Associations between Sleep Duration, Sleep Quality, and Cognitive Performance among Older Adults from Six Middle Income Countries: Results from the Study on Global AGEing and Adult Health (SAGE)

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INTRODUCTION

Detrimental changes in sleep duration and quality are more common with increasing age (Bombois, 2010; Descamps and Cespuglio, 2010). Older adults report an increased occurrence of sleep disorders associated with disrupted and fragmented sleep patterns. These conditions often reduce slow wave sleep (SWS) and rapid eye movement (REM) sleep, the deepest and most restorative sleep stages.

Age-related changes in sleep may contribute to cognitive decline among older individuals, yet this issue has not been extensively studied. Both short and long sleep durations have been linked with reduced cognitive performance (Crenshaw and Edinger, 1999; Faubel et al., 2009). Sleep deprivation dulls the senses, slows reaction times, and impedes memory formation (Crenshaw and Edinger, 1999). Conversely, long sleep duration may reflect poor sleep quality or disturbed sleep patterns, which may impair cognitive performance (Faubel et al., 2009). Furthermore, studies on sleep quality in older adults indicate that the impairment of normal sleep structure may detrimentally affect cognitive function (Nebes et al., 2009). Reports of chronic problems with sleep latency (time to sleep onset) and maintenance are often associated with adverse consequences, including drowsiness and reduced performance on cognitive tests (Nebes et al., 2009).

Sex differences also appear to influence sleep and cognitive test performance in older individuals, with women reporting more sleep onset and maintenance problems than men (Baldwin et al., 2004). Cultural differences also influence sex differences in cognitive performance. Specifically, women in many countries receive less schooling than men, likely contributing to observed differences in cognitive test performance (Faubel et al., 2009). Still, cross-cultural studies in this area are needed to assess the extent to which these changes represent global patterns or those strongly influenced by cultural and environmental conditions. This information is critical since the development of effective dementia treatments and the ability to minimize age-related cognitive changes are dependent on the identification of key contributing factors to cognitive decline.

The present study examines links between sleep patterns and cognitive test performance using data from the first wave of the World Health Organization's Study on global AGEing and adult health (SAGE) (Kowal et al., 2012). Data from six middle income countries (China, Ghana, India, Mexico, the Russian Federation, and South Africa) are utilized to construct a more comprehensive picture of how sleep architecture and cognitive performance among older adults varies across these countries. Three hypotheses are tested. First, short and long sleep duration will be significantly associated with poor cognitive test performance. Second, good sleep quality will be positively correlated with cognitive scores. Third, age will be inversely correlated with cognitive scores.

METHODS

Study Design and Participants

Nationally-representative samples of older adults ($\geq$50 years old) and comparative samples of younger adults (18-49 years old) were drawn from each SAGE country. Face-to-face interviews were used to collect household and individual level data (Kowal et al., 2012).

Sleep and Cognitive Variables

Participants were asked about their sleep duration during the preceding two nights and then asked to rate their sleep quality on a scale of 1 to 5. In accordance with other sleep studies, the duration values were averaged together to create a participant summary measure of sleep length so mean sleep durations could be compared (Faubel et al., 2009; Patel et al., 2006). Similarly, the quality values were also averaged to compute the sleep quality typical for each individual.

Five cognitive performance tests (included immediate and delayed verbal recall, forward and backward digit span, and verbal fluency) were used to create a summary variable of cognitive function for each participant. In accordance with other cognitive studies, composite z-scores were calculated to facilitate the comparison of cognitive test performance between individuals (Grodstein et al., 2003; Scarmeas et al., 2006). Z-scores for each cognitive test were first computed and these five z-scores were then summed for each individual, resulting in a final composite z-score.

Statistical Analysis

A series of linear regressions were conducted to assess the relative contribution of age, sleep duration, and sleep quality to cognitive test performance. Education level was used to measure the highest educational degree attained. In each linear regression, the education level dummy codes were entered in the first step to control for the contribution of education to variation in cognitive test performance. Participants were pooled and divided into younger individuals (18-49 years) and older individuals ($\geq$50 years); this dichotomous age variable was entered in the second step of the regression and sex was entered in the third step. A second linear regression was performed to determine if categories of age by decade (50-59; 60-69; 70-79; 80+) contributed significantly to the model, using the youngest age category (50-59) as the reference group. These dummy codes were entered in the second step of the regression, and sex was entered in the third step.

A third linear regression examined if sleep duration contributed to cognitive test performance. Individuals were divided into three categories: short sleep (0-6 hrs); intermediate sleep (6.01-9 hrs), and long sleep (>9 hrs). Intermediate sleep duration as the reference group, and the dummy codes were entered in the second step of the regression. A fourth regression estimated the relative contribution of sleep quality categories to cognitive score variation. Three average sleep quality categories were created: low sleep quality (average rating of 1-2); intermediate sleep quality (average rating of 2.5-3.5), and high sleep quality (average rating of 4-5), low sleep quality served as the reference group.

A final linear regression was conducted to examine the relative association of country, sex, the interaction between country and sex to cognitive z-scores after controlling for education. The six country categories were dummy coded using China as the reference group (because this country had the highest z-scores for the cognitive tests used in this study). The country dummy codes were entered in the second step of the regression, sex in the third step, and the interactions between sex and each country dummy code were entered in the fourth step.

RESULTS

Age and Cognitive Test Performance

The results of the linear regression examining the contribution of age to cognitive test performance variation indicate that education level explained a significant 12.7% of the variance in cognitive scores ($p < .001$). Adding the dichotomous younger/older age variable explained an additional 1.3% of the variance ($p < .001$). Adding sex to the model explained less than 1% additional variance, yet this was a significant amount ($p < .001$). Older individuals ($p < .001$) exhibited lower cognitive test scores compared to their younger counterparts. Further, females exhibited lower cognitive scores relative to their male counterparts on this battery of cognitive tests ($p < .001$).

The results of a second linear regression examining the contribution of age categories by decade to composite cognitive z-scores indicate that education level explained a significant 10.6% of the variance in cognitive scores ($p < .001$). Adding the age by decade dummy codes explained an additional 7.2% of the variance ($p < .001$). Adding sex to the model explained a non-significant amount of variance

(p = .145). Individuals aged 60-69, 70-79, and 80+ exhibited lower cognitive scores compared to their younger (50-59) counterparts (p < .001).

Sleep Patterns and Cognitive Test Performance

A third linear regression was used to assess the contribution of sleep duration to cognitive score variation while controlling for education. Education level explained a significant 10.1% of the variance in cognitive scores (p < .001). Adding sleep duration explains an additional 0.5% of the variance (p < .001). Short sleepers (< 6 hrs) and long sleepers (> 9 hrs) exhibited significantly lower cognitive scores (p < .001) compared to intermediate sleepers (6.01-9 hrs).

Significant differences were also observed in the linear regression examining cognitive performance between the sleep quality categories. Education level explained a significant 10.6% of the variance in cognitive scores (p < .001). Adding sleep quality explains an additional 0.7% of the variance (p < .001). Compared to low quality sleepers (rating of 1-2), cognitive test performance increases linearly in intermediate (rating of 2.5-3.5) and high quality (rating of 4-5) sleepers (p = .001).

Country, Sex, and Cognitive Test Performance

A final linear regression was used to examine the effect of country and sex on cognitive test performance variation while controlling for schooling. Education level explained a significant 10.6% of the variance in cognitive scores (p < .001). Adding country explained an additional 7.8% of the variance, (p < .001), indicating that there are significant country differences in test performance on the set of cognitive measures used. Adding sex to the model explained a non-significant amount of variance (p = .397). Adding the interaction between country and sex explained an additional less than 1% of the variance, a significant amount (p = .038).

Discussion

The present study found support for all three hypotheses. Short (0-6 hours/night) and long (>9 hours/night) sleep durations were significantly associated with poorer cognitive test performance relative to intermediate sleep lengths (6.01-9 hours/night). Higher average sleep quality scores ($\geq$4) were significantly associated with increased cognitive test performance. Composite cognition z-scores were lower in older individuals.

Sex differences were evident with women generally exhibiting significantly lower composite cognition z-scores on this specific set of cognitive measures relative to their male counterparts. Lower cognitive scores may result from women receiving less schooling than their male counterparts (Faubel et al., 2009). The present study supports this idea and indicates that when education level is taken into account sex was not a significant predictor of cognitive z-scores beyond what was accounted for by education and country.

The present study has several important limitations. First, the battery of cognitive tests used was not developed in the countries studied. It is unlikely these five tests accurately captured all aspects of cognitive function, and differences in composite z-scores were likely affected by cultural variation (e.g., differences in schooling). A second limitation is that the sleep data used were reliant on accurate participant responses in sleep duration. A third limitation is the reliance on data from only the two nights of sleep prior to the interview, which may not accurately capture typical sleep patterns. Finally, because the data in the present study were cross-sectional, it is impossible to determine the causality between the variables assessed.

In conclusion, this study documented relationships between sleep quality and quantity and cognitive test performance among older individuals from six middle income countries. These results confirm previous findings in Western populations and suggest that sleep patterns are associated with cognitive test performance cross-culturally in diverse societies. Thus, optimizing sleep duration and quality are important considerations in future clinical studies aimed at mitigating cognitive decline in older individuals.

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