EPIDEMIOLOGY OF BEDTIME, ARISING TIME,
AND TIME IN BED: ANALYSIS OF AGE,
GENDER, AND ETHNICITY

by

S. JUSTIN THOMAS

A THESIS

Submitted in partial fulfillment of the requirements
for the degree of Master of Arts
in the Department of Psychology
in the Graduate School of
The University of Alabama

TUSCALOOSA, ALABAMA

2011

ABSTRACT

This study investigated the epidemiology of subjective behavioral sleep variables (i.e., bedtime, arising time, and time in bed) as a function of age, gender, and ethnicity. Sleep diaries were analyzed for 756 participants. Regression analysis showed a main effect of age on subjective bedtime, arising time, and time in bed, but not for gender or ethnicity. Younger adults had later bedtimes and arising times than other age groups. Older adults had earlier bedtimes and later arising times, which resulted in greater time spent in bed than any age group. These results suggest that there are distinct behavioral sleep patterns based on age but not gender or ethnicity and may have significant clinical implications, particularly for older adults.

DEDICATION

This thesis is dedicated to my family—most importantly, Ashley and Luke.

LIST OF ABBREVIATIONS AND SYMBOLS

β	Beta, standardized multiple regression coefficient
B	Unstandardized multiple regression coefficient
n	Total number in a sample
p	Probability associated with the occurrence under the null hypothesis of a value as extreme as or more extreme than the observed value
r	Pearson product-moment correlation
SE	Standard error
<	Less than
$\pm$	Plus or minus

ACKNOWLEDGMENTS

I am blessed to be a graduate student at the University of Alabama, studying what I love and working with great faculty and my fellow graduate students. I must first specifically thank my mentor, Dr. Kenneth L. Lichstein, who has been extremely supportive of my interests in sleep, even before my graduate career began. I still remember first calling him to inquire about research. Often, it is easy for faculty to dismiss undergraduates. However, Kenny indicated that he is always interested in collaboration, and I quickly became involved in a research project that continues today. He has always pushed me to do my best, and for all these things I will be eternally grateful.

Dr. James Geyer, a neurologist and Board-Certified Sleep Specialist, is serving as a clinical supervisor for my current placement at the Insomnia Clinic. His clinical input throughout this year has been invaluable. Additionally, he provides a clinical environment that is both pleasant and intellectually stimulating. He has provided much support and valuable feedback as a member of my thesis committee. Thank you.

Dr. Beverly Thorn has taught more of my classes (three) than any other faculty member. So, I feel that it is fair to say that I have learned a tremendous amount from her over the past three years. I am deeply grateful for her clinical and research knowledge, and I look forward to working with her in the future.

I would like to thank my family, as I would not be here without everything they have done for me. I would specifically like to thank my wife, as she is living graduate school vicariously. She makes everything in life more pleasant, even writing my thesis.

CONTENTS

ABSTRACT.....	ii
DEDICATION.....	iii
LIST OF ABBREVIATIONS AND SYMBOLS	iv
ACKNOWLEDGMENTS	v
LIST OF TABLES.....	vii
LIST OF FIGURES	viii
1. INTRODUCTION	1
2. METHOD	7
a. Participants.....	7
b. Materials and Procedure	8
c. Procedure.....	9
3. RESULTS	11
4. DISCUSSION	19
REFERENCES	24
APPENDIX.....	27

LIST OF TABLES

1. Descriptive Statistics for Full Sample.....	11
2. Pearson Correlations	12
3. Regression of bedtime on age, gender, and ethnicity	14
4. Regression of arising time on age, gender, and ethnicity	16
5. Regression of time in bed on age, gender, and ethnicity	18

LIST OF FIGURES

1. Lowess scatterplott of bedtime	13
2. Lowess scatterplot of arising time	15
3. Lowess scatterplot of time in bed	17

INTRODUCTION

Little normative data exist on behavioral parameters such as bedtime, arising time, and time spent in bed (TIB). The majority of studies that have collected data on bedtime and arising time typically focus on a specific age group (Campbell, Gillin, Kripke, Erikson, & Clopton, 1989; Dautovich, McCrae, & Rowe, 2008; Ishihara, Miyasita, Inugami, Fukuda, & Miyata, 1987; Ohayon & Vecchierini, 2005), although a few studies exist that have included more diverse age groups (Czeisler et al., 1992; Hume, Van, & Watson, 1998; Lichstein, Durrence, Reidel, Taylor, & Bush, 2004). Thus, there is a dearth of literature regarding basic behavioral circadian parameters. Most circadian research has focused on a wide range of physiological parameters, largely ignoring behavioral factors that may impact or respond to the underlying circadian system. Indeed, Ohayon, Carskadon, Guilleminault, and Vitiello (2004) performed a meta-analysis of quantitative sleep variables across the lifespan and included 65 studies. However, there are relatively few studies that focus this same attention on behavioral parameters, despite their potential impact on sleep patterns. The present study focuses on behavioral aspects of circadian patterns (i.e., bedtime, arising time, and time in bed), and their association with age, gender, and ethnicity. The importance of these behavioral components of the larger circadian mechanism may lie in their role in circadian entrainment and their resulting clinical relevance.

The sleep-wake cycle is largely controlled by the interaction of two processes: circadian rhythms and sleep homeostasis. Circadian rhythms are approximately 24-hour cycles of behavior and physiology that are generated by an endogenous biological clock. This endogenous

biological clock (the suprachiasmatic nucleus) functions to receive and process photic and non-photic inputs for the purpose of regulating gene expression as well as behavioral and physiologic rhythms. Alterations in the circadian system are associated with changes in sleep-wake patterns (Gooley & Saper, 2005). Sleep homeostasis is defined as the sleep-wake balance of sleep regulation, as homeostatic mechanisms counteract deviations from an average “reference level” of sleep (Borbely & Achermann, 2005). Simply stated, as sleep debt increases, sleep drive also increases. As a person sleeps and begins to fulfill his or her sleep debt, sleep drive begins to decrease. The two-process model hypothesizes that homeostatic sleep (process S) interacts with circadian rhythms (process C) to determine the timing of sleep and waking (Borbely & Achermann, 2005; Dijk, Duffy, & Czeisler, 1992). However, circadian rhythms may be able to exert control over the influence of homeostatic mechanisms in determining the sleep-wake cycle (Strogatz, Kronauer, & Czeisler, 1986). This model speaks of the endogenous factors that influence the propensity and timing of sleep and waking. However, exogenous influences may also be critical in establishing the sleep-wake cycle.

Circadian rhythms are influenced by external photic and non-photic time cues, also known as zeitgebers (“time givers”). Such time cues serve either an entraining effect or a masking effect. An important aspect of entrainment is that the entraining process directly affects the underlying circadian rhythm. Light serves to entrain the circadian system to the light-dark cycle and is likely the most potent entraining stimulus (Mistlberger & Rusak, 2005). Examples of non-photic entrainment are scheduled feedings, temperature, activity and arousal states (e.g., exercise at specific time), and social cues (e.g., evening activity with family). In contrast, masking effects are differentiated from entraining effects by their indirect influence on the underlying circadian rhythm. However, masking effects may still have a powerful influence on

behavior and physiology without affecting the circadian system. Exogenous temperature and feeding schedules may serve as masking effects as well as entraining effects, thus it often becomes difficult to discern between the two (Mistlberger & Rusak, 2004).

Although the interaction of circadian rhythms and sleep homeostasis establishes the sleep-wake rhythm, this is loosely set and easily influenced by environmental factors. Societal factors are often strong entraining and/or masking stimuli. The term social zeitgeber was proposed to recognize the importance of social and interpersonal factors in entraining the circadian clock. For example, a newborn child serves as a social zeitgeber, as parents' circadian rhythms adapt to that of the newborn child (Ehlers, Frank, & Kupfer, 1988). Watching television has been found to be a potent social zeitgeber for bedtime (Basner & Dinges, 2009). Certainly, social zeitgebers are specific to the individual and other examples may include computer use, talking on the telephone, and socializing with friends. The ultimate importance of social zeitgebers lies in their ability to entrain the circadian rhythm apart from the body's natural circadian rhythm.

Circadian patterns demonstrate a number of changes over the lifespan, and age is likely the most potent predictor of circadian patterns. Young adults (ages 20-21) tend to show a natural delayed phase, independent of exogenous influences, that has been found to be cross-cultural. The mechanism by which young adults develop a phase delay has been attributed to both homeostatic and circadian influences (Hagenauer, Perryman, Lee, & Carskadon, 2009; Roenneberg et al., 2004). Thus, behavioral events alone are not sufficient in explaining the observed phase delay and associated later bedtimes in young adults. However, behavioral events (e.g., working or social obligations) may combine with this endogenous delay to explain later bedtimes in young adults (Carskadon, Acebo, & Jenni, 2004). There are little data on circadian

sleep patterns during adulthood, as the bulk of circadian sleep research is conducted on the poles of the human lifespan. However, beyond adolescence, circadian and homeostatic mechanisms appear to stabilize, and a majority of the population advances to a more “normal” circadian pattern. During late adulthood, there are marked circadian changes under both entrained and free-running conditions (Myers & Badia, 1995). These circadian changes likely result in an advanced circadian phase, fragmented sleep, and increased napping during the day, whereas studies regarding total sleep time (TST) in older adults have been mixed (Czeisler et al., 1992; Jean-Louis, Kripke, Ancoli-Israel, Klauber, & Sepulveda, 2000; Miles & Dement, 1980; Myers & Badia, 1995). However, a recent meta-analysis found that TST decreased as individuals age (Ohayon et al., 2004).

Gender differences in circadian patterns are not as salient as age differences in circadian patterns. As stated, females exhibit a delayed phase earlier than males; therefore, they may also initially exhibit later bedtimes and arising times. There are little data to suggest that females display different bedtimes, arising times, or time in bed (TIB) throughout most of adulthood. Jean-Louis et al. (2000) found that adult women had greater TIB and TST. Whereas Hume et al. (1998) found no gender differences in TST. Campbell, Gillin, Kripke, Erikson, and Clopton (1989) found that older adult females exhibited a greater phase advance than older males and reported poorer sleep, earlier waketimes, and shorter total sleep time. Interestingly, bedtimes were the same between the genders, but women had earlier waketimes and thus less TST. Lastly, Czeisler et al. (1992) found no differences in TIB between older males and females.

There is a paucity of ethnicity data regarding circadian rhythms, and the data that exist are largely conflicting. Research has suggested that African-Americans may be more susceptible to phase advancement. However, one study found no differences noted in bedtimes or waketimes

between African-Americans and Caucasians (Smith, Burgess, Fogg, & Eastman, 2009). Furthermore, African-Americans may be more likely to be short-sleepers or long-sleepers than Caucasians, in part due to psychosocial stressors (Hale & Do, 2007). In a study of men and women age 40 to 64, minorities were found to have less TST than Caucasians with similar TIB (Jean-Louis et al., 2000). However, another study found no differences in TST between elderly African-Americans and Caucasians (Pittsley et al., 2005).

The majority of circadian and homeostatic research focuses on mechanisms underlying the circadian and homeostatic systems. Additional research has focused on how alterations in the circadian and homeostatic systems impact sleep-wake rhythms. However, little epidemiological data exist on the sleep-wake rhythms themselves. Frequently, circadian sleep-wake data are secondary variables, and the data exist only in specific populations. Ohayon et al. (2004) conducted a meta-analysis of quantitative sleep variables across the lifespan in an attempt at developing normative sleep values. However, this meta-analysis included mostly polysomnographic data and did not consider behavioral aspects of circadian variables, such as bedtimes and waketimes. One study did assess normal distributions of sleep variables from a large number of participants, but this population was restricted to older adults (age 60 years or older) living in metropolitan France (Ohayon & Veccierini, 2005).

The current study investigated the epidemiology of circadian sleep patterns by age, gender, and ethnicity by analyzing bedtime, arising time, and TIB of participants in a currently existing sleep database. Other sleep variables from this database (i.e., sleep onset latency, number of awakenings, wake after sleep onset, TST, sleep efficiency (SE), sleep quality rating, and nap times) were analyzed and reported previously (Lichstein et al., 2004). The current study provided normative sleep data across the adult age range and allowed analysis between genders

and two ethnic groups. The data provided insight into normative circadian patterns to allow for comparisons with published circadian pathology. Furthermore, these data may prove to be important in providing education about normative sleep-wake patterns. It was hypothesized that the mean bedtime and arising time would show a significant main effect for age but not for gender or ethnicity, with mean bedtime and arising time being earlier as individuals age. TIB was not expected to show a main effect for age, gender, or ethnicity.

METHOD

Participants

The study utilized a currently existing database that was collected for the purpose of examining the epidemiology of sleep. Random-digit dialing was used to obtain 772 participants from Shelby County, Tennessee comprised of the city of Memphis and the surrounding suburbs. At the time of the study, Shelby County had a population of 897,472, nearly equally distributed between males (47.8%) and females (52.2%), as well as being nearly equally distributed between two ethnic groups: Caucasian (47.3%) and African-American (48.6%) (Lichstein et al., 2004). Inclusion criteria for the original study required a minimum age of 20 and the ability to read, write, and speak English. There were minimal exclusionary criteria to obtain a maximally broad sample. Two cohabitating partners were not allowed to both participate in the original study. However, members of different generations within the same household were allowed to participate.

The final sample was composed mostly of Caucasians and African-Americans. The ages ranged from 20-98. The distribution was 20-29 (14%), 30-39 (16%), 40-49 (14%), 50-59 (15%), 60-69 (14%), 70-79 (14%), and 80-89+ (13%). Gender was evenly distributed at 381 males (49.4%) and 391 females (50.6%) (Lichstein et al., 2004). A total of 756 participants of the original 772 participants were analyzed for this study. Thirteen individuals who reported sleeping during the day were excluded due to the extreme nature of their sleep schedule as compared to the average of the rest of the participants. Three individuals were excluded from analysis due to insufficient data. Sleep disorders were not excluded from the present study. There

were a small number of participants who identified themselves as belonging to an ethnic group other than African-American or Caucasian. These ethnic groups could not be analyzed due to the small number of participants in their respective groups.

Materials and Procedure

This study focused on the circadian rhythm data provided in the sleep diaries (Appendix 1) and demographic information provided by the participant. The database contains a number of measures that were not utilized in this study (i.e. Beck Depression Inventory, Insomnia Impact Scale, and Health Survey). Details of the full extent of the database may be found in Lichstein et al. (2004).

Sleep diaries. Sleep diaries are self-report questionnaires that provide detailed information on various sleep parameters such as bedtime, final waketime, number of nocturnal awakenings, waketime during the night, napping activity, and alcohol or medication consumption. Although polysomnography is considered the gold standard in measuring sleep parameters, sleep diaries are considered to have good validity and reliability in terms of sleep latency, total sleep time, and sleep efficiency (Espie, 2000). Sleep diaries are recommended for use in analyzing circadian patterns and have face validity (Sack et al., 2007). In addition to their validity and reliability, sleep diaries are more cost-effective than polysomnography and less invasive to the research participant.

The sleep diary provided the participant seven columns, one for each day of the week, to record a number of variables. Specifically, the variables included the amount of time spent napping, bedtime, sleep latency, number of awakenings, total wake time, final wake time, time out of bed, a sleep quality rating, and bedtime medication use. Other sleep variables may be calculated from the sleep diary data (i.e., time in bed, total sleep time, and sleep efficiency). This

study utilized only two of the recorded variables, bedtime and time out of bed. Bedtime is defined as the time at which the participant indicated on the sleep diary that he or she went to bed at night. Arising time is defined as the time at which the participant indicated on the sleep diary that he or she got out of bed for the final time in the morning. It is important to note that these two variables are behavioral in nature, as the participant is actively choosing to go to bed to go to sleep and choosing to get out of bed after his or her final awakening. These two pieces of data will be used to compute TIB. This study will focus on bedtime, arising time, and calculated TIB.

Procedure

Undergraduate students called each randomly generated telephone number. A script was used by the undergraduate students to give information about the study and to screen potential participants for inclusion criteria. Individuals who agreed to participate in the study were mailed a study packet, which contained sleep diaries for two weeks, seven daytime functioning questionnaires, two consent forms (one to return and one for the participant's records), a university reimbursement form, a cover sheet with instructions, and a preaddressed, postage-paid envelope to return the packet. Each participant in the database completed sleep diaries for 14 days (Lichstein et al., 2004). Diagnostic criteria generally suggest a minimum of seven days of sleep diaries to diagnose any of the circadian rhythm sleep disorders (American Academy of Sleep Medicine, 2005). Therefore, a 14-day collection of sleep diaries is sufficient to establish a pattern, minimizing the error of capturing an unusual week without overburdening the participant with sleep diaries. After completion of the sleep diaries and other questionnaires, participants returned the study packet by mail in the preaddressed, postage-paid envelope included in the original study packet. Upon receipt of the completed study packet, participants were

compensated \$15-200. Initially participants were reimbursed \$15. However, due to difficulty recruiting older adults, compensation was increased such that 43% (329) of the participants were reimbursed \$15, 31% (241) were reimbursed \$50, and 12% (92) were reimbursed \$150. 17 individuals were reimbursed either \$175 or \$200. The original study was supported by National Institute on Aging grants AG12136 and AG14738, by Methodist Healthcare of Memphis, and by the Center for Applied Psychological Research, Department of Psychology, University of Memphis, part of the State of Tennessee's Center of Excellence Grant program (Lichstein et al., 2004).

The dataset for each individual consists of two weeks of sleep diary data, 14 bedtimes and 14 arising times, each broken into hours and minutes. The bedtimes and arising times were originally entered into the database using standard military time. However, to allow for statistical analysis, a system of reverse military time was employed, in which a value of 12 was subtracted from each bedtime and a value of 12 was added to each arising time. For example, a bedtime of 22:00 was converted to 10:00 and an arising time of 06:00 was converted to 18:00. Additionally, the reported number of minutes for each bedtime and arising time was converted to a decimal by dividing the value by 60. Thus, 14 distinct bedtimes and arising times, each in reverse military time and decimal form, were created.

RESULTS

The analyzed sample contained 756 participants. The descriptive characteristics of this sample are presented in Table 1.

Table 1

Descriptive Statistics For Full Sample

Characteristics	Participants (n = 756)
Avg. Age (years)	54 ± 19.89
Gender	
Male	373 (49.3%)
Female	383 (50.7%)
Ethnicity	
Caucasian	532 (70.6%)
African-American	214 (28.4%)
Avg. Bedtime	11:01 ± 1.23
Avg. Arising Time	7:10 ± 1.32
Avg. Time in Bed (hours)	8.14 ± 1.21

All variables were entered into a correlation matrix to determine the relationship between the variables prior to regression analysis. As would be expected, the dependent variables (average bedtime, arising time, and TIB) were strongly correlated with each other. Age was moderately correlated with average bedtime ($r = -.33$, $p < .001$). All other variables were either weakly correlated or were non-significant (Table 2).

Table 2

Pearson Correlations for Participant Characteristics and Behavioral Sleep Variables

	Age	Gender	Ethnicity	Avg Bedtime	Avg. Arising time	Avg. Time in Bed
Age	---	-.026	.097**	-.330**	-.109**	.215**
Gender	-.026	---	-.126**	-.054	.043	.102**
Ethnicity	.097**	-.126**	---	.079*	-.011	-.092*
Avg. Bedtime	-.330**	-.054	.079*	---	.550**	-.414**
Avg. Arising time	-.109**	.043	-.011	.550**	---	.533**
Avg. Time in Bed	.215**	.102**	-.092*	-.414**	.533**	---

*p < 0.05

**p < 0.01

Bedtime

A linear relationship was found between age and bedtime, such that as individuals became older, they tended to go to bed earlier (Figure 1).

Figure 1. Lowess scatterplot for average bedtime

Standard linear regression was used to regress bedtime on age prior to adding gender and ethnicity to the hierarchical regression model. Age was entered in the first step due to its relatively strong correlations with the dependent variables as compared to gender and ethnicity. Gender and ethnicity were then added to the hierarchical model to determine their additive effects. Age accounted for 10.9% of explained variance and the addition of gender and ethnicity added only 1.4% variance to the model. The results are summarized in Table 3.

Table 3

Regression of bedtime on age, gender, and ethnicity

	B	SE B	β	p
Constant	12.113	.122		< .001
Age	-.020	.002	-.330	< .001
Constant	11.885	.234		< .001
Age	-.021	.002	-.341	< .001
Gender	-.121	.085	-.049	.152
Ethnicity	.258	.085	.106	< .001

Arising Time

A quadratic relationship was found between age and arising time (Figure 2), such that individuals (age 20 – 38) initially trended towards earlier arising times with increasing age, but beyond age 38 individuals began trending towards later arising times.

Figure 2. Lowess scatterplot of reverse military average arising time

Curvilinear regression was used to regress arising time on age prior to adding gender and ethnicity to the regression model. Age accounted for 7.0% of the explained variance and the addition of gender and ethnicity added only 2.5% variance to the model. The results are presented in Table 4.

Table 4

Regression of arising time on age, gender, and ethnicity

	B	SE B	β	P
Constant	21.811	.355		< .001
Age	-.103	.014	-1.552	< .001
Age 2	.001	.000	1.463	< .001
Constant	21.808	.356		< .001
Age	-.103	.014	-1.550	< .001
Age 2	.001	.000	1.462	< .001

Note. Gender and ethnicity were excluded from the quadratic regression model.

Time In Bed

A quadratic relationship was also found between age and TIB (Figure 3), such that individuals (age 20 – 50) initially spent progressively less TIB, but beyond age 50 individuals trended towards increasing TIB.

Figure 3. Lowess scatterplot of average time in bed

Curvilinear regression was used to regress TIB on age. Age accounted for 13.3% of the explained variance and the addition of gender and ethnicity added only 2.6% of variance to the model. The results are presented in Table 5.

Table 5

Regression of time in bed on age, gender, and ethnicity

	B	SE B	β	P
Constant	9.961	.315		< .001
Age	-.094	.013	-1.540	< .001
Age 2	.001	.000	1.779	< .001
Constant	9.959	.315		< .001
Age	-.094	.013	-1.538	< .001
Age 2	.001	.000	1.778	< .001

Note. Gender and ethnicity were excluded from the quadratic regression model.

DISCUSSION

The hypotheses were generally supported by this study, as there was a main effect of age on subjective bedtime, arising time, and time in bed (TIB), but no main effect for gender or ethnicity. Interestingly, the specific hypotheses regarding the effects of age on bedtime, arising time, and TIB were only partially supported. Age and bedtime demonstrated a negative and linear relationship as hypothesized. However, age and arising time demonstrated a quadratic relationship, such that younger and older individuals got out of bed later than middle-aged individuals. This effect of age and arising time interacted with bedtime to produce a quadratic relationship for TIB, such that younger and older individuals had the greatest TIB. These results demonstrate that there are distinct behavioral sleep patterns based on age but not gender and ethnicity.

In general, this subjective behavioral data for young adults reflecting a delayed sleep phase is consistent with circadian and behavioral research (Hagenauer et al., 2009). Although physiological research has supported precipitating mechanisms for this delayed pattern, behavioral research supports perpetuating mechanisms. As individuals move from young adulthood into adulthood (ages 30 – 60), the relationship between age and bedtime remains linear and negative. Individuals continue the trend of going to bed earlier as they age. Literature supports the end of a physiological delay in this age group; however, a small percentage of individuals continue to demonstrate a delayed phase (American Academy of Sleep Medicine, 2005). This earlier bedtime may reflect young adults' transition from school to the workforce. As was predicted, bedtime continued to be linear and negative beyond age 60, suggesting that this

age group tends to go to bed earlier than other age groups. The earlier bedtime in older adults agrees with physiological data suggesting older adults experience an advance in the sleep phase and thus, earlier bedtimes.

The arising time curve was sharpest for young adults, suggesting that the largest difference in sleep patterns between young adults and other age groups may be the time when they wake up, as young adults wake up significantly later than other age groups. This later arising time may be multi-factorial. Younger adults may have increased sleep need and the later arising times may be a natural result of later bedtimes, the physiological delay, or a more flexible morning schedule. The arising time continues to decline from young adulthood into adulthood and reaches its nadir between ages 40 – 50 before reaching a plateau. These earlier arising times for this age group is most likely tied to work needs. Contrary to the hypothesis, older adults trended towards progressively later arising times. The later arising time, similar to younger adults, is likely multi-factorial. Older adults may perceive a greater sleep need while experiencing a decline in sleep quality, thus spending more TIB. Older adults may also have more flexibility in their morning schedule and may linger in bed later than other age groups.

These behavioral sleep patterns in bedtime and arising time drive time in bed, where young adults spend the most time in bed of any age group except older adults. As younger adults move into adulthood, time spent in bed sharply decreases. Again, contrary to the hypothesis, TIB increased sharply for older adults, as they spent the most TIB of any age group. This increase in TIB was driven predominantly by the expected earlier bedtime combined with an unexpected later arising time.

Just as physiologic sleep variables must be considered within the context of behavioral variables, these behavioral variables do not exist within a vacuum. Lichstein et al. (2004)

reported that young adults (ages 20 – 29) had greater total sleep time (TST) than most age groups other than older adults. In a broad sample, which was defined by including poor sleepers, young adults had the second highest sleep efficiency (SE) (ages 50 – 59 had the highest); however, their SE was slightly below 90%, which is clinically significant. In a narrow sample, which was defined by excluding poor sleepers, young adults had the highest SE of all age groups. Adults (ages 30 – 60) experienced the lowest TST of all age groups. Interestingly, regardless of the sample used, this age group experienced the highest SE. The increased SE is likely due to the reduction in TIB, an effect similar to sleep restriction. Older adults experienced the highest TST of any age group and the increase in TST began at age 60. However, regardless of the sample, this age group generally experienced the lowest SE of any age group. As opposed to middle-aged adults, the decrease in SE is likely due to the increase in TIB. Despite a significant increase in TST, the discrepancy between TIB and TST results in a nonsignificant reduction in SE (Lichstein et al., 2004). However, this reduction in SE may be clinically significant. Prior studies have focused on TST and excluded TIB (Hume et al., 1998; Jean-Louis et al., 2000; Ohayon et al., 2004) and found mixed results, suggesting that TST either increases or decreases as individuals age. Prior research using this data adds to the TST and SE literature on aging (Lichstein et al., 2004) and the current study adds TIB.

Gender and ethnicity were either weakly correlated to the dependent variables or were non-significant. Additionally, when added to the hierarchical regression models, neither variable added any variance. These results support the hypothesis that there is not a main effect of gender or ethnicity for bedtime, arising time, or TIB. The lack of a main effect of gender and ethnicity agrees with literature that suggests there are no significant behavioral sleep differences between males and females (Campbell et al., 1989; Jean-Louis et al., 2000) or between ethnic groups

(Smith et al., 2009). The mixed findings regarding gender may reflect the fact that males and females share similar sleep patterns, particularly for cohabitating individuals. Additionally, although there may be differences between males and females' sleep behaviors, these differences do not appear to be significant. It has been postulated that psychosocial stressors are the underlying mechanism driving sleep differences between ethnicities (Hale & Do, 2007). However, little research has been found to support these claims.

The current study demonstrated that age only accounted for 10.9% of the variance in bedtime, 7.0% of the variance in arising time, and 13.3% of the variance in TIB. Additionally, age was moderately correlated to bedtime. Therefore, other factors must account for the observed differences in bedtime, arising time, and time in bed in this sample. Social zeitgebers may explain a large portion of the variation in bedtime, arising time, and TIB, as television and computer use is common throughout most age groups.

This study had several limitations. Firstly, these data were obtained from participants living in a city in the southeastern United States; therefore, these results may not generalize to other regions of the United States or to other countries. It is convenient to think of human sleep as generalizable; however, different geographic regions and cultures have unique characteristics that may differentially affect sleep behaviors and ultimately, sleep patterns. Secondly, it is important to note that sleep diaries yield subjective sleep data in that participants estimate much of their sleep experience. Thus, some error is inherent in their use. However, sleep diaries are well-validated and are generally consistent with more objective data, such as polysomnography. Next, these cross-sectional data represent behavioral sleep variables during a specific period in time. Longitudinal data may present a more pristine picture of sleep behaviors across the

lifespan. Lastly, specific behaviors resulting in the reported bedtimes and arising times were not obtained; therefore, underlying reasons for these behaviors are mere speculation.

There is a paucity of data on the relationship between sleep and ethnicity, and more research needs to be conducted in this area. Although these data demonstrated no main effect for ethnicity, inclusion of additional ethnic groups is warranted. Furthermore, socioeconomic status may be a more potent predictor of sleep behaviors than ethnicity alone. Data was not collected on television and computer use; however, future research into specific social zeitgebers may help explain greater portions of the variance in bedtime, arising time, and TIB. Additionally, research is needed into potential health factors that may contribute to these observed behaviors, particularly in older adults.

This study provided data for the gap in literature on normative sleep behaviors. Besides adding to the normative literature, these results suggest that sleep behaviors differ significantly based on age, but there are no significant differences between gender or the sampled ethnicities. This normative data and the observed differences may be clinically important. Sleep behaviors, particularly in the context of age, should be considered when diagnosing and treating patients with complaints of obstructive sleep apnea and/or insomnia. Furthermore, factors contributing to these sleep behaviors (e.g., pain in older adults) should be factored into the management of sleep disorders. More research needs to be conducted into underlying factors contributing to sleep behaviors, particularly taking a multi-cultural approach.

REFERENCES

- American Academy of Sleep Medicine. (2005). *The international classification of sleep disorders: Diagnostic & coding manual* (2nd ed.). Westchester, IL: Author.
- Basner, M., & Dinges, D. F. (2009). Dubious bargain: Trading sleep for Leno and Letterman. *Sleep*, 32, 747-752.
- Borbely, A. A. (1982). A two process model of sleep regulation. *Human Neurobiology*, 1, 195-204.
- Borbely, A. A., & Achermann, P. (2005). Sleep homeostasis and models of sleep regulation. In M. H. Kryger, T. Roth, & W. C. Dement (Eds.), *Principles and practice of sleep medicine* (4th ed., pp. 335-350). Philadelphia, PA: Elsevier Saunders.
- Campbell, S. S., Gillin, J. C., Kripke, D. F., Erikson, P., & Clopton, P. (1989). Gender differences in the circadian temperature rhythms of healthy elderly subjects: Relationships to sleep quality. *Sleep*, 12, 529-536.
- Carskadon, M. A., Acebo C., & Jenni O. G. (2004). Regulation of adolescent sleep: implications for behavior, *Annals of the New York Academy of Science*, 1021, 276–291.
- Czeisler, C. A., Dumont, M., Duffy, J. F., Steinberg, J. D., Richardson, G. S., Brown, E. N., Sanchez, R., Rios, C. D., & Ronda, J. M. (1992). Association of sleep-wake habits in older people with changes in output of circadian pacemaker, *Lancet*, 340, 933-936.
- Dautovich, N. D., McCrae, C. S., & Rowe, M. (2008). Subjective and objective napping and sleep in older adults: Are evening naps “bad” for nighttime sleep, *Journal of the American Geriatrics Society*, 56, 1681-1686.
- Dijk, D. J., Duffy J. F., & Czeisler C. A. (1992). Circadian and sleep/wake dependent aspects of subjective alertness and cognitive performance. *Journal of Sleep Research*, 1, 112-117.
- Ehlers, C. L., Frank, E., & Kupfer, D. J. (1988). Social zeitgebers and biological rhythms. *Archives of General Psychiatry*, 45, 948-952.
- Espie, C. A. (2000). Assessment and differential diagnosis. In K. L. Lichstein & C. M. Morin (Eds.), *Treatment of late-life insomnia* (pp. 81-108). Thousand Oaks, CA: Sage.
- Gooley, J. J., & Saper, C. B. (2005). Anatomy of the mammalian circadian system. In M. H. Kryger, T. Roth, & W. C. Dement (Eds.), *Principles and practice of sleep medicine* (4th ed., pp. 335-350). Philadelphia, PA: Elsevier Saunders.

- Hagenauer, M. H., Perryman, J. I., Lee, T. M., & Carskadon, M. A. (2009). Adolescent changes in the homeostatic and circadian regulation of sleep. *Developmental Neuroscience*, 31, 276-284.
- Hale, L., & Do, D. P. (2007). Racial differences in self-reports of sleep duration in a population-based study. *Sleep*, 30, 1077-1078
- Hume, K. I., Van, F., & Watson, A. (1998). A field study of age and gender differences in habitual adult sleep. *Journal of Sleep Research*, 7, 85-94.
- Ishihara, K., Miyasita, A., Inugami, M., Fukuda, K., & Miyata, Y. (1987). Differences in sleep-wake habits and EEG sleep variables between active morning and evening subjects. *Sleep*, 10, 330-342.
- Jean-Louis, G., Kripke, D. F., Ancoli-Israel, S., Klauber, M. R., & Sepulveda, R. S. (2000). Sleep duration, illumination, and activity patterns in a population sample: Effects of gender and ethnicity. *Biological Psychiatry*, 47, 921-927.
- Lichstein, K. L., Durrence, H. H., Reidel, B. W., Taylor, D. J., & Bush, A. J. (2004). *Epidemiology of sleep: age, gender, and ethnicity*. Mahwah, NJ: Lawrence Erlbaum.
- Miles, L. E., & Dement, W. C. (1980). Sleep and aging. *Sleep*, 3, 119-220.
- Mistlberger, R. E., & Rusak, B. (2005). Circadian rhythms in mammals: Formal properties and environmental influences. In M. H. Kryger, T. Roth, & W. C. Dement (Eds.), *Principles and practice of sleep medicine* (4th ed., pp. 335-350). Philadelphia, PA: Elsevier Saunders.
- Myers, B. L., & Badia, P. (1995). Changes in circadian rhythms and sleep quality with aging: Mechanisms and interventions. *Neuroscience and Biobehavioral Reviews*, 19, 553-571.
- Ohayon, M. M., Carskadon, M. A., Guilleminault, C., & Vitiello, M. V. (2004). Meta-analysis of quantitative sleep parameters from childhood to old age in healthy individuals: Developing normative sleep values across the human lifespan. *Sleep*, 27, 1255-1273.
- Ohayon, M. M., & Vecchierini, M. (2005). Normative sleep data, cognitive function and daily living activities in older adults in the community. *Sleep*, 28, 981-989.
- Pittsley, M., Gehrman, P., Cohen-Zion, M., Stepnowsky, C., Marler, M., & Ancoli-Israel, S. (2005). Comparing night-to-night variability of sleep measures in elderly African Americans and Whites. *Behavioral Sleep Medicine*, 3, 63-72.
- Roenneberg, T., Kuehnle, T., Pramstaller, P. P., Ricken, J., Havel, M., Guth, A., & Mewes, M. (2004). A marker for the end of adolescence. *Current Biology*, 14, R1038-R1039.

- Sack, R. L., Auckley, D., Auger, R. R., Carskadon, M. A., Wright, K. P., & Vitiello, M. V., et al. (2007). Circadian rhythm sleep disorders: Part II, advanced sleep phase disorder, delayed sleep phase disorder, free-running disorder, and irregular sleep-wake rhythm. *Sleep*, 30, 1484-1501.
- Smith, M. R., Burgess, H. J., Fogg, L. F., & Eastman, C. I. (2009). Racial differences in human endogenous circadian period. *PLoS ONE*, 4, e6014. doi:10.1371/journal.pone.0006014.
- Strogatz, S. H., Kronauer, R. E., & Czeisler, C. A. (1986). Circadian regulation dominates homeostatic control of sleep length and prior wake length in humans. *Sleep*, 9, 353-364.

APPENDIX

Sleep Diary from Lichstein et al., 2004

SLEEP QUESTIONNAIRE

Department of Psychology, University of Memphis

ID# _____

Please answer the following questionnaire **WHEN YOU AWAKE IN THE MORNING**. Enter yesterday's day and date and provide the information to describe your sleep the night before. Definitions explaining each line of the questionnaire are given below.

EXAMPLE

Yesterday's day→ Yesterday's date→	TUES 10/14/97							
		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
1. Nap (yesterday)	70							
2. Bedtime (last night)	10:55							
3. Time to fall asleep	65							
4. # awakenings	4							
5. Wake time (middle of night)	110							
6. Final wake-up	6:05							
7. Out of bed	7:10							
8. Quality rating	2							
9. Bedtime Medication (Include amount & time)	Halcion 0.25mg 10:40pm							

ITEM DEFINITIONS

1. If you napped yesterday, enter total time napping in minutes.
2. What time did you enter bed for the purpose of going to sleep (not for reading or other activities)?
3. Counting from the time you wished to fall asleep, how many minutes did it take you to fall asleep?
4. How many times did you awaken during the night?
5. What is the total minutes you were awake during the middle of the night? This does **not include** time to fall asleep at the beginning of the night or awake time in bed before the final morning arising.
6. What time did you wake up for the last time this morning?
7. What time did you actually get out of bed this morning?
8. Pick **one** number below to indicate your overall QUALITY RATING or satisfaction with your sleep.
1. Very poor   2. Poor   3. Fair   4. Good   5. Excellent
9. List any sleep medication or alcohol taken at or near bedtime, and give the amount and time taken.