely to report poor health-related practice, as well as their risky contextual lifestyle factors.

In line with this evidence, lifestyle factors are believed to be highly important determinants of cognitive outcomes of older adults. Several longitudinal studies have sggested active cognitive reserve that may be caused by healthy lifestyle, including physical activities (Fratiglioni, et al., 2004; Lee et al., 2015), leisure activities (Scarmeas et al., 2001), and social participation (Chiao, 2018; Scarmeas et al., 2001; Small, 2017). Accordingly, we proposed relaxation practice that is integrated within a given cultural context is likely to be the most proximal niche in which modifiable daily lifestyle practices can act to shape older adults' cognitive health (Bronfenbrenner, 1994).

A related, but somewhat separate hypothesis, which is based on the biological mechanism, underscores the importance of the levels of inflammation or cortisol that may elevate the risks for stress, depression, and sleep problems, which in turns leads to cogntivie impairment (Wang et al., 2010) although relaxation practices may serve as a protective practice to greater increase in

attentional resources improving cognition (Wayne et al., 2017). As a result of the knowledge gaps associated with prior research, investigations of lifestyle factors have relatively less often used the social ecological hypothesis that highlights the lifestyle such as relaxation practice as an important factor of an increased likelihood of promoting cognition in later life. Furthermore, there has also been little research on sleep quality and its association with cognition, and, overall, even less is known about its interplay with SES. The present study used data from a population-based survey of older adults in Taiwan and explores whether SES and sleep quality are jointly and significantly associated with differences in late-life cognitive status among older adults. This analysis specifically takes into account APOE polymorphism and a wide range of individual characteristics as one covariate in the investigation. Furthermore, an additional gap in the literature was also addressed, namely whether or not relaxation practice, the lifestyle are associated with the relationship between SES, sleep quality, and cognitive status.

Methods

Study population

The study participants were adults aged 53 or older who formed the 2006 Social Environment and Biomarkers of Aging Study (SEBAS), which is a subsample of the respondents from the Taiwan Longitudinal Survey of Ageing (TLSA). The 2006 SEBAS sample was randomly selected from the 1999 and 2003 waves of the TLSA. It oversampled urban residents living within 23 community (township) clusters. Further details on the SEBAS sampling and design are reported elsewhere (Weinstein & Goldman, 2012). This study focused on sleep quality and the general cognitive status. The analytical sample is further restricted to the 2006 SEBAS members who self-reported on sleep quality and cognition and therefore the final sample consists of a total of 1,196 individuals. The study protocol was approved by the Ethical Committee of National Yang-Ming University.

Measures

General cognitive performance was assessed by ten questions posed during the personal interviews. The questions were part of the Short Portable Mental Status Questionnaire (SPMSQ) (Pfeiffer, 1975), a 10-item free-recall test (Tractenberg, Aisen, & Chuang, 2005), and of a modified Digits Backward test (Wechsler, 1981). Among the ten questions, the eight from the SPMSQ were: ‘what are the day, the month, and the year’; ‘what day of the week is it’; ‘how old are you’; ‘what is your home address’ and ‘count backwards from 20 by 3 a total of four times’. This part of the measure

is based on the correct answer count and has a possible range of 0 to 13. The 10-item free-recall test was to recall 10 words and this has a possible range of 0 to10. One question from the modified Digits Backward test was to reverse the order of the numbers that the interviewers had read out to respondents. The latter two questions assessed the participants' memory span, which has been shown to be associated with the risk of developing dementia (Wagner, Dipl-Psych, Reischies, et. al., 2012). The total score for cognitive performance thus ranged from 0 to 24 and a higher score was indicative of a better cognitive status (Cronbach's α=0.71). Use of these ten questions as cognitive tests has been validated using the Chinese equivalent of the Mini-Mental State Examination (MMSE) (Katzman, Zhang, Qu OU et al., 1988; Salmon, Riekkinen, & Katzman et al., 1989).

The primary variables of interest are SES and sleep quality. SES consisted of self-reported measures related to the participants' education and their subjective SES. The highest education attainment of the participants was measured by years of schooling. Subjective SES was assessed using a questionnaire to determine where respondents rate their socioeconomic position relative to other people in Taiwan. A ladder, ranging from 1 to 10, was shown to participants and the higher score they reported, the higher socioeconomic status they perceived (Singh-Manoux et al., 2003). Sleep quality questions were asked in the 2006 wave of SEBAS. A shortened version of the Pittsburgh Sleep Quality Index was utilized to capture the five dimensions of sleep over one month prior to the interview. We used subjective sleep quality and sleep duration as a measures of sleep. Subjective sleep quality was rated on a four-point scale, ranging from very good, good, bad to very bad. Participants were then categorized into two groups: good sleep quality and poor sleep quality. Sleep duration was assessed by average hours a night over the past month. The hours spent in bed not asleep were not included. Sleep hours were categorized into 3 groups: less than 6 hours (short duration), 6 - 8 hours (normal duration), and more than 8 hours (long duration).

Relaxation practice/exercise was obtained by self-reported questions (Weinstein & Goldman, 2012), whether participants "engage in activities that help clear the mind and bring a feeling of calm such as tai-chi, qigong, yoga, meditation and other similar activities". This question attempts to distinguish between relaxation practice and exercise, where the focus is not on the physical movement but rather the calming and expanding of the mind. Participants who reported any one of the activities were then counted as a practitioner of relaxation practice. During the subsequent

question, participants were asked if they "exercised regularly apart from the activities that were just listed". In this study, exercise is used to refer to activities other than relaxation practice and focuses more on the physical component. Participants who reported yes were counted as exercisers. Afterwards, participants were categorized into four distinct groups. Participants who only engaged in relaxation practice were coded as relaxers, participants who did not engage in relaxation practice but only exercise were coded as exercisers, participants who engaged in both relaxation practice and exercise were coded practitioners of both, and those who did not engage in neither relaxation practice nor exercise were coded as neither.

Covariates. The analyses adjusted for several covariates. Social participation was assessed whether respondents participated in any of listed clubs. These activities and clubs included neighborhood, religious, farmers' and political associations, social service groups, senior groups and learning centers. A total score ranged from 0 to 8, with higher scores reflecting greater amounts of social participation (Lee et al., 2014). Depressive symptoms were assessed using a shortened version of the Center for Epidemiologic Studies Depression Scale (CES-D) with a total score of 30, higher scores reflecting greater depressive symptoms (Radloff, 1977). And, a set of demographic and Apolipoprotein E genetic variables were also examined (Zhang, Lewis, Yang, et. al., 2008).

Statistical analysis

The present study examined associations between SES, sleep quality, and general cognitive status. The process started with descriptive analyses that characterized the sample distributions. Next, multivariate regression models were conducted to examine the association between cognitive status and SES, sleep quality, relaxation/exercise practice and other independent variables that may affect cognitive status, such as the presence of an APOE4 allele and individual characteristics. Due to the nature of the multistage cluster sampling used by the SEBAS survey, participants within the same community cluster may share some unobserved homogeneity and this might lead them to be correlated with each other (Cornman et al, 2014). How cognitive status is clustered was examined at the primary sampling unit (PSU). The random effect at the PSU level were found to be significant ($p<0.05$), and the intraclass correlation coefficient was 0.07. As suggested by Zhang and his colleagues (Zhang et. al., 2008), multilevel regression was thus employed in the present study.

The analyses were carried out separately for older adults with and without poor sleep quality. A final analysis was conducted with the data from the total sample using a dummy variable to indicate the sleep quality difference. To test whether SES and sleep quality are jointly associated with general cognitive status, an interaction term of SES with sleep quality was included. In the interest of parsimony, any non-significant interactions were not included in the multivariate models.

STATA 14 (StataCorp., 2015) was used for data management and analysis. All of the above analyses were conducted using the maximum likelihood estimation method. The variables in the regression models may be highly correlated, thus an analysis of the variance inflation factor (VIF) was employed to assess multicollinearity. VIFs less than 5 were not regarded as of concern with respect to multicollinearity.

Preliminary results

Table 1 presents the characteristics of the study participants. A multilevel model was used to examine the relationships being investigated separately among older adults with and without poor sleep (Table 2). Among older adults with and without poor sleep, education attainment was significantly associated with higher levels of cognitive status. A significant interaction effect involving education and poor sleep was observed (β=1.13, p<0.001); this indicates that older adults who have poor sleep but who are part of a social group with a high education attainment have an even higher level of cognition although poor sleep has a non-significant association with cognitive status. Among lifestyle factors, a significant association was found between relaxation practice and better cognitive status (β=1.22, p<0.01). Low levels of cognitive status were found to be associated with high levels of depressive symptoms.

<Insert Tables 1 and 2 about here>

Table **1**: Descriptive statistics of older Taiwanese adults [mean (SD) or percentage], SEBAS

Variable	Percentage or mean (SD)
Age	64.87 (8.70)
Gender	
Male	53.27
Female	46.73
Ethnicity	
Fukienese	74.77
Hakka	16.16
Mainlander	9.07
Marital status	
Currently married	77.27
Widowed	18.12
Never married/separated/divorced	4.61
Subjective socioecomic status (SES)	4.24 (1.80; 1-10)
Education attainment (in years)	1.37 (1.04)
APOE4 allele	
Non-carrier	70.33
Carrier	12.73
Unknown	16.94
Relaxation practice	
Relaxation practice	13.13
Other exercise	36.37
Both	11.04
Neither	39.46
Social participation	0.84 (1.11)
Subjective sleep quality	
Good	71.79
Poor	28.21
Sleep duration (in hours)	
Less than 6	25.62
6-8	57.31
Greater than 8	17.07
Depressive symptoms	4.69 (5.55)
Cognitive function	18.93 (4.56)
N	1,196

Note: *N* is unweighted; percentages and means are weighted. Percentages may not sum to 100 owing to rounding.

Table **2**: Results from multilevel regression models of SES measures and the covariates associated with cognitive function by sleep quality, SEBAS (N=1,196)

	Poor sleep quality			Good sleep quality			Total sample		
	Est.		SE	Est.		SE	Est.		SE
SES measures									
Subjective SES	-0.21		0.13	0.19	**	0.07	0.16	*	0.07
Education attainment	2.21	***	0.24	1.10	***	0.14	1.07	***	0.14
SES comparison									
Poor sleep quality (ref=Good)							0.25		0.61
Subjective SES × Poor sleep							-0.38	**	0.13
Education attainment × Poor sleep							1.13	***	0.23
Covariates									
Relaxation practice/other exercise (ref=Neither)									
Relaxation practice	1.38	**	0.72	-0.19		0.38	0.35		0.34
Other exercise	1.33	*	0.49	-0.16		0.27	0.29		0.24
Both	0.76	*	0.40	2.40	**	0.87	1.22	**	0.37
Social participation	0.56	*	0.24	0.24	**	0.10	0.31	**	0.10
Sleep duration (ref=6-8 hours)									
Less than 6	0.59		0.45	-0.58		0.32	-0.08		0.26
Greater than 8	-1.08		0.82	-0.93	**	0.29	-0.93	**	0.28
Depressive symptoms	-0.08	*	0.04	-0.06	*	0.03	-0.08	***	0.02

Note: All models adjusted for individual characteristics (i.e., age, gender, ethnicity, APOE4 allele, and marital status). $^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$

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