Stroop Task as a Measure of Executive Functioning in Older Adults: Preliminary Data from a Multi-Site Study of Moderate Sleep Restriction

By

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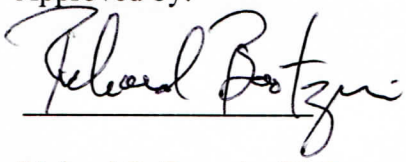

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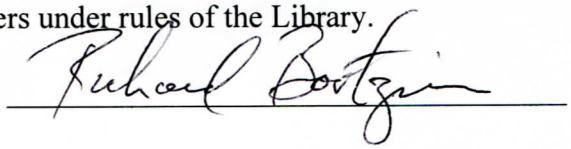
Signed: 

Abstract

Aim of Multi-Site Sleep Study is to examine the effects of chronic moderate sleep restriction on adults. Participants must be between 60- 80 years and sleep 8-9 hours (long sleepers) or 6-7.25 (average sleepers) hours per night. For my thesis, I will examine the first year data of the Stroop task (pre and posttest) looking at Stroop interference and Stroop time. My hypotheses are that long sleepers will benefit from moderate sleep restriction, but average sleepers will not. I predict no change will occur for the control group (both average and long sleepers). The study is fourteen weeks. Following baseline, participants will be assigned to the sleep restriction treatment or control treatment. The sleep restriction group will get an hour less of nightly sleep. Participants in the control group will get the same amount of sleep as baseline. Analysis revealed that there was a main effect of pre-post for interference of the Stroop task. There was no significant main effect of group or interaction between pre-post and group. For part 1, 2, and 3 Stroop time, there was a main effect of pre-post. There was no significant main effect of group or interaction between pre-post and group.

Background

Prior sleep research has focused primarily on the risks of short sleep (<6 hours per night) (Youngstedt et al., 2009). Experimental studies have inferred that short sleep duration is linked to an assortment of medical problems such as "diabetes, obesity, and hypertension" (Gangwisch et al., 2008, p. 1087). Youngstedt & colleagues (2004) suggest that both short and long sleepers (≥ 7.5 hours) experience more health concerns than average sleepers. Researchers also proposed the theory that a "u-shaped relationship exists between sleep duration and mortality" in both long and short sleepers" (Gangwisch et al., 2008, p. 1087).

Kripke & colleagues (2002) were the first researchers to introduce the association between long sleep duration and mortality. In the 1950s and 1960s, the Cancer Prevention Study I (CPSI), examined the association between long sleep duration and mortality. "Health questionnaires were provided to more than a million adults" (p. 132). Researchers remained in contact with the participants for six years after the duration of the study. Results inferred that "the lowest mortality was experienced by women and men who reported sleeping 7 hours. Higher mortality was associated with sleep durations of 8 hours or more." A more recent study, the Cancer Prevention Study II of the American Cancer Society, also examined the association between long sleep duration and mortality. About "half of the sample reported a sleep duration of 7.5 hours or more." In fact, "the longer the reported sleep, the higher the mortality rate" (p. 133). "When reported sleep exceeded 8.5 hours, the added risk associated with long sleep exceeded 15%. Reported sleep had to be less than 3.5 hours among women or less than 4.5 hours among men for the added risk associated with short sleep to exceed 15%."

The proposed association between long sleep duration and mortality remains controversial, as evidence that supports this u-shaped relationship for long sleepers is less

substantiated than for short sleepers. This is because no prior experimental studies had examined the effect of chronic moderate sleep restriction in older adults (Youngstedt et al., 2004). Despite the lack of evidence of the association between long sleep duration and medical conditions, some scientists have focused on justifying this finding, including Mesas & colleagues (2010).

In a study conducted in Spain (Mesas, Lopez-Garcia, Leon-Munoz, Guallar-Castillon, & Rodriguez-Artalejo, 2010) sleep duration and mortality in older adults (≥ 60 years) was examined. The initial sample size was 4,000 people. Starting at baseline, information was collected during home-based interviews. "The main variable of the study was usual sleep duration" (p. 1871). The participant's sex, age, and health status were also taken into consideration (p. 1872).

Researchers asked the participants how much sleep they typically receive on a daily basis. Their responses were then placed into the following categories: 5, 6, 7, 8, 9, 10, and ≥11 hours of sleep. A participant's level of cognitive functioning was assessed using the Mini Examen Cognoscitivo (MEC). The MEC ranged from 0 to 30 points. Higher scores indicated a more advanced cognitive state.

Results indicated that there was a higher prevalence of long rather than short sleep. About "two-thirds of the sample reported sleeping at least eight hours [per night]" and 20% of them "slept at least ten hours" (p. 1876). However, the most pertinent finding was that long sleep was significantly associated with mortality and morbidity.

The participants that slept at least 8 hours per night had similar characteristics. For instance, many of the long sleepers "had no formal education, did not engage in physical activity, and consumed more alcohol and coffee beverages than those who slept 7 hours" (p. 1872). The

long sleepers were also more likely to have "suboptimal health and depression and worse cognitive function" compared to the average sleepers. The long sleepers that did have optimal health status were worse off than short sleepers that had suboptimal health status. This finding infers that other factors, in addition to worse health status, affect mortality in long sleepers. Thus, "long sleep duration is an independent predictor of mortality" (p. 1872)

The results of the study have important implications for future research. However, the limitations of the study should also be taken into consideration. For instance, little is known about the mechanisms that infer the association between long sleepers and mortality. "It is possible that difficulty falling or staying asleep may require being in bed for a long period of time. Hence, poor sleep quality could be more important in greater mortality than sleep duration" (p. 1874). Despite this explanation, there is a need for an objective, randomized study that will examine the effects of chronic moderate sleep restriction in older adults.

Youngstedt and colleagues (2009) conducted the first experimental pilot study that objectively examined the influence of chronic Time in Bed (TIB) restriction in older, long sleepers. Preceding studies were epidemiological, as participants were subjectively asked to indicate the amount of sleep they typically receive on a nightly basis.

Participants in the Youngstedt study were between the ages of 50 and 70 and slept at least 8.5 hrs per night. There were 42 participants. During the two-week baseline (BL) period, both groups followed their usual sleep-wake routine. After "BL, participants were randomly assigned into one of two groups; TIB restriction (participants were asked to adhere to a fixed sleep schedule with a TIB of 90 minutes less than BL) or a control treatment (following their baseline fixed sleep schedule)" (p. 1468).

Results were important, as they indicated that there was "little detrimental effect of TIB restriction on measures of depression, sleepiness, and neurobehavioral performance" (p. 1474). Many participants in the sleep restriction group continued to restrict their sleep by 60 minutes at the one-year follow-up. Overall the findings of the study suggest "good tolerance of chronic moderate TIB restriction with few harmful results among older long sleepers." My honors thesis project is a subset of an extension of this pilot study.

Introduction to the Multi-Site Sleep Study

The Multi-Site Sleep Study (MSSS) is a five-year fully funded NIH grant. MSSS is the first large scale study to examine chronic moderate sleep restriction in older adults. The University of Arizona is in correspondence with three other sites; University of South Carolina, UCLA, and SUNY-Downstate. Data will be collected by each of the four sites. Each site will run ten participants per year. Data will be collected for a total of 200 participants over a 5-year period. The participants must be between the ages of 60- 80 to be eligible for this study. They must also sleep between 8-9 hours (long sleepers) or 6-7.25 hours (average sleepers) per night.

For my senior honors thesis, I will examine the first year data of the Stroop task. The goal of the present study was to examine the effects of chronic moderate sleep restriction on attentional modulation of parallel processing, a type of executive function. The Stroop task will be given during the baseline period of the study and after the intervention (week 12).

My hypothesis is that long sleepers will benefit from moderate chronic sleep restriction and improve their cognitive functioning on the Stroop (time and interference score). I hypothesize that long sleepers in the sleep restriction group will become faster on all three parts of the Stroop task. They will decrease their time (s) from pre to posttest. I do not think that average sleepers will benefit from an hour of sleep restriction. I propose that time and

interference score will increase from pre to posttest. I predict no change will occur in time and interference score for participants in the fixed sleep schedule for both average and long sleepers.

Method

The present study used available data from all four sites: the University of Arizona, University of South Carolina, UCLA, and SUNY- Downstate. The MSSS study contains two weeks of baseline followed by twelve weeks of the experimental condition. Participants are instructed not to travel until the completion of the study. Prior to baseline, potential participants will undergo a phone screen, in-person initial questionnaire screening, laboratory screening, sleep apnea screen, blood screen, and physical examination. In order to be eligible for the study, participants must also drink less than 600 mg of caffeine, not smoke, not use tobacco or marijuana, not take Androgen/Testosterone, not take DHEA, not have an inflammatory disorder, or be excessively sleepy. Participants will also be excluded if they currently have cancer, bipolar disorder, high blood pressure, take two or more naps daily, take sleeping pills regularly, and sleep less than six hours or more than nine hours per night. During baseline, participants will adhere to their routine sleep schedule.

Following baseline, participants will be tested on a host of objective tests (Stroop, Psychomotor Vigilance Task, and Trailmaking.) Participants will then be randomly assigned to one of two treatment groups; sleep restriction treatment or a fixed sleep schedule. Participants assigned to the sleep restriction group will be instructed to reduce their Time in Bed (TIB) by 60 minutes per night based on their baseline TIB. The participants in the sleep restriction group can go either go to bed an hour later or wake up an hour earlier, as long as it is consistent throughout

the study. Participants in the control condition will be asked to maintain their usual sleep schedule. They are allowed to consume up to 800 mL of caffeine in this condition.

A pre and posttest analysis will be conducted on the Stroop task (baseline vs. week 12). The primary outcome variable was performance on the Stroop task, in particular, Stroop interference and Stroop time. The Stroop test has three parts and yields several scores that were examined in the present study. Part one of the Stroop task measures time taken for participants to identify colors by word, printed in black ink. Part two of the Stroop task measures time taken for participants to identify colors by the color of ink used to print four X's. Part three of the Stroop test measures time taken for participants to identify colors by the color of ink used to print an incongruent color word. The Stroop test indicates that the time for naming the color of ink with which color words are incongruently written is greater than the time for naming the colors of the Xs. Interference is the ratio of time taken to complete part 3 to part 2. Lower levels of interference reflect increased attentional modulation of the dual processing of the incongruent stimuli.

Table 1. Examples of Stroop Items

Part 1	GREEN	RED	BLUE
Part 2	XXXX	XXXX	XXXX
Part 3	BLUE	GREEN	RED

The present study consisted of twenty participants distributed among the four sites. Thirteen of which were assigned to the 60 minute sleep restriction group. At the University of Arizona site, seven people participated in the study. Four of the participants were classified as average sleepers, and three were long sleepers. Five participants were randomly assigned to the sleep restriction group; the remaining two participants were assigned to the fixed sleep group. At SUNY Downstate, there were six participants. Five were average sleepers and one was long. Four participants were randomly assigned to the sleep restriction group; two were assigned to the fixed sleep group. At UCLA only one person's data was available for analysis. At University of South Carolina, there were five participants. Two were average sleepers and three were long. Three participants were randomly assigned to the sleep restriction group; the other two were assigned to the fixed sleep group.

Results

A repeated measure analysis of variance was conducted (ANOVA). Results show that the interference score was significantly affected by the time the task was completed (pre- versus post), $F(1,16)= 22.011$, $p<.001$. Our hypotheses that there would be a difference between the sleep restriction group and the fixed sleep schedule group on the Stroop interference score at pre and post is not supported, $(F (1,16))= .019$, $p= .892$. There was no significant interaction between pre-post and group, $F(1,16)= .018$, $p=.183$.

Table 1. Means for Pre and Post Interference Scores

Group	Time	N	Mean
Fixed Sleep	Pre	5	179.172
	Post	5	152.131
Restricted Sleep	Pre	13	176.294
	Post	13	150.915

Change in Interference Over Time

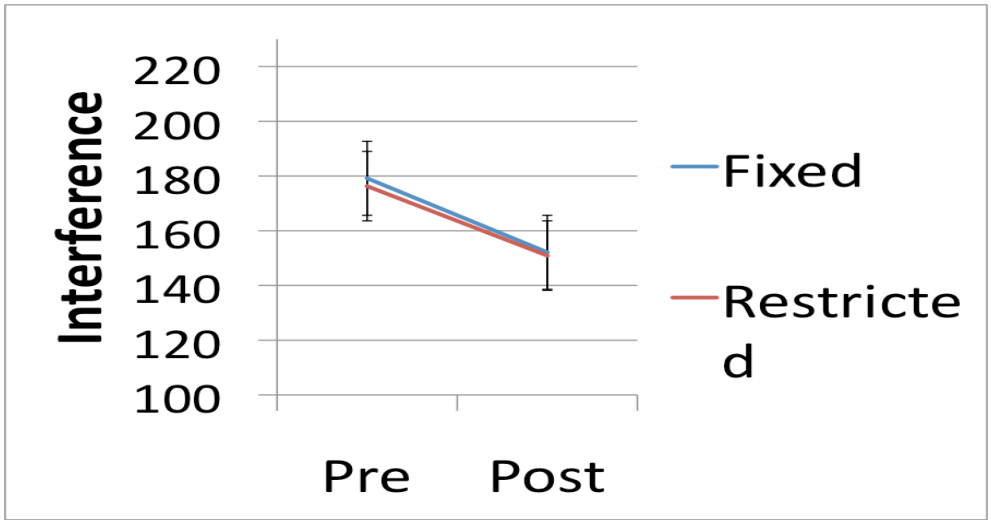


Figure 1. Stroop interference was significantly affected by the time the task was completed (pre vs. post). There was a main effect for time on the Stroop interference score, $F(1,16)= .532$, $p= .001$. There was not a main effect for time on the Stroop interference score based on group interaction, $F(1,16)= .001$, $p= .894$.

Another repeated measure of ANOVA was used to examine Part 1 time of the Stroop task. There was a main effect of pre-post, $F(1,16)= 8.059$, $p= .012$. There was no significant main effect of group $F(1,16)= .298$, $p= .593$ or interaction between pre-post and group, $F(1,16)= .874$, $p= .371$.

Table 2. Means for Pre and Post Part 1 Stroop Time

Group	Time	N	Mean
Fixed Sleep	Pre	5	49.750
	Post	5	45.034
Restricted Sleep	Pre	13	50.948
	Post	13	48.475

Another repeated measure of ANOVA was conducted to assess part 2 time of the Stroop task. There was a main effect for pre-post, $F(1,16)= 7.555$, $p= .014$. There was no significant main effect of group $F(1,16)= 1.917$, $p= .185$ or interaction between pre-post and group, $F(1,16)= .707$, $p= .413$.

Table 3. Means for Pre and Post Stroop Part 2 Time

Group	Time	N	Mean
Fixed Sleep	Pre	5	54.156
	Post	5	51.076
Restricted Sleep	Pre	13	72.881
	Post	13	65.652

Another repeated measure of ANOVA was conducted to assess Part 3 time of the Stroop task. There was a main effect of pre-post, $F(1,16)= 24.093$, $p<.001$. There was no significant effect of group $F(1,16)= 1.864$, $p= .191$ or interaction between pre-post and group, $F(1,16)= .943$, $p= .346$.

Table 4. Means for Pre and Post Stroop Part 3 Time

Group	Time	N	Mean
Fixed Sleep	Pre	5	97.174
	Post	5	77.754
Restricted Sleep	Pre	13	127.812
	Post	13	95.80

Part 3 Stroop Time

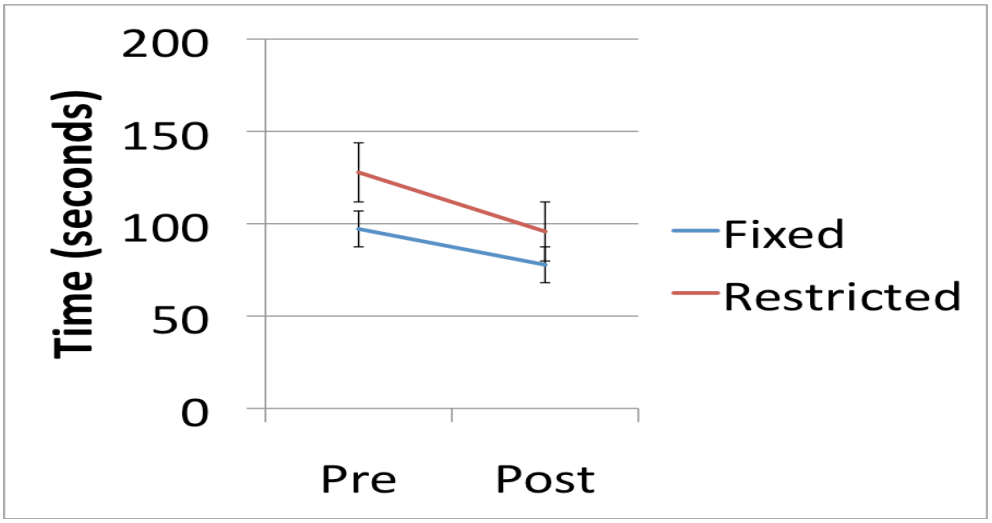


Figure 2. **Time taken on part 3 of the Stroop task was not affected by the experimental group that the participant was assigned to, F(1,16)= .056, p= 0.346. However, there was a main effect for part 3 time, F(1,16)= .496, p= .001.**

Discussion

These findings do not support our proposed hypotheses. Although variables; Stroop interference and Stroop time (part 1, 2, & 3) are not statistically significant according to group assignment, these preliminary findings indicate that chronic moderate sleep restriction is not detrimental to certain aspects of cognitive functioning in older adults. Thus, older adults can get one hour less of sleep per night over a 12-week period, but still function at the same cognitive level as measured by performance on the Stroop task. Repeated ANOVA analysis should be repeated with a bigger sample size after the study has been completed. The Multi-Site Sleep Study will be recruiting and running participants at each of the four sites for an additional three years.

The preliminary findings also suggest that the amount of sleep needed for optimal cognitive functioning varies greatly with age. For instance, children experience a decrease in cognitive functioning with less sleep (Touchette et al., 2007). Children who extend their sleep by 60 minutes for three consecutive nights show significant improvement in cognitive functioning. Our results indicate that cognitive functioning may be better protected from small variations in sleep in older adults.

Participants in both the sleep restriction and control group may have benefited from practice effects. The Stroop task is administered a total of five times during the study. Only data from pre and post were examined for this analysis. Future analysis will examine data from the other cognitive instruments in the study, Psychomotor Vigilance Task (PVT) and Trail making, in order to get a more complete depiction of cognitive functioning.

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