The Effects of Smoking on Sleep Quality and Efficiency



Psychology Senior Comprehensive Project

April 1, 2013

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ACKNOWLEDGEMENTS

I would like to thank the following individuals for providing me with the opportunity to conduct my senior comprehensive research project.

I would like to thank Dr. Sarah Conklin and Dr. Aimee Knupsky for providing me with support, guidance, and encouragement throughout this research process. Special thanks to Dr. Conklin for always providing words of wisdom and enthusiasm throughout my time here at Allegheny College.

Finally, I would like to thank Dave, my mom, family, and God for providing constant love, encouragement, and support throughout this journey.

Table of Contents

Acknowledgements……..…2

Table of Contents…….....3

List of Tables……..5

List of Appendices……...5

Abstract……...….6

Introduction……..7

Nicotine Withdrawal and Sleep Disturbances……..…8

Sleep and its Effects on Health……..12

Sleep Patterns Among College Students……13

Social Smoking……..15

Measurement of Sleep……15

Polysomnography……..16

Pittsburgh Sleep Quality Index …….16

Actigraphy……..16

Pittsburgh Sleep Quality Index and Actigraphy……17

Measurement of Smoking……..17

Self-Reports……...17

Surveys…….....17

Hypotheses…….18

Pittsburgh Sleep Quality Index……..18

Actigraphy……..19

Methods……..19

Participants……...…….19

Materials…….....19

Sleep, Smoke, and Actigraph Removal Journal…….…...…….19

Pittsburgh Sleep Quality Index……...……..20

Actigraphy……..……....20

Procedure…….....20

Data Analysis…….21

Results……21

Demographics……21

Pittsburgh Sleep Quality Index…….....23

Actigraphy…….….24

Discussion……..25

Limitations…….28

Conclusion and Future Directions…….29

References……..31

Appendix……36

List of Tables

Table 1. Participant Demographic, Self-reported Sleep, and Actigraphic Measures ……...21

Table 2. Smoking Status Groups' Comparison of Global PSQI and Subscales Scores……....……..23

Table 3. Smoking Status Groups' Comparison of Actigraphic Measures……...24

List of Appendices

Appendix A. Recruiting Flyer……...……..36

Appendix B. Consent Form…….37

Appendix C. Demographics Questionnaire…….39

Appendix D. PSQI Questionnaire……40

Appendix E. Sleep, Smoke, and Actigraph Removal Journal…….43

Appendix F. Debriefing Form……..49

ABSTRACT

The purpose of this study was to examine the effects of smoking on sleep as evidenced by PSQI and Actigraphic measures among college students who self-identified as non-smokers, smokers, and social smokers. Pittsburgh Sleep Quality Index [PSQI] questionnaires were completed at the beginning of the testing period. Participants (N=46) completed three days and two nights of Actigraphic data collection. While wearing the Actigraph, participants were instructed to record bed times and morning wake times, Actigraphy removal and replacement, daytime naps, and number of cigarettes smoked per day, if any. Results showed that non-smokers experienced the least amount of sleep disturbances as evidenced by multiple PSQI subscale scores compared to smokers and social smokers. Although additional significant differences were not found between smoking status groups, trends emerged demonstrating that non-smokers experience better sleep quality compared to smokers and social smokers.

The Effects of Smoking on Sleep Quality and Efficiency

According to the Centers for Disease Control and Prevention [CDC], approximately 3,450 people between the ages of 12 and 17, smoke their first cigarette each day; 25% of those adolescents continue smoking on a daily basis (2013). In 2011, an estimated 19% of United States adults were cigarette smokers (CDC, 2013). There has been a slight decline in the percentage of smoking compared to other decades; however, this percentage has remained higher in males (CDC, 2013). According to the United States Department of Health and Human Services [HHS], cigarette smoking can lead to disease and disability including heart disease, stroke, and lung diseases such as emphysema, bronchitis, and airway obstruction (2013). Smoking also has reproductive and early childhood effects, including increased risk for infertility, preterm delivery, stillbirth, low birth weight, and sudden infant death syndrome.

Although smoking increases morbidity and mortality, smoking cessation offers substantial gains for the body. Within 20 minutes of smoking cessation, both blood pressure and pulse rate drop to normal, and the temperature of the hands and feet increase to average numbers, varying for everyone. Blood oxygen levels increase to standard levels eight hours after smoking cessation occurs. Within 24 hours, the risk of sudden heart attack decreases and within 48 hours, the nerve endings begin to regenerate and senses of smell and taste return. Between 2 and 13 weeks free of smoking cigarettes, circulation improves, lung function increases by 30%, and walking becomes easier (Parks, 2008).

While smoking cessation offers benefits for the body, use of tobacco remains as the leading preventable cause of death and is accountable for nearly 20% of all annual deaths in the United States. This number estimates 443,000 deaths per year and about 49,000 of these tobacco-related deaths are due to the exposure of secondhand smoke; the inhalation of smoke by

individuals other than the intended active smoker (CDC, 2013). Globally, tobacco use causes more than five million deaths per year. Death due to smoking is approximated to reach eight million per year by 2030. For every person who dies from a smoking-related disease, 20 more will suffer from at least one serious illness due to smoking. On average, individuals who engage in smoking will die 13 to 14 years earlier than those who do not smoke (CDC, 2013).

As smoking is accountable for a significant number of deaths per year, the National Cancer Society (2012) reports that withdrawal from nicotine, found in cigarettes, causes both acute and chronic side effects such as depression, impatience, irritability, trouble concentrating, restlessness, sleep disturbances, and insomnia. As nicotine causes various negative health effects, insomnia is reported in approximately 39% of all smokers (Brook et al., 2012; Jaehne et al., 2009). Both insomnia and smoking have the potential to cause significant impairment to health, even leading to death (CDC, 2013; Neubauer, 2011). Investigating smoking and its influence on sleep is important as the combination of both factors can negatively impact overall health and well-being.

Nicotine Withdrawal and Sleep Disturbances

Disturbances in sleep patterns have been attributed to withdrawal from nicotine during smoking cessation and also to the stimulating effects of nicotine while smoking (Wetter & Young, 1994; Zhang, Samet, Caffo, & Punjabi, 2006). Smoking has also been demonstrated to interfere with and cause increased daytime sleepiness and decreased sleep quality (Jaehne et al., 2009; Peters, Fucito, Novosad, Toll, & O'Malley, 2011; Sabanayagam & Shankar, 2011). In one study, researcher's compared the effects of a 48 hour smoking abstinence period between smokers with a full night's sleep and smokers who were sleep deprived (Hamidovic & de Wit, 2009). A six hour testing session occurred following the 48 hour smoking abstinence and sleep

condition periods. Every hour during the testing session, participants' self-ratings of sleepiness were recorded and cigarette cravings were measured by the Brief Questionnaire of Smoking Urges. The questionnaire consists of ten questions about participants' craving for cigarettes, measuring both desire to smoke for stimulation and to relieve nicotine withdrawal. Results demonstrated that participants smoked more cigarettes after 48 hours of smoking abstinence in the sleep deprivation condition than the non-sleep deprivation condition. Researchers concluded that increased smoking was dependent upon the sleep condition (Hamidovic & de Wit, 2009).

Evidence demonstrates that smoking throughout the night indicates nicotine dependence, but may also be attributed to insomnia, depression, or perceived stress, predicting cessation failure. Although research reveals that nighttime smoking interrupts sleep cycles, smokers typically do not report sleep disturbances (Bover, Foulds, Steinberg, Richardson, & Marcella, 2008). One study examined pre-cessation risk factors of smoking at night and sleep disturbances among night smokers and non-night smokers, predicting smoking cessation failure (Peters et al., 2011). Pittsburgh Sleep Quality Index [PSQI] questionnaires were completed to measure sleep disturbances (Buysse, 1989). Additionally, exhaled carbon dioxide levels of less than 10 were examined to ensure the validity of the self-reported abstinence of smoking. Results indicated that night smokers experienced increased sleep disturbances and higher scores on the PSQI compared to non-night smokers (Peters et al., 2011).

Significant rates of sleep disturbances have been associated with cigarette smoking; however, the effects of specific sleep parameters, such as total sleep time, sleep efficiency, and latency to sleep onset have not been extensively researched among smokers (Zhang et al., 2006). Smokers often experience sleep disturbances due to the withdrawal from nicotine over the course of the night. Compared with non-smokers, smokers are typically more dissatisfied with the

quality of their sleep. Zhang et al. (2006) examined the effects of smoking on sleep among smokers and non-smokers recruited from the Sleep Heart and Health Study [SHHS]; a longitudinal study examining the effects of sleep disordered breathing on cardiovascular disease. At initial meeting, polysomnography [PSG] data and self-reported smoking status were collected. Several components of sleep, including total sleep time, latency to sleep onset, and sleep efficiency were measured using PSG. PSG data reported that, compared to non-smokers, smokers had less nightly total sleep time, longer latency to sleep onset as well as decreased sleep efficiency. These results coincide with findings from other studies, indicating increased sleep disturbances in smokers (Peters et al., 2011; Philips & Danner, 1995).

Similar to Zhang et al., (2006), additional studies examine the relationship between sleep disturbances and smoking (Wetter and Young, 1994). Data were collected through surveys regarding participants' sleep characteristics and smoking habits. Smoking status was determined through two questions, "do you currently smoke" and "have you ever been a regular smoker, that is smoked at least a pack a week" (Wetter & Young, 1994). Smoking was associated with difficulty in initial sleep onset due to the stimulating effects of nicotine. Sleep disturbance was more common among smokers, compared to non-smokers, as a result of the nightly withdrawal from nicotine.

Complaints about sleep quality and efficiency often occur with unhealthy lifestyles such as extreme alcohol intake, little physical exercise, and cigarette smoking (CDC, 2012). Other studies have suggested the association of smoking and poor sleep, including the effects of nicotine and nicotine withdrawal on sleep (Wetter & Young, 1994; Zhang et al., 2006). One study explored the relationship between cigarette smoking, poor sleep habits, and complaints regarding sleep (Phillips & Danner, 1995). Participants between the ages of 14 and 84 completed

a sleep and health questionnaire, similar to the Stanford Sleep Questionnaire and Assessment of Wakefulness. High school aged participants completed an in-class survey and adults, age 20 and older, completed a mail survey. Smokers from both age brackets had increased sleep latency and reduced total sleep time. Smokers were more likely than non-smokers to report problems staying asleep during the night, daytime sleepiness, and depression (Phillips & Danner, 1995).

Another study examining the relationship between smoking and sleep quality implemented PSQI questionnaires and questions regarding participants' smoking status and intensity (Hu, Sekine, Gaina, & Kagamimori, 2007). Smoking status was divided into three separate groups: non-smoker, ex-smoker, and current smoker. Smoking intensity was defined as less than or equal to 20 cigarettes per day, between 21 and 40 cigarettes per day, and more than 40 cigarettes per day. Hu et al. (2007) found that males who smoked between 21 and 40 cigarettes per day and females who smoked less than or equal to 20 cigarettes per day demonstrated highest rates of poor sleep, compared to non-smokers and ex-smokers. Overall, current female smokers had higher global PSQI scores than both current male smokers and female and male non-smokers and ex-smokers, indicating that smoking negatively effects sleep quality and efficiency (Hu et al., 2007).

Data collected from the 2008 Behavioral Risk Factor Surveillance System [BRFSS] demonstrated that 11% of Americans complain about insufficient sleep (Sabanayagam & Shankar, 2011) and it also reports higher prevalence of insufficient sleep among smokers (McKnight-Eily et al., 2009; Sabanayagam & Shankar, 2011). Cigarette smoking is associated with a variety of sleep problems including shorter sleep duration (Krueger & Friedman, 2009), difficulty initiating and maintaining sleep (Mak, Ho, Thomas, Lo, Cheuk, Lai, 2010; Wetter & Young, 1994), snoring (Franklin et al., 2004), and daytime sleepiness (Phillips & Danner, 1995).

Sleep and its Effects on Health

As symptoms of decreased sleep quality and insomnia are becoming more prevalent, insufficient sleep has developed into a greater public health concern worldwide (CDC, 2012; Harding & Feldman, 2008). According to the National Sleep Foundation (2011), between 20 and 30 million Americans experience insomnia which is defined as the inability to fall asleep or frequent awakenings during the night. Symptoms of insomnia include trouble returning to sleep, waking up too early in the morning, daytime sleepiness, difficulty concentrating, and irritability. Insomnia is the leading sleep complaint among Americans. It can either occur for one to several nights as an acute effect, or it can last months to years, indicating a chronic condition. The National Sleep Foundation (2011) states that between 10% and 15% of adults report chronic insomnia, which can increase the risk of early death (Neubauer, 2011). Similarly, people who receive less sleep are at a greater risk for heart disease and heart attacks. In 2005, approximately 28% of Americans stated they missed work, activities, and made errors at work as a result of sleep related issues (Neubauer, 2011). Over the course of two weeks, losing the recommended seven to nine hours of nightly sleep for adults (Morgenthaler, 2010), adds up to two full nights of sleep loss (Neubauer, 2011). If a person attains approximately four hours of sleep for several nights, the brain reacts as though that person had not slept for three consecutive nights. Sleep deprivation causes slowed reaction time, weakened memory, and thinking impairments (Neubauer, 2011).

Several studies demonstrate that insomnia affects a greater percentage of women than men, especially older women between the ages of 60 and 70 (CDC, 2012; Phillips & Mannino, 2005; Roth, 2007; Zhang & Wing, 2006). Researchers examined the relationship between insomnia and smoking over the course of 25 years in older women, beginning at age 40 and

ending at age 65 (Brook et al., 2012). Based on smoking habits, participants were placed in one of four groups; chronic heavy smokers, moderate smokers, late quitters, and non-smokers. During a 25 year span, four separate meetings were held with participants to record information regarding smoking activities. Participants were asked to indicate the amount of cigarettes smoked per day. Reponses ranged from, “none”, “less than half a pack a day”, “half a pack a day”, and “more than one pack a day” (Brook et al., 2012). During the last meeting, participants responded to four questions based on recent experiences of symptoms related to insomnia: trouble falling asleep and remaining asleep, waking up early in the morning, and daytime sleepiness. Results demonstrated that long term heavy smoking habits among women were associated with insomnia in the later stages of life (Brook et al., 2012).

Sleep Patterns Among College Students

Transitioning from high school to college introduces several new elements that can significantly interfere with one’s sleep; reduced parental supervision, new social opportunities, difficult courses (Taylor & Bramoweth, 2010), erratic schedules, and easy access to over-the-counter prescription and recreational drugs (Lund, Reider, Whiting, & Prichard, 2010). As it is recommended that adults sleep for seven to nine hours per night (Morgenthaler, 2010), college students typically achieve seven hours or less of sleep each night (Lund et al., 2010). In 1969, college students slept for approximately eight hours per night; however, in 2009 that number decreased to seven hours of sleep per night (Taylor & Bramoweth, 2010). Few studies have examined the changes in sleep patterns among students during the transitional period of high school to college. Because little research has been conducted on this population, factors contributing to poor sleep remain unclear (Lund et al., 2010).

Researchers examined sleep patterns among college students, specifically observing the influences of mood and health on sleep behavior and measuring sleep patterns using PSQI (Lund et al., 2010). Results indicated that sleep efficiency in college students may be influenced by several factors, including late night caffeine intake, an unhealthy diet, limited amount of physical exercise, or stress. Other factors consist of excessive noise at night, sharing a bed with someone or using a bed as a workspace, and consuming over-the-counter or prescription drugs to alter sleep/wakefulness, causing irregular sleep patterns (Lund et al., 2010). Although these factors influence college students' sleep efficiency, some factors have greater influence than others. Stress, excessive noise, and co-sleeping significantly affect sleep efficiency (Lund et al., 2010). As measured by PSQI, Lund et al. (2010) reported that over 60% of college students experienced sleep disturbances. PSQI scores indicated that 34% of college students experience good sleep quality and 38% experience poor sleep quality. Students' whose PSQI scores indicated poor sleep quality reported significantly more problems with physical and psychological health compared to those who had good sleep quality. Participants with poor sleep quality also reported significantly higher negative moods, such as anger, confusion, depression, fatigue, and tension. Overall, students reported that emotional and academic stress negatively impacted quality of sleep. Lund et al. (2010) concluded that college students who engaged in more structured lifestyles, better time management, limited alcohol intake, regular exercise, and an overall healthy lifestyle had satisfactory sleep quality.

Social Smoking

As a variety of studies have examined the effects of smoking and smoking cessation on sleep, the effects of social smoking on sleep have not been extensively researched (Peters et al., 2011; Phillips & Danner, 1995; Wetter & Young, 1994; Zhang et al., 2006). Social smoking

among college students is not well understood as it is not clearly or consistently defined in research (Ling & Glantz, 2004; Philpot, Ryan, Torre, Wilcox, Jalleh, & Jamrozik, 1999). Various definitions of social smoking found in literature are as follows: “those who smoke more commonly with others rather than alone” (Moran, Wechsler, & Rigotti, 2004), “those who smoke exclusively in social situations” (Waters, Harris, Hall, Nazir, & Waigandt, 2006), “those who smoke a large proportion of their cigarettes when they go out to ‘hospitality venues’” (Philpot et al., 1999), and “those who smoke only at festivities” (Herlitz & Westholm, 1996). When asking college student social smokers smoking status questions, most report responses such as, “I only smoke when I go out” or “I only smoke socially” (Ling & Glantz, 2004; Philpot et al., 1999). Due to the existing variety of classifications of social smoking, defining the term poses as a challenge, inhibiting consistency and validity in research.

Measurement of Sleep

Measurement of sleep can be collected through self-reports such as PSQI or other measures including Actigraphy (Actigraph, Pensacola, FL), and PSG (Jaehne et al., 2009; Zhang et al., 2006). With self-reports, participant’s record daily activities such as bed times, wake times, and daytime naps in order for researchers to gain a primary resource to understand participants’ sleeping behaviors (Chin, Oga, Takegami, Nakayama-Ashida, & Wakamura, 2010).

Polysomnography

PSG measures and records physiological changes that occur while sleeping such as eye movements, muscle activity, and heart rhythm. PSG is an accurate and concise method for measuring sleep stages. Because PSG testing takes place in a sleep laboratory, participants’ sleep quality may be altered due to the unfamiliar surroundings, therefore PSG is limited by poor ecological validity (Jaehne et al., 2009; Zhang et al., 2006).

Pittsburgh Sleep Quality Index

The PSQI is a self-rated questionnaire which assesses sleep quality and disturbances, regarding a one month time interval. There are 19 individual items that generate seven subscale scores including, habitual sleep efficiency, subjective sleep quality, daytime dysfunction, sleep disturbances, sleep latency, use of sleeping medications, and sleep duration. The individual subscales are scored based on a scale of zero to three; zero indicating good sleep, whereas a score closer to three represents poor sleep. The global PSQI score is a calculation of all subscale scores added together, with a score that ranges from 0-21. A score less than or equal to five is associated with good sleep quality, whereas a score that is greater than five is associated with poor sleep quality and clinically significant sleep dysfunction (Buysse, 1989).

Actigraphy

The Actigraph is a small device that is typically worn on the wrist, allowing participants to sleep in the comfort of their own homes. Utilizing Actigraphy creates a more accurate measure of sleep, rather than measuring sleep in an unfamiliar setting, such as a laboratory. Actigraphy monitors body movement and assesses sleep wake cycles over an extended period of time through accelerometers. Actigraphs measure percentage of sleep efficiency, minutes of total sleep time and latency to sleep onset, number of nighttime awakenings, and time awake during the night.

Pittsburgh Sleep Quality Index and Actigraphy

Although PSQI and Actigraphy have been utilized independently of one another to collect data regarding sleep activity, (Bryant, Bonevski, Paul, & Lecathelinais, 2011; Chin et al., 2010; Hu et al., 2007; Lund et al., 2010), the combination of both methods have not been

studied. Incorporating PSQI and Actigraphy would extensively verify sleep behavior through several different modes of measurement.

Measurement of Smoking

Self-reports

Smoking frequency and behavior can be measured through self-reports (Bryant et al., 2011; Sabanayagam & Shankar, 2011), allowing researchers to record participants' specific daily activities or events. For example, researchers may ask participants to record the number of cigarettes smoked per day, frequency of smoking, or timing of daily and weekly smoking habits. Because self-reports are a primary resource, they offer subjective information regarding the participants' behavior.

Surveys

Another method implemented for measuring smoking behavior is surveys. The BRFSS is a commonly used telephone survey that measures participants' use of tobacco (Sabanayagam & Shankar, 2011). Utilizing surveys is also an effective method for measuring smoking as researchers can attain specific information regarding participants' smoking status. However, telephone surveys also have the potential to lead to a decreased number of respondents due to people not answering the telephone or are simply too busy to take a survey.

The Global Adult Tobacco Survey [GATS] is a nationally representative household survey and a global standard used to measure adult tobacco use (2007). The survey includes multiple categories of questions that can be used to create questionnaires on a smaller scale. The GATS examines several smoking status groups including current daily smokers, current non-daily smokers, former smokers, and those giving up tobacco smoking (Almeida, Szklo, Sampaio,

Souza, Martins, & Szklo, 2012). These categories focus on detailed information about smoking behavior and frequency.

As there are several ways for measuring smoking behavior and its many effects, each method has its own advantages and disadvantages in research. Self-reports offer a subjective measure, whereas surveys provide an objective measurement of smoking behavior. A reasonable approach for measuring smoking behavior would surmount to objectively asking participants questions about specific smoking habits, such as the number of cigarettes smoked on a daily basis.

Hypotheses

Pittsburgh Sleep Quality Index

It is hypothesized that non-smokers will have better sleep than smokers and social smokers at the beginning of testing and at the end, as evidenced by global PSQI, less than or equal to five, and subscale scores closet to zero (efficiency, quality, daytime dysfunction, disturbances, latency to sleep onset, use of sleeping medications, and duration). Smokers will have higher subscales scores, closer to three and global PSQI scores greater than five. Social smokers will have the highest subscales scores, closet to three and global PSQI scores greater than five.

Actigraphy

It is hypothesized that non-smokers' will sleep better than smokers and social smokers on night one and night two as evidenced by Actigraphic measures indicating highest sleep efficiency and total sleep time, shortest latency to sleep onset, and lowest number of nighttime awakenings and time awake during the night. Smokers' Actigraphic measures will report lower sleep efficiency and total sleep time, longer latency to sleep onset, and lower number of

nighttime awakenings and time awake during the night. Social smokers' Actigraphic measures will demonstrate the lowest sleep efficiency and total sleep time, longest latency to sleep onset, and lowest number of nighttime awakenings and time awake during the night.

Methods

Participants

A total of 46 participants, female (N=37) and male (N=9), ages 18-23 voluntarily participated in the three day, two night study. Participants who self-identified as non-smokers (N=26), smokers (N=12), and social smokers (N=8) were assigned to the sample groups for this study. Due to technical error during testing, the sample size is reduced (N=45). Participants were recruited from classes at Allegheny College, Meadville, PA. Flyers (See Appendix A) were posted around the campus for recruiting purposes. The current investigation was approved by the Allegheny College Institutional Review Board in November 2012.

Materials

Sleep, Smoke, and Actigraph Removal Journal

In the provided Sleep, Smoke, and Actigraph Removal Journal, participants recorded the times of physically getting into bed at night and wake times in the morning. Participants also recorded in the journal the number of cigarettes smoked per day, number and duration of naps taken per day, and recorded each time the Actigraph was removed and replaced.

Pittsburgh Sleep Quality Index

PSQI questionnaires were distributed to participants at the beginning of the study and at the end of the study to measure sleep quality and sleep disturbances.

Actigraphy

Through measurement of Actigraphy, the GT3X Tri-Axis Actigraphy Monitor (Actigraph, Pensacola, FL) was utilized to validate the measurement of sleep efficiency, total sleep time, latency to sleep onset, nighttime awakenings, and time awake during the night.

Procedure

Upon arrival, informed consent (See Appendix B) was obtained, explaining the purpose of the study. Once the informed consent was signed, a demographics questionnaire (See Appendix C) was completed inquiring about gender, age, class standing, smoking habits, and packs of cigarettes smoked per day. Assignment to one of three groups was based on responses from the demographics questionnaire regarding smoking habits: the groups were non-smokers, smokers, and social smokers. Self-identified non-smokers were not asked to smoke cigarettes. Following group assignment, PSQI questionnaires (See Appendix D) were completed.

A GT3X Tri-Axis Actigraphy Monitor was worn on the non-dominant wrist for three consecutive weekdays and nights: Wednesday, Thursday, and Friday. Participants were directed to maintain normal activity patterns. In the provided Sleep Journal (See Appendix E), participants were mandated to report smoking and sleeping behaviors as well as Actigraphy removal and replacement times. Upon showering or swimming, the Actigraph was removed then replaced once the shower or swim was completed. In addition to recording the number of cigarettes smoked per day, it was also required that participants report times of physically climbing into bed at night and morning wake times. Sleeping in one’s own bed and sleeping alone during the testing period was instructed.

Following the three day testing period, participants returned the wrist Actigraph, completed the PSQI questionnaire for the second time, and received a debriefing form (See Appendix F).

Data Analysis

A two-way mixed repeated measures ANOVA was conducted to compare smoking status groups and global and PSQI subscale scores as well as smoking status groups and Actigraphic measures during a three day, two night testing period. LSD post-hoc tests were conducted if $p<.05$.

Results

Demographics

Participant demographic information including gender, age, class standing, smoking status groups, and packs of cigarettes and number of cigarettes smoked per day are presented in Table 1. Average sleep measures verified by PSQI and Actigraphy for all smoking status groups are also reported in Table 1.

Table 1.

Participant Demographic, Self-reported PSQI, and Actigraphic Measures

Measure	*M* ± *SD*	Range
Gender (%female)	80.4	
Age[1]	19.76 ± 1.25	18-23
Class standing[2]	2 ± 1	1-4
Smoking status groups[3]	2 ± 1	1-3
Packs smoked per day (%)[4]	85.0	
Smokers' cigarettes[5]	6.55 ± 4.40	0-15
Social Smokers' cigarettes[6]	1.05 ± 1.79	0-6
PSQI:[7]		
Global	6.11 ± 2.84	1-15
Efficiency	0.50 ± 0.73	0-3
Quality	1.10 ± 0.50	0-2
Daytime dysfunction	1.10 ± 0.59	0-3
Disturbances	1.23 ± 0.45	0-2
Latency	1.37 ± 0.95	0-3
Medications	0.51 ± 0.96	0-3
Duration	0.40 ± 0.65	0-3
Actigraphy:		
Efficiency[8]	82.3 ± 10.9	22-98
TST[9]	383.9 ± 83.5	26-541
LSO[10]	15.8 ± 27.3	0-202
Nighttime Awakenings[11]	20.7 ± 8.43	6-53
Time Awake[12]	79.0 ± 47.8	9-268

Notes. Mean ± SD; [1] Age-years; [2] Class standing-current academic year, 1-freshman, 2-sophomore, 3-junior, 4-senior; [3]Smoking status groups-smoking habits, 1-smoker, 2-non-smoker, 3-social smoker; [4] less than one pack of cigarettes; [5] Smokers cigarettes – smokers' average number of cigarettes smoked per day; [6] Social Smokers' – social smokers' average number of cigarettes smoked per day; [7] PSQI-Pittsburgh Sleep Quality Index; [8] percentage; [9] TST-Total Sleep Time in minutes; [10] LSO-Latency to Sleep Onset in minutes; [11] number of awakenings during the night; [12] in minutes throughout the night.

Pittsburgh Sleep Quality Index

The hypotheses that non-smokers would have better sleep than smokers and social smokers as evidenced by global PSQI scores less than or equal to five and PSQI subscales scores closet to zero, was not confirmed. No significant difference was found between the interaction of smoking status groups at the beginning of the study or at the end. Individual global PSQI and subscales scores at the beginning and end were combined to average one score for each subscale between smoking status groups.

As can be seen in Table 2, there was no significant difference between smoking status groups and global PSQI scores except for the sleep disturbance subscale $F(2,43)=3.97$, $p \leq .05$. An LSD post-hoc test showed a significant difference between smokers and social smokers and between non-smokers and social smokers.

Although there was no significant difference between smoking status groups and subscales scores, trends exist indicating non-smokers experience higher sleep efficiency and least amount of daytime dysfunction compared to smokers and social smokers. Other trends signify that social smokers experience lower efficiency, longer latency to sleep onset, and shorter duration of sleep compared to smokers.

Table 2.

Smoking Status Groups' Comparison of Global PSQI and PSQI Subscales Scores

	Smoking Status Groups					
	Non-smokers		Smokers		Social Smokers	
Measure	*M* ± *SD*	Range	*M* ± *SD*	Range	*M* ± *SD*	Range
PSQI:						
Global PSQI	5.93 ± 3.07	2-15	5.63 ± 2.31	1-10	7.44 ± 2.82	3-12
Efficiency	0.46 ± 0.76	0-3	0.50 ± 0.74	0-2	1.19 ± 0.41	1-2
Quality	1.06 ± 0.51	0-2	1.00 ± 0.52	0-2	0.50 ± 0.86	0-2
Daytime dysfunction	1.06 ± 0.64	0-3	1.17 ± 0.67	0-2	1.13 ± 0.23	1-2
Disturbances	1.11 ± 0.38*	0-2	1.13 ± 0.34*	1-2	1.51 ± 0.52*	1-2
Latency	1.45 ± 1.04	0-3	1.00 ± 0.73	0-2	1.89 ± 0.91	0-3
Medications	0.46 ± 0.92	0-3	0.50 ± 1.08	0-3	0.69 ± 2.10	0-3
Duration	0.38 ± 0.57	0-2	0.34 ± 0.76	0-3	0.57 ± 0.75	0-2

Notes. Mean ± SD; PSQI - Pittsburgh Sleep Quality Index, *p<.05.

Actigraphy

The hypotheses that non-smokers' Actigraphic measures would indicate highest sleep efficiency and total sleep time, shortest latency to sleep onset, and lowest number of nighttime awakenings and time awake during the night, was not confirmed. No significant difference was found between the interaction of smoking status groups at the beginning of the study or at the end. Individual Actigraphic measures at the beginning and end were combined to average one score for each measure between smoking status groups.

As can be seen in Table 3, there was no significant difference found between smoking status groups and Actigraphic measures; however, trends exist indicating non-smokers experience highest sleep efficiency and total sleep time as compared to smokers and social smokers. Other trends exist suggesting non-smokers have the shortest latency to sleep onset and least amount of time awake during the night as compared to smokers and social smokers.

Additional trends signify that social smokers experience lower efficiency, decreased total sleep time, longer latency to sleep onset, and increased nighttime awakenings and time awake.

Table 3.

Smoking Status Groups' Comparison of Actigraphic Measures

	Smoking Status Groups					
	Non-smokers		Smokers		Social Smokers	
Measure	M ± SD	Range	M ± SD	Range	M ± SD	Range
Actigraphy:						
Efficiency[1]	84.11 ± 7.91	22-98	81.40 ± 14.22	22-93	77.34 ± 8.79	55-88
TST[2]	388.37 ± 73.68	249-251	379.34 ± 105.48	26-541	375.00 ± 75.84	213-488
LSO[3]	9.94 ± 8.53	0-38	19.46 ± 40.0	0-202	31.72 ± 33.57	0-110
Nighttime[4] Awakenings	20.90 ± 9.88	5-53	18.95 ± 6.70	8-33	23.14 ± 4.65	14-30
Time Awake[5]	71.66 ± 43.33	9-179	77.91 ± 56.49	28-268	108.00 ± 39.04	53-177

Notes. Mean ± SD; [1] percentage; [2] TST - Total Sleep Time in minutes; [3] LSO – Latency to Sleep Onset in minutes; [4] number of awakenings during the night; [5] in minutes throughout the night.

Discussion

The aim of the present study was to investigate the effects of smoking on sleep quality and efficiency among college students. Because several studies have found correlations between smoking and poor sleep quality (Jaehne et al., 2009; Krueger & Friedman, 2009; Phillips & Danner, 1995; Wetter & Young, 1994; Zhang et al., 2006), it was hypothesized that non-smokers would sleep better than smokers and social smokers as verified by PSQI and Actigraphic measures. The significant finding between smoking status groups and the PSQI subscale sleep disturbance supports the hypothesis. As hypothesized, non-smokers reported the least amount of sleep disturbances, followed by smokers, then social smokers.

Despite the significant findings in research, the hypotheses were not confirmed; however, several trends exist indicating that smoking negatively impacts sleep. This demonstrates that non-smokers have better overall sleep quality and efficiency compared to smokers and social

smokers. Other trends also suggest that social smokers experience decreased sleep quality and efficiency compared to smokers.

It is probable that the current investigation did not find significant results due to several factors contributing to Type II error. Studies that have analyzed the effects of smoking on sleep with larger sample sizes found significant results, indicating that non-smokers sleep better than smokers (Hu et al., 2007; Jaehne et al., 2009; Sabanayagam & Shankar, 2011; Zhang et al., 2006); therefore small sample size warrants cautious interpretation and recognition of increased likelihood of Type II error. Provided that the current study examined a larger sample size, PSQI scores and Actigraphic measures may have resulted in significant findings, indicating the negative effects of smoking on sleep quality and efficiency. The small sample size in the current study may have contributed to the single significant finding between PSQI subscale scores and smoking status groups. With a larger sample size, it is likely that significant differences would have occurred between all PSQI subscales and smoking status groups, suggesting the relationship between non-smokers and increased sleep quality and efficiency.

Another factor that may have contributed to Type II error is age of participants. The current study examined a sample population consisting of college students between the ages of 18 and 23. It is possible that sleep may not be significantly affected within the first few years of smoking. Studies that have found results indicating increased sleep disturbances and decreased sleep efficiency and quality among smokers, examined these effects in an older population, over the age of 40 (Brook et al., 2012; Sabanayagam & Shankar, 2011; Wetter & Young, 1994).

Type II error may have also occurred due to other aspects such as participants' health. It is possible that participants had underlying health concerns that interfered with gaining an accurate measure of sleep efficiency and quality. Primary or unexpected illnesses may have

occurred during the testing period, effecting participants' normal sleeping behaviors. For example, bed and morning wake times could have potentially been altered as well as increased nighttime disturbances such as coughing, sneezing, or achiness. To reduce the likelihood of poor health influencing participants' normal sleeping behavior, exclusion criteria could have been implemented such as, eliminating any participants with present illnesses or medical conditions requiring medication (Hamidovic & de Wit, 2009).

Another contributing factor to Type II error may result in the already existing poor sleep among college students (Lund et al., 2010; Taylor & Bramoweth, 2010.) To reduce the probability of Type II error due to existing poor sleep, exclusion criteria could have been employed excluding participants with any sleep disorders such as insomnia or sleep apnea (Hamidovic & de Wit, 2009). Excluding participants with sleep disorders may result in increased accuracy of sleep behaviors.

One other possible explanation for Type II error involves improper use of the Actigraph. Although participants were instructed to wear the device at all times, it is possible that it was not replaced following removal for swimming or showering. If the Actigraph was not replaced shortly after removal, data may be skewed indicating an inaccurate increase or decrease in measures due to the stationary position of the Actigraph. Additionally, the Actigraph could have malfunctioned while testing, resulting in faulty data. The batteries could have died or periodically stopped recording altogether. To reduce technical malfunctioning, other measurement could have been utilized such as PSG. PSG allows for physical observation to ensure that everything is functioning correctly which reduces the possibility of participants' incorrect use of equipment (Zhang et al., 2006).

Limitations

The current investigation had a variety of limitations such as small sample size, uneven sample groups, and homogeneity of participants. Because the sample population consisted of participants in one geographical location and one liberal arts college, the findings are not generalizable to young adult, college students in the United States; therefore the study lacks validity. To increase generalizability, college students from a variety of geographical locations and types of schools would encompass a broader variation of the young adult, college population.

The present study had limited resources such as time and funding. Increased time and funding would have allowed for further investigation over longer periods of time and incorporation of various measures such as analyzing exhaled carbon dioxide levels and PSG. Conducting a longitudinal study with significantly more funding may have resulted in similar findings to Zhang et al. (2006) and Wetter and Young (1994), as both studies found smoking to negatively affect sleep quality and efficiency.

Other limitations include factors such as loud noises or increases and decreases in temperature amongst the sleeping environments of participants. These factors could not be controlled for, causing a decreased measure of accurate sleeping behaviors.

Despite the limitations in the present study, one recent study examined the effects of smoking on sleep in non-smokers and smokers through PSG analysis in a younger population. PSG measurements and an alternate version of the PSQI were utilized to rate sleep habits and sleep quality of participants. PSG and PSQI data indicated that smokers experience increased sleep latency and shorter sleep duration (Jaehne, Unbehaun, Feige, Lutz, Batra, & Riemann, 2012). These findings support the current hypotheses as well as previous studies and reports of

reduced sleep quality in smokers (Jaehne et al., 2009; Krueger & Friedman, 2009; Phillips & Danner, 1995; Wetter & Young, 1994; Zhang et al., 2006).

Conclusions and Future Directions

As tobacco use is the leading cause of preventable death in the United States (CDC, 2013), it is accountable for additional side effects such as depression, irritability, restlessness, sleep disturbances, and insomnia (Brook et al., 2012; Jaehne et al., 2009; National Cancer Society, 2012). While insomnia is emerging as a worldwide public health concern, numerous studies have examined the relationship between smoking and sleep, finding that smoking negatively interferes with sleep quality and efficiency (Jaehne et al., 2009; Phillips & Danner, 1995; Wetter & Young, 1994; Zhang et al., 2006).

The present study could be further investigated in a variety of ways. A larger sample size would provide an increased, accurate measure of the effects of smoking on sleep, demonstrating similar results to other studies that have conducted comparable research (Jaehne et al., 2009; Krueger & Friedman, 2009; Phillips & Danner, 1995; Wetter & Young, 1994; Zhang et al., 2006).

Similar to many studies, exclusion criteria could be implemented to increase accuracy of measurement (Hamidovic & de Wit, 2009; Jaehne et al., 2012). Specific exclusion criteria would consist of participants with any form of illnesses or sleep disorders such as insomnia or sleep apnea to reduce skewed data. Implementing exclusion criteria would allow for accurate measures of sleep without underlying reasons for decreased sleep quality and efficiency. Applying exclusion criteria also increases generalizability of the study.

To attain an accurate measure of sleep, external environmental factors such as noises and extreme temperatures should be eliminated during testing periods. A laboratory setting could monitor both noises and temperature, creating one stable testing environment for all participants.

If the above changes were implemented in the present study, the existing trends may reflect the findings in studies that demonstrate the negative effects of smoking on sleep quality and efficiency. If future studies continue to reaffirm the significance of smoking and its negative effects, it may increase public awareness, potentially establishing an increased number of individuals who choose to lead a smoke free lifestyle.

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Appendix A: Recruiting Flyer



I WANT YOU FOR THIS COMP!

RECRUITING SMOKERS
AND SOCIAL SMOKERS!

This investigation will be examining the relationship between cigarette smoking and sleep efficiency. Your participation will last for 3 days.

Testing dates: January, 22 2013 – March 5, 2013

**Interested? For more information and sign up availability, please visit the following website http://alleghenypsych.sona-systems.com/ and choose the study entitled,

"The Effects of Smoking on Sleep Quality and Efficiency".

Any questions, please e-mail **Kara Izing** at izingk@allegheny.edu**

Appendix B: Informed Consent Form

RESEARCH PARTICIPANT CONSENT FORM

Title of project: Smoking and its Effects on Sleep Quality and Efficiency

Kara R. Izing
Allegheny College
Department of Psychology

Purpose of Research:

The purpose of this research is to determine the relationship between cigarette smoking and sleep efficiency in college students.

Specific Procedures:

I understand that I must be at least 18 years old to participate in this research study and that I will receive a copy of the Informed Consent Form for my records. I understand that I will be asked to complete questionnaires about my smoking habits and sleep patterns. I understand that the tasks I will complete include wearing a wrist Actigraph for three consecutive days and two consecutive nights, Wednesday, Thursday, and Friday. An Actigraph is a small device that is typically worn on the wrist that is used to measure a persons' sleep efficiency and also total sleep time. I understand that if I self-identify as a nonsmoker, I will not be asked to smoke cigarettes. I understand that as a participant in this study, I will sleep in my own bed and I will sleep alone. I will not sleep in bed with others or sleep in a bed other than my own while participating in this study.

Risks to the Individual:

I understand that the risks of participating in this study are no more than what I would experience in everyday life.

Benefits to the Individual or Others:

I understand that the primary potential benefit of this research study will be obtained by other researchers studying cigarette smoking and sleep efficiency, and the benefit to me is minimal.

Compensation:

I understand that there is no compensation for participation in this study

Confidentiality:
I understand that the data I provide today are completely confidential and that my name will never be associated with the data I provide. I understand that the researcher is not interested in any single person's data and will combine the data I provide with all other participants' data to determine general patterns. Any reports made based on this study's data will focus only on general patterns. I understand that my data and consent form will be stored separately under lock and key in the desk of the researcher at Allegheny College. I understand that the data I provide today will not be destroyed for at least five years. It may be used for future research projects.

Voluntary Nature of Participation:
I understand that I am at NO time required to participate in this study. I understand that if I agree to participate, I may withdraw my participation at any time with no penalty. I understand that I may skip any and all parts of today's procedures that I wish and that I may skip any questions that I wish not to answer.

Contact Information:

• For any questions or concerns about this research project, please contact **Kara R. Izing** at **(814) 525-0517** or email her at **izingk@allegheny.edu**. You may also contact **Dr. Sarah Conklin** at **(814) 332-2392** or email her at **sconklin@allegheny.edu**.

• For any questions or concerns about the treatment of research participants, including yourself, please contact **Dr. Rich Bowden**, Chair of the Allegheny College Institutional Review Board (IRB), at **(814) 332-2975** or email him at **rbowden@allegheny.edu.**

Participant's Signature_____ Date_____

Researcher's Signature_____ Date_____

Appendix C: Demographics Questionnaire

Smoking and its Effects on Sleep Quality and Efficiency

Please answer the following questions.

What is your gender? Male or Female

What is your age? 18 19 20 21 22 23 Other

What is your class standing? First Year Student Sophomore Junior Senior

Do you smoke cigarettes?
Yes, I smoke No, I do not smoke Occasionally, I am a social smoker (only smoke cigarettes when socializing with friends)

If you are a smoker, how many cigarettes do you smoke per day?
Less than 1 pack/day One pack/day More than one pack/day

Appendix D: Pittsburgh Sleep Quality Index Questionnaire

Date: _____ Participant I.D # _____

PITTSBURGH SLEEP QUALITY INDEX

INSTRUCTIONS:
The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month.
Please answer all questions.

---

1. During the past month, what time have you usually gone to bed at night?

   BED TIME _____

2. During the past month, how long (in minutes) has it usually taken you to fall asleep each night?

   NUMBER OF MINUTES _____

3. During the past month, what time have you usually gotten up in the morning?

   GETTING UP TIME _____

4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.)

   HOURS OF SLEEP PER NIGHT _____

For each of the remaining questions, check the one best response. Please answer all questions.

5. During the past month, how often have you had trouble sleeping because you . . .

a) Cannot get to sleep within 30 minutes

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

b) Wake up in the middle of the night or early morning

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

c) Have to get up to use the bathroom

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

d) Cannot breathe comfortably

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

e) Cough or snore loudly

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

f) Feel too cold

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

g) Feel too hot

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

h) Had bad dreams

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

i) Have pain

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

j) Other reason(s), please describe_____
_____

How often during the past month have you had trouble sleeping because of this?

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

6. During the past month, how would you rate your sleep quality overall?

Very good _____

Fairly good _____

Fairly bad _____

Very bad _____

7. During the past month, how often have you taken medicine to help you sleep (prescribed or "over the counter")?

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

8. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

9. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?

No problem at all _____

Only a very slight problem _____

Somewhat of a problem _____

A very big problem _____

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Appendix E: Sleep, Smoke, and Actigraph Removal Journal

Allegheny College



Sleep, Smoke, and Actigraph Removal Journal

Instructions:

- In the provided journal, please indicate each time you physically get into bed at night and each time you wake up in the morning.
- Please record any night time awakenings or daytime sleep/naps.
- Please record if you slept in bed with someone or if you slept alone during the study.
- Please record if you slept in your own bed or if you slept in someone else's bed.
- Please record the number of cigarettes you smoked per day.
- Wear the Actigraph on your **NON-DOMINANT** wrist.
- Please **DO NOT** remove the Actigraph at any time, other than when showering, bathing, or swimming
- Please record each time you removed the Actigraph.
- Please record each time you replaced the Actigraph.

Reminders:

- Please **look at the clock** each time you get into bed at night and wake up in the morning.
- **IMPORTANT: IF ACTIGRAPH IS LOST, PLEASE NOTIFY ME, KARA IZING, OR DR. CONKLIN IMMEDIATELY.** The contact information is at the bottom of this page.
- Please take care of the Actigraph.
- If you misplace your Sleep, Smoke, and Actigraph Removal Journal, please contact me immediately so that I can give you another one.
- Please continue all normal activity patterns.

Contact Information

If you have any questions or concerns about the study or your participation during the experiment, please contact me, Kara Izing or my advisor, Dr. Sarah Conklin.

Kara R. Izing
E-mail: izingk@allegheny.edu
Phone: (814) 525-0517

Dr. Sarah Conklin
E-mail: sconklin@allegheny.edu
Office Phone: (814) 332-2392
Office: 9 Carnegie Hall

Day 1 – Wednesday

Time you woke up in the morning: _____ (am)

Any night time awakenings last night? _____ Number _____ Duration _____

Did you sleep in bed alone? _____

Did you sleep in your own bed? _____

Did you sleep in someone else's bed? _____

Any daytime sleep/naps? _____ Number _____ Duration _____

How many cigarettes did you smoke today? _____

What time did you remove the Actigraph? _____ (am/pm)

What time did you replace the Actigraph? _____ (am/pm)

Time in bed at night: _____ (am/pm)



Day 2 – Thursday

Time you woke up in the morning: _____ (am)

Any night time awakenings last night? _____ Number _____ Duration _____

Did you sleep in bed alone? _____

Did you sleep in your own bed? _____

Did you sleep in someone else's bed? _____

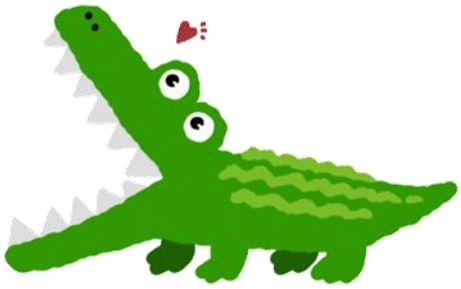
Any daytime sleep/naps? _____ Number _____ Duration _____

How many cigarettes did you smoke today? _____

What time did you remove the Actigraph? _____ (am/pm)

What time did you replace the Actigraph? _____ (am/pm)

Time in bed at night: _____ (am/pm)



A good laugh and a long sleep are the best cures in the doctor's book. – Irish Proverb

Day 3 – Friday

Time you woke up in the morning: _____ (am)

Any night time awakenings last night? _____ Number _____ Duration _____

Did you sleep in bed alone? _____

Did you sleep in your own bed? _____

Did you sleep in someone else's bed? _____

Any daytime sleep/naps? _____ Number _____ Duration _____

How many cigarettes did you smoke today? _____

What time did you remove the Actigraph? _____ (am/pm)

What time did you replace the Actigraph? _____ (am/pm)

Time in bed at night: _____ (am/pm)



Thank you for participating in my senior comprehensive project!

After the three day testing period, please return the wrist Actigraph as well as your journal to complete the final phase of the experiment.

If you begin to feel uncomfortable while participating in this experiment, you may withdraw participation at any time with no penalty. You may contact the Allegheny College **Counseling Center**, located in Reis Hall if you feel uncomfortable with your participation in the experiment. The Counseling Center may be contacted at the following phone number: **(814) 332-4368**. For any health concerns, please visit or call the **Allegheny College Health Center (Winslow Health Center)** at **(814) 332-4355**.



Appendix F: Debriefing Form

RESEARCH PARTICIPANT DEBRIEFING FORM

Smoking and its Effects on Sleep Quality and Efficiency

Kara R. Izing
Allegheny College
Department of Psychology

Thank you very much for your participation in this study!
Your participation is greatly appreciated!

Purpose of Research:

The purpose of this research is to determine the relationship between cigarette smoking and sleep efficiency in college students. It is hypothesized that those who self-identify as nonsmokers will experience the least amount of daytime sleepiness and have the shortest delay in sleep onset with minimal sleep disturbances. Therefore, individuals who smoke will experience a greater delay in sleep onset and daytime sleepiness compared to the nonsmokers. It is also hypothesized that self-identified social smokers will experience increased sleep disturbances and daytime sleepiness with the greatest delay in sleep onset compared to both smokers and nonsmokers.

Deception:

Deception was not used in this study.

Compensation:

Compensation was not included in this study.

Confidentiality:

The data provided by all participants are completely confidential and participants' names will never be associated with the data they provide. The data and consent forms are stored in a separate drawer under lock and key in my desk. The data will not be destroyed for at least five years once the comprehensive project is complete.

Additional Sources of Information:

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Wetter, D., & Young, T. (1994). The relation between cigarette-smoking and sleep disturbance. Preventive Medicine, 23(3), 328-334.

Zhang, L., Samet, J., Caffo, B., & Punjabi, N. M. (2006). Cigarette smoking and nocturnal sleep architecture. American Journal of Epidemiology, 164(6), 529-537.

Contact Information:
Please feel free to contact any of the following people.

• For any questions or concerns about this research project, please contact **Kara R. Izing** at **(814) 525-0517** or email her at **izingk@allegheny.edu**. You may also contact **Dr. Sarah Conklin** at **(814) 332-2392** or email her at **sconklin@allegheny.edu**.

• For any questions or concerns about the treatment of research participants, including yourself, please contact **Dr. Rich Bowden**, Chair of the Allegheny College Institutional Review Board (IRB), at **(814) 332-2975** or email him at **rbowden@allegheny.edu**.

• For any psychological concerns, please visit or call the **Allegheny College Counseling Center** at **(814) 332-4368**.

• For any health concerns, please visit or call the **Allegheny College Health Center (Winslow Health Center)** at **(814) 332-4355** or visit your personal physician.

THANK YOU AGAIN FOR YOUR PARTICIPATION