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QUANTITATIVE WORKLOAD, PHYSICAL ACTIVITY, AND QUALITY OF SLEEP: AN INVESTIGATION OF NURSES WORKING THE NIGHT SHIFT AND 10 HOUR OR LONGER SHIFTS

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QUANTITATIVE WORKLOAD, PHYSICAL ACTIVITY, AND QUALITY OF SLEEP: AN INVESTIGATION OF NURSES WORKING THE NIGHT SHIFT AND 10 HOUR OR LONGER SHIFTS

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ABSTRACT

Approximately 30% to 40% of adults suffer from some form of insomnia in any given year. Insomnia-related productivity losses for organizations are estimated at $5 billion dollars annually. Long work weeks, shift work, and high workload have been linked to poor sleep quality. Currently, there is a gap in research on how physical activity affects quality of sleep among nurses who work long hours and nurses who work the night shift. Therefore two samples of nurses were examined; nurses who work 10 hour or longer shifts (N = 222) and nurses who work the night shift (N = 97). This study investigated the following; Hypotheses 1a and 1b predicted that quantitative workload would be negatively associated with nurses' quality of sleep. Hypotheses 2a and 2b predicted that quantitative workload would be negatively associated with physical activity behaviors. Hypotheses 3a and 3b predicted that physical activity would be positively associated with nurses' quality of sleep. Hypotheses 4a and 4b predicted that physical activity would mediate the relationship between quantitative workload and quality of sleep. Hypotheses 5a and 5b predicted that physical activity would moderate the relationship between quantitative workload and quality of sleep. Finally, Hypotheses 6a and 6b predicted that neuroticism would moderate the relationship between physical activity and quality of sleep. The results confirmed Hypotheses 1a, 1b, and 3a, but failed to support Hypotheses 2a, 2b, 3b, and Hypotheses 4ab-6ab. Theoretical and organizational implications are discussed.

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CHAPTER ONE

INTRODUCTION

Quality sleep is increasingly difficult to attain in today's fast paced society. Approximately 30% to 40% of adults suffer from some form of insomnia in any given year (The College of Family Physicians of Canada, 2008). Americans spend a significant amount of time at work, averaging 1,778 hours of work per year, ranking 9th among the average of 32 nations who are part of the Organization for Economic Co-operation and Development (OECD). In comparison, Koreans top the charts with the highest average work hours per year, at 2,193 hours and the Dutch work the least hours, averaging 1,391 hours annually (OECD, 2010). Considering that Americans work so many hours it comes as no surprise that 37% of the American workforce has been classified as at risk for sleep disorders (Swanson et al., 2010). People who suffer from sleep disturbances may have trouble falling asleep, may wake up several times throughout the night and suffer from fatigue throughout the day.

Poor sleep quality can be a result of circadian rhythm disorders, insomnia, sleep apnea, narcolepsy, restless leg syndrome, sleep walking, sleep terrors, or stress (The National Sleep Foundation, 2009). Sleep disturbances are also associated with reduced quality of life, lack of physical activity and exercise, working long hours, shift work, and occupational stress. (Drake, Roehrs, & Roth, 2003; Peppard & Young, 2004; Sekine, Chandola, Martikainen, Marmot, & Kagamimori, 2006; Utsugi et al., 2005; Virtanen et al., 2009; Waage et al., 2009).

Virtanen et al. (2009) suggest that the link between long working hours and sleep disturbances may be due to a lack of recovery after work, which could take the form of activities during leisure time. Sonnentag (2001) explains that leisure activities can play a factor in a person's psychological recovery after work. This could include recreational activities that involve physical activity, or simply doing physically demanding household chores. It is believed that physical activities provide a temporary relief from job related demands, and allow the body's functional systems to recover (Sonnentag, 2001). Additionally, Yeung (1996) explains that physical activity provides a cognitive distraction from job related activities. Importantly, physical activity may buffer the negative effects that stress has on employee sleep quality.

Insomnia and sleep disturbances have potentially significant financial implications for organizations. Daley et al. (2009) report that insomnia-related losses for organizations are estimated at $5 billion dollars annually for reduced productivity and $970 million annually for absenteeism. In addition, Daley et al. (2009) estimate that healthcare expenses associated with insomnia total over $6 billion dollars per year. According to the National Sleep Foundation (2009), employees' poor sleep quality costs U.S. organizations approximately $18 billion dollars annually in lost productivity. Further, The National Highway Traffic Safety Administration (2009) estimate vehicle crashes due to driver fatigue cost Americans in excess of $12 billion dollars annually in reduced productivity and property damage. It is clear that sleep disturbances have large financial implications. However, an examination of the antecedents to sleep disturbances is needed in order to understand how to reduce factors that contribute to poor sleep quality.

Although sleep disturbances are widespread across many occupations, insomnia and fatigue are particularly problematic in the healthcare industry. Chan (2008) found that 70% of nurses reported poor quality and high strain as a result of their job. Nurse fatigue has been estimated to cost hospitals approximately $8.5 billion as a result of reduced performance and safety (Congress on Nursing Practices and Economy, 2006). According to the U.S. Bureau of Labor Statistics (2005) the rate of non-fatal illnesses requiring days away from work among healthcare workers was 72.9 cases per 10,000 full-time employees in comparison to 27.9 private industry (non-healthcare) cases, which can be partly attributed to fatigue resulting from sleep disturbances.

Beyond the financial cost of fatigue in the healthcare industry, there are safety concerns. Sleep disturbances among nurses are a major cause of accidents that injure the patient. Fatigued nurses have been shown to commit more medication errors and incorrectly operate medical equipment (Berger & Hobbs, 2005). Further, Lockley et al. (2007) found that on-call residents who work the night shift are 300% more likely to make fatigued-related medical errors that lead to a patient's death.

Fatigued nurses also put their own safety at risk. Lockley et al. (2007) report that physicians who are on call 24-hours a day are at an increased risk of experiencing an occupational injury. Further, accidents outside of the work environment such as falling asleep while driving to and from work are a problem commonly ignored by employers

(Mckenzie-Green & Shofer, 2007; Suzuki, Ohida, Kaneita, Yokoyama, & Uchiyama, 2005).

It is apparent that fatigue has both financial and safety implications for organizations and the healthcare industry. Fatigue and lack of quality sleep can occur when employees are over-worked and must work unreasonably long hours (Congress on Nursing Practices and Economics, 2006). In addition, these indicators of poor health have become an accepted norm within many organizations. It is important to recognize the pervasiveness and severity of poor sleep quality and fatigue among employees.

The purpose of this study is twofold. The first goal of this study is to address the antecedents of poor sleep quality among nurses. Specifically, this study will examine how workload and work-schedule demands affect sleep quality. The second goal of this study is to determine whether physical activity can ameliorate the harmful effects of high workload on nurses' health. It is important for organizations to understand how employee well-being can be influenced by health behaviors both within and outside the workplace in order to recognize how health can be promoted.

Currently, there is a gap in the literature with regards to promoting positive health behaviors among nurses, including physical activity promotion and exercise. In addition, there is a need to examine whether physical activity can improve sleep quality among sleep deprived nurses. Studies have examined the effects of exercise; however less attention has been given to lower intensity physical activity. Further, studies that examine the effects of physical activity or exercise on sleep predominantly focus on populations that suffer from diagnosed sleep disorders such as sleep apnea (Sherrill et al., 2008).

Although nurses may be at risk for sleep disorders, they may not be diagnosed with a sleep disorder. The current study will bridge the gap in the literature in two important ways. First, the effects of physical activity on nurses' sleep will be examined instead of focusing on exercise. In addition, the study will focus on nurses instead of focusing entirely on a sample that is diagnosed with sleep disorders.

Biology of Sleep Processes

Before the antecedents and influences on quality of sleep are discussed, the biological processes which regulate sleep patterns must be understood. An examination of the human body's sleep processes is essential in understanding how sleep affects the body, and how the environment and individual factors can affect sleep.

Tamakoshi and Ohno (2004) have shown that people who sleep between five and seven hours per night have the lowest mortality rates, while those who sleep more than eight hours a day have significantly higher mortality rates. In general, those who reduce their sleep also tend to sleep more efficiently, wake up less, and experience an increase in Stage 4 sleep waves, which is when a person is in deep sleep. However, an individual will not adapt to a reduction in sleep duration if a person is sleeping significantly less than the generally prescribed recommendation of 7-9 hours of sleep per night.

Tsui and Wing (2009) have also suggested that sleep deprivation will occur if sleep quality and duration are not sufficient. Fatigue generally occurs when a person is not able to get enough Stage 4 sleep. Stage 4 sleep is thought to be the part of the sleep cycle that is the most important for recovery, and is shorter in duration than the other stages of sleep. If even a small portion of Stage 4 sleep is disrupted it can result in fatigue and poor sleep quality.

The stages of sleep are heavily dictated by a person's biological clock and circadian rhythms. The biological clock consists of a group of cells in the brain, called the suprachiasmatic nucleus (SCN), located in the hypothalamus of the brain. The SCN consists of approximately 20,000 nerve cells, which send signals to the body to coordinate biological rhythms (National Institute of General Medical Sciences, 2012). The biological clock controls the cycle of biological rhythms, including circadian rhythms.

Circadian rhythms are the 24 hour cycle in humans and other animals that are displayed through physiological processes. Circadian rhythms persist for approximately 24 hours without any external time cues. However, these biological rhythms change around external cues such as exposure to light. For example, the cycle between sunrise and sunset has a strong influence on a person's body temperature. Body temperature will tend to be lowest during the night, and reach a peak temperature during the middle of the day. Exposure to light during the night can cause an increase in body temperature, disrupting the body's natural biological rhythms (Klei et al., 2005). Also, the circadian rhythms regulate the sleep/wake cycle, which is based on the time when people wake up until the time they fall asleep (National Institute of General Medical Sciences, 2012).

Researchers have used isolation studies to examine the cycle of participants' circadian rhythms (Monk & Moline, 1989). In these studies, participants live in a controlled environment, free of any external cues to the time of day. These cues include access to windows with a view of the outside environment, meal times, or planned activities relating to the time of day (Kraft, Inoue, Mizuno, Ohshima, Murai, & Sekiguchi, 2002). Participants are free to eat whenever they choose, and they watch pre-recorded television or listen to old radio clips for entertainment. The ability to go to sleep whenever you want, sleep as long as you desire and eat whenever you choose to is referred to as “free running time” (Klei et al., 2005). Free running time occurs when there are no external cues to influence behavior or biological rhythms. Participants may live in these experimental environments for several weeks. These studies have helped researchers understand that biological rhythms run on their own cycle in the absence of external cues, and that factors such as varying shift schedules can alter these cycles.

It is important to note that the settings that shift workers often work in do not provide external environmental cues to the time of day. For example, a nurse may not have access to windows (external environmental cue), which can affect an individual’s biological rhythms. In this case, the nurse’s circadian rhythms may be disrupted because the body does not have any external cues to help keep it in sync. Importantly, disrupted biological rhythms result in fatigue and make it more difficult to adapt to a particular work schedule (National Institute of General Medicine, 2012).

Biological rhythms generally run on a 24-hour to 25-hour cycle. However, there are large differences between people in their actual length. One study found that these biological rhythms can be as short as 16 hours or as long as 50 hours (Kerkhof, 1985). However, these large variations are generally not found because people are not confined to one room, with no external environmental cues for periods of 16-50 hours.

Environmental cues help maintain a 24-hour cycle, but people who may have a naturally short or long cycle will react differently to the 24-hour cycle (Munch et al., 2011). For example, a person with a naturally short biological rhythm will achieve their peak alertness earlier in the day compared to a person with a long cycle.

Physiological Processes of Stress

Stress is another factor which can interact with biological rhythms. Stress affects well-being and sleep processes, and is a complicated process involving several physiological changes in the human body. Before the effects of stress on sleep are examined, an overview of how stress functions at the physiological level is important for a complete picture of the stress process.

Importantly, the effects of stress on the human body are cause for concern. O`Leary (1992) explains that acute stress results when an immediate situation or event is perceived as a stressor. Acute stress causes the activation of the autonomic nervous system (ANS). The ANS consists of two branches; the sympathetic nervous system and the parasympathetic nervous system. The sympathetic nervous system is responsible for physiological processes which increase arousal and attention, including increased heart rate, dilated pupils, respiration, and the release of adrenalin. These physiological changes were adaptive in the past when humans had to survive in the wilderness. These processes helped humans survive by preparing the body to "fight or flee" a potential threat or predator. The parasympathetic system is designed to bring back homeostasis to the ANS, by returning physiological processes back to a normal rate, which includes the following;

decreased heart rate, slower rates of respiration, and reduced levels of adrenalin (O`Leary, 1992).

Long-term stress results when the amount or frequencies of experienced stressors are too great for the parasympathetic system to stabilize. Long-term stress can cause excessive secretion of epinephrine, norepinephrine, and can suppress the immune system (O`Leary, 1992). Stress activates the sympathetic nervous system and the HPA activation-adrenomedullary system. Cortisol levels also take longer to return to normal among stressed individuals (O`Leary, 1992). Long-term stress can lead to reduced well-being, insomnia, nightmares, and disturbing dreams (The American Institute of Stress, 2011).

Effects of Stress on Sleep

Stress is a major underlying factor of poor sleep quality among the workforce. Doi, Minowa, and Tango (2003) found that the most strongly associated antecedent of poor sleep quality was perceived stress, followed by job dissatisfaction. In addition, Vgontzas and Bixler (2008) found that obese individuals who report poor sleep quality also report high levels of psychological distress and dissatisfaction with their lives. The link between obesity, distress, and sleep suggests that being obese may increase psychological stress, which therefore has a negative impact on sleep, or obesity could affect a person’s ability to cope with a stressor. In addition, obesity is related to increased levels of the stress hormone cortisol, which can also affect sleep (Beccuti & Pannain, 2011).

Additional stressors may also interact with an individual's sleep efficiency when a person is under stress. Bonnet and Arand (2003) found that individuals reacted differently to situational stress. Participants who were classified as efficient sleepers maintained good sleep quality under stress. In contrast, inefficient sleepers suffered from poor sleep quality under varying levels of situational stress. Further, Bixlor et al. (2009) found that women sleep better than men when under stress and younger women are more resilient to externally induced sleep disturbances such as noise. However, it is not clear whether women experience less perceived stress or whether women cope better with perceived stress compared to men.

Shift Work

Shift work has long been thought to have an adverse impact on employees' health and quality of sleep. According to the U.S. Bureau of Labor Statistics (2004) approximately 15% of Americans have been scheduled for shift work other than a day time schedule, and a survey conducted in 2000 found that 22% of the European workforce have been scheduled for shift work (Boisard, Cartron, Gollac, & Valeyre, 2003).

Before the effects of shift work on quality of sleep are discussed it is necessary to define shift work. Shift work encompasses several variations of work schedules. This work schedule system involves one group of employees replacing another group of employees during the workday so that the operating hours of the organization exceed the work hours of any individual worker**.** Shift work generally refers to the time of day that employees start their shifts (day, evening, night), the rotation between these shifts, length of the shift and whether these shifts are permanent or temporary (Coffey, Skipper, & Jung, 1988).

Rotating shifts come in many forms, and there are several different labels and names used. There is the traditional rotating shift which involves two groups of employees who alternate shifts every week (Gold et al., 1992). There are also slow rotation shifts which are similar to the traditional rotating shift, except rotation between shifts occurs every month or year as opposed to a weekly rotation (Monk, 1986). There are also oscillating shift schedules which involve three groups of employees. Two groups will rotate shifts and the third group will remain fixed (Colligan, Frockt, & Tasto, 1979). In addition, there are partial rotation schedules which require a portion of a group of employees to rotate, while the rest of the group remains on a fixed schedule (Rosa & Colligan, 1997). Finally, there are clockwise direction rotating shifts (forward rotation) and counter-clockwise rotation, also called backward rotation (Cruz, Detwiler, Nesthus, & Boquet, 2003). Shift work consists of many different schedules and rotations, each of which can affect human sleep processes (Institute of General Medical Science, 2012).

Shift Work and Circadian Rhythms

In the industrialized world people are generally faced with two main types of disruptions to circadian rhythms; jet lag and shift work. Jet lag occurs when circadian rhythms are accelerated during east-bound flights or decelerated during west-bound flights (National Institute for General Medical Science, 2012). For example, it usually takes 10 days to completely adjust to a flight from Tokyo to New York, which is a phase advance of 10.5 hours. There is also evidence that indicates jet lag can have negative health effects. For example, jet lag can affect normal, daily fluctuations in heart rate, blood pressure, and elevated levels of cortisol (Lemmer et al., 2002). However, the effects of jetlag subside after approximately ten days.

In shift work, the circadian rhythms are neither accelerated or decelerated. In this situation, workers are forced to adjust their natural sleep-wake cycles in order to meet the demands of changing work schedules. Both of these disruptions can cause sleep disturbances, fatigue, general malaise, and deficits on physical and cognitive functioning (Choy & Salbu, 2011). The negative side effects of shift work can last for several days.

Given the large variations in circadian rhythms among people, employees will likely differ in their reaction to a night shift schedule. People with longer biological rhythms may adapt to a night shift with more ease, and people with shorter biological rhythms may adapt better to a morning or afternoon shift. (Sack et al., 2007). It is possible that a person may never fully adapt to shift work because external and environmental cues are constantly changing. (Costa, 2003). For example, a person who works the night shift will be driving home to end their day while the sun is rising. The external cue of the sunlight signals that it is time to wake up when a night shift worker is preparing to go to bed. The sunlight disrupts the shift worker's circadian rhythms, and not only makes it difficult to fall asleep, but also makes it difficult to adapt to the night shift schedule. This same employee may be scheduled to work a day shift the next week, and the person's body will have to reinterpret external cues. These changing biological rhythms prepare employees for sleep when they are supposed to start work. The changes in circadian rhythms also prepare employees to be alert when they would naturally sleep, while on a night shift (Institute of General Medical Science, 2012). The difference between external cues and the body's natural biological rhythms cause a mismatch between a person's circadian rhythms and their work schedule. The result of the mismatch between circadian rhythms and a work schedule can lead to disrupted sleep and fatigue.

Shift Work and Quality of Sleep

Shift work has been shown to disrupt circadian rhythms, making it difficult to get a good night sleep. Garbarino et al. (2002) examined sleep disturbances in a sample of 1,280 police officers in Italy. Twenty-six percent of shift workers suffered from insomnia compared to 16% of non shift workers. Additionally, 5% of shift workers suffered from chronic insomnia compared to 2% of the non shift workers. Chronic insomnia is a severe problem, which is characterized by insomnia lasting longer than 3 weeks. Akerstedt (1998) explains that shift workers are at an increased risk of developing chronic insomnia. In addition, Ohayon, Lemoine, Arnaud-Briant, and Dreyfus (2002) found that night shift workers suffer from a higher prevalence of circadian rhythm sleep disorders compared to daytime employees. The negative effects of shift work also appear to carry over to off days, further disrupting the sleep cycle.

It is clear that shift work disrupts circadian rhythms; however the timing of the shift also dictates when an employee is working during a particular phase in the circadian rhythm cycle. For example, Akerstedt (1990) explains that employees who work rotating shifts often work the night shift during the low phase of their circadian rhythm, when they are least alert. These employees often have no problem falling asleep after their shift, however they are prematurely awakened by their circadian rhythms before their shift, resulting in extreme fatigue.

Shift work, especially working the night shift has documented negative psychological and health outcomes; however rotating shifts may further exacerbate these problems. For example, Esquirol et al. (2009) found that, compared to daytime workers, rotating shift workers were at increased risk of metabolic syndrome and demonstrated higher levels of job strain. Employees who work rotating shifts have also been found to have an increased risk of stroke and heart disease compared to employees who work shifts without rotating schedules (Brown et al., 2009). Further, Pilcher, Lambert, and Huffcutt (2000) conducted a meta-analysis of 36 studies, examining the different effects of working a permanent day shift compared to a rotating shift schedule. The results indicated that rotating shifts had a negative impact on sleep length, compared to rapidly rotating shifts; however slow rotating shifts were less detrimental to sleep duration compared to rapidly rotating shifts. Employees who work rapidly rotating shifts have also displayed disruptions with neurotransmitters associated with circadian rhythms. Another important study by Sookoian et al. (2007) reported that serotonin was significantly lower in the rotating shift employees compared to employees on a fixed daytime schedule. Rotating shifts clockwise has also been shown to have a less detrimental effect on sleep duration compared to rotating shifts counter-clockwise (Cruz et al., 2003). It is apparent that rotating shifts have a negative impact on nurses' health and quality of sleep, however certain recommendations for employers are necessary if rotating shifts must be scheduled. If shifts must be rotated, the shifts should be rotated slowly (weekly), in a clockwise direction in order to have the least detrimental effect on sleep quality (Cruz et al. 2003; Pilcher et al., 2000).

Working a night shift can cause excessive fatigue and insomnia associated with the night shift schedule (Waage et al., 2009). Permanent night shifts have also been associated with reduced sleep duration. Night shift schedules disrupt the sleep/wake cycle, which can trigger various psychiatric disorders in people (Meyrer et al., 2009). For example, a troubling study found that working the night shift can trigger psychiatric problems such as bipolar disorder (Meyrer, Demling, Kornhuber, & Nowak, 2009). The synergising effect of negative health outcomes from a night shift schedule can make it difficult for a person to attain a healthy sleep schedule. Working a night shift has also been shown to increase stress and raise blood pressure (Wu, Chi, Chen, Wang & Jin, 2009). In addition, Chen, Lin and Hsiao (2010) concluded that employees working a 12 hour night shift are at an increased risk for high blood pressure and obesity.

Shift Work and Healthcare Workers

Although employees in many occupations may deal with shift work, the investigation of healthcare workers and shift work is quite intriguing. Healthcare workers work to improve the health of others, which may come at the expense of their own well-being. Shift work is the norm in the healthcare industry because healthcare workers must take care of sick and injured patients 24 hours a day. Chan (2008) found that 70% of nurses reported poor quality of sleep and high strain. Substantial evidence suggests that nurses who work permanent shifts are more alert, and feel less sleepy. Nurses who work the same schedule everyday have been shown to commit fewer errors on the job, and nurses who are "rotators" have a tendency to suffer from increased fatigue and are twice as likely to commit medical errors (Gold et al., 1992). Medical errors can be partly attributed to the fatigue and reduced quality of sleep that affects nurses because their bodies do not have sufficient time to adapt to a new work schedule.

In addition, night shifts have also proved problematic for healthcare workers' energy levels and performance. Patient safety is significantly reduced during the last half of a night shift, when the nurses have the most difficulty staying awake. Coffey et al. (1988) found that job performance was highest for nurses on a day shift, followed by the night, afternoon, and rotating shift. In the Coffey et al. (1988) study, performance was defined as properly caring for patients without any errors which could place the patient at risk for injury or illness. Night shift workers are also more likely to incorrectly operate medical equipment, largely due to fatigue (Suzuki et al., 2005). The improper operation of medical equipment poses risks of injury to the nurse operating it, in addition to the patient.

Sleep quality is important, but nurses and physicians still need to have enough time to actually sleep in the first place. Willhelm, Widmann, Durst, Heine, and Otto (2009) found that the mean sleep duration of physicians on night shift duty was 4 hours. Considerable fatigue and sleepiness was found in physicians after night shift duty. A qualitative study by Nasrabadi, Seif, Latifi, Rasoolzadeh, and Emami (2009) also found that nurses who work night shifts suffer from extreme fatigue and poor sleep quality. One nurse described how she felt while on a night shift schedule: "My sleep is not enough, even during the days, so I always have a sense of fatigue and listlessness."

Shift Length and Hours Worked

Long work hours can also have a negative impact on employee health, and appear to be a pervasive problems. U.S workers averaged 1,778 hours of work per year in 2010, ranking ninth among the most hours worked annually by a country. Further, the U.S. worked more hours than the average of all OECD countries, which was 1,749 hours annually. Korea works the most hours, working 2,193 hours annually, and the Netherlands work the least, at 1,377 hours annually. Although there has been a slight decrease in annual working hours for the U.S. population in the past several years, the U.S. still works more hours than most countries (OECD, 2012). It is important to understand the risks and consequences of working excessive hours.

A review by NIOSH (2004) examined 52 published reports that examined the association between long work hours and health outcomes such as illnesses, injuries, and health behaviors (Caruso, Hitchcock, Dick, Russo, & Schmit, 2004). Sixteen studies from this review found that overtime was associated with poorer perceived general health, increased injury rates, increased illness, and increased mortality rates. Reduced performance, and increases in health complaints and occupational injuries were also associated with long work hours; specifically 12 hour shifts combined with more than 40 hours of work per week. The NIOSH (2004) review also found that 12 hour shifts were associated with increased physical fatigue, smoking, and alcohol use.

In addition to the NIOSH review, several studies conducted since then have found an association between long work hours and health outcomes. Specifically, working in excess of 55 hours per week is related to sleep disturbances such as short sleep duration, difficulty falling asleep, and waking up feeling tired (Virtanen et al., 2009). Basner et al. (2007) also found that people who work more than 50 hours per week were at a greater risk to be short sleepers (<6.5 hrs) and less likely to be long sleepers (>8.5 hrs), compared to people who work less than 35 hours per week. Interestingly, each additional hour of work has been equated to a 7-10 minute loss in sleep per night. Sekine et al. (2006) reported that long work hours and shift work were independently associated with poor quality of sleep among civil servants. The results from the Sekine et al. (2006) study suggest that shift work can disrupt employees' sleep quality, even if employees do not work long hours. The cumulative effects of shift work and long shifts would likely have an even greater negative impact on sleep quality.

Long work hours are common among many occupations, but are specifically a major problem within the healthcare industry. Findings from the National Sample Survey of Registered Nurses (2000) report that the average full-time and part-time nurse works 1,996 hours and 1,102 hours per year, respectively (Bureau of Health Professionals, 2000). Full-time nurses average 42.4 hours of work per week, in comparison to the average scheduled hours per week of 39.5. The difference between worked hours (24.7 h) and scheduled hours (23.1 h) per week was less for part-time nurses.

Nurses are often subjected to long shifts or choose to work long shifts, which can have a negative impact on nurses' health and performance. Of primary concern is the quality of care that patients receive from nurses. If a nurse is getting poor quality sleep, patient care will likely suffer. Studies generally investigate the relationship between nurses' work schedule and how the quality of care patients receives. For example, Berger and Hobbs (2005) found that working an excessively long shift or being awake for long periods of time (17 hours) can result in the patient`s safety being significantly threatened. Working these long shifts affects nurses' sleep patterns, thereby making them feel fatigued. Patient safety is significantly reduced during the last half of a night shift, when the nurses have the most difficulty staying awake. In addition, medication errors were three times more likely when working a shift longer than 12.5 hours (Berger & Hobbs, 2005).

McKenzie-Green and Shofer (2007) found that nurses who get less than 7 hours of sleep before working a 12 hour shift are at a particularly high risk for making job errors. Long shifts seem to increase nurse fatigue, which in turn increases the risk of job errors when working a long shift. Job errors have serious consequences in the healthcare industry. Dealing with sick patients and infectious diseases increases the potential consequences that an accident on the job can have. For example, Mckenzie-Green and Shofer (2007) found that increases in accidental blood exposure among nurses significantly increased during shifts lasting longer than eight hours, and further increased when shifts last twelve hours.

Work Demands and Health

Shift work is not the only factor that can affect employee health and sleep quality. Work characteristics and demands not related to shift schedule can also affect health. Quantitative workload has been linked to occupational stress (Glaser, Tatum, Nebeker, Sorenson, & Aiello, 1999). There is a distinction between quantitative workload and general workload. General workload refers to the general volume of work an employee must complete, which can include number of hours worked, work demands, and level of production (Spector & Jex, 1998). In contrast, quantitative workload refers to the amount of work required for a given job task. Glaser et al. (1999) explain that individuals who are attempting to achieve goals when dealing with high volumes of work will be faced with high quantitative workload. Spector and Jex (1998) also define quantitative workload as the perceived amount of work an employee is faced with and the perceived work pace. Further, qualitative workload is the complexity of the work task. (Shaw & Weekley, 1985). Before quantitative workload is fully examined it is important to understand how general workload can affect stress and well-being.

Occupational stress has been linked to workload and poor quality sleep. Work characteristics such as having too many tasks to complete while at work or having to deal with too many clients or customers on the job can affect an employees' quality of sleep. Utsugi et al. (2005) studied the relationship between occupational stress and insomnia and short sleep duration in a sample of 8,770 Japanese employees. The study revealed that high occupational stress predicted insomnia in both men and women, and short sleep duration in men.

Gander, Van den Berg, and Signal (2008) also found an association between high workload among shift workers and acute sleep loss and fatigue. Employees had to sleep in between rotating shifts for several weeks. In this study, long work hours and workload had a negative impact on sleep quality. Variance in employees' workload has also been linked to sleep-related breathing disturbances (Jacquinet-Salord et al., 1993). It is clear that high workload and job strain resulting from a high workload have a negative impact on employees' sleep processes. In addition, shift work, working longer than 48 hours per week and being hurried to complete job tasks have been linked to sleep disorders in employees (Ribet & Derriennic, 1999). Nakata et al. (2007) suggest that exposure to high levels of job stress could be a risk factor for developing or aggravating sleep-related breathing disturbances. These work schedule and workload stressors appear to be a major contributor to occupational stress. Further, Arora et al. (2008) examined medical interns' workload, and its relation to on-call sleep. Increased on-call workload such as a high number of admitted patients was associated with sleep loss and reduced sleep duration. This study also found that high levels of short term sleep loss and waking up feeling un-refreshed was linked to high workload.

A review of workload would not be complete without examining how quantitative workload affects stress and health. Park, Beehr, Han, and Grebner (2012) found that there was a significant relationship between quantitative workload and psychological strain in the workplace. Further, quantitative workload has been found to predict physical symptoms related to job strain (Nemattavosi, 2010). In addition, Takashi, Michiko, and Takashi (2011) found that high quantitative workload was related to increased occupational stress and burnout among a sample of Japanese nurses. Interestingly, less attention has been given to the effects of quantitative workload on quality of sleep. A study by Nakata et al. (2007) reported that quantitative workload is related to an increased prevalence of sleep related breathing problems, and Takahashi et al. (2006) found that quantitative workload predicts daytime sleepiness in daytime and shift workers. Although workload has been linked to sleep disturbances (Gander, 2008), the specific term quantitative workload has received less attention. Further, the effects of quantitative workload on nurses' quality of sleep have received even less attention.

The Current Study

The present study examined the effects of high quantitative workload on quality of sleep among two samples; nurses who work 10 hour or longer shifts and nurses who work the night shift. For the current study, the definition of quantitative workload posited by Spector and Jex (1998) was used; the perceived amount of work that nurses are faced with and perceived work pace. In the current study, quantitative workload consists of nurses' perceptions of work quantity and work pace. Examples include perceptions of working too many hours per shift or too many shifts per week. In addition, work demand perceptions such as not having enough time to complete tasks and properly care for patients will be examined.

The problem in the literature is that work-schedule characteristics and quantitative workload are examined separately without consideration for the additive effects of work-schedule characteristics and quantitative workload on quality of sleep. Further, there is scarce literature specifically looking at the effects of quantitative workload on the sleep quality of nurses who work long shifts or the night shift. The NIOSH (2004) review also notes that although there is abundant research on long work hours, there is a need for research to investigate the health outcomes of workers. Further, the NIOSH (2004) review points out that few studies have investigated the influence of shift work and long work hours in the same study. The current study bridges the gap between the investigation of work schedule demands and time constraints/task. Further, this study is unique in that it specifically examines two separate groups of nurses; nurses who work 10 plus hour shifts and nurses who work the night shift. Nurses who work 10 plus hour shifts will likely have different sleep outcomes in comparison to nurses who work shorter shifts. Nurses who work shorter shifts will also have more recovery time to enhance sleep. Further, nurses who work the night shift are faced with unique stressors, such as circadian disruptions, which impact quality of sleep. This leads into the first hypotheses of the present study.

Hypothesis 1a: High quantitative workload will be negatively associated with the quality of sleep among nurses who work 10 hour or longer shifts.

Hypothesis 1b: High quantitative workload will be negatively associated with the quality of sleep among nurses who work the night shift.

The research that has been reviewed thus far has discussed the negative effects that high quantitative workload has on quality of sleep. Therefore, it is important to consider factors which can reduce the harmful effects that a high quantitative workload can have on quality of sleep in order to increase employee health. Personal factors such as physical activity and exercise may play a role in how people deal with stress, and could possibly ameliorate the harmful effects that a high workload has on quality of sleep (Atlantis et al., 2006). Before the effects of physical activity on sleep quality are examined it can be helpful to gain an understanding of what physical activity is and the frequency with which the American workforce engages in this positive health behavior.

Exercise and Physical Activity

According to a recent survey 52% of Canadian adults are inactive and 36% of Americans engage in no leisure time physical activity (Canadian Fitness and Lifestyle Research Institute, 2008; Centers for Disease Control and Prevention, 2008). Exercise is defined as bodily exertion for the sake of developing and maintaining physical fitness (Merriam-Webster Online, 2010). Exercise is also a structured activity, which involves setting aside time for a specific workout program. Exercise can include aerobic training which increase a person's resting heart rate, or resistance training, which focuses on improving muscular strength and flexibility. Physical activity is more broadly defined, and includes activities that require some form of physical movement or exertion, which could range from walking to gardening. A key differentiation between exercise and physical activity is that physical activity is unstructured, as it is not specifically aimed at improving health, although it generally does improve health (Casperson, Powell, & Christenson, 1985). In addition, physical activity results in the body burning an increased amount of calories compared to the body's normal resting rate. Exercise and physical activity have incorrectly become interchangeable terms within the psychological literature (Casperson, Powell, & Christenson, 1985).

Physical activity has a wide array of health benefits. Physical activity has been shown to reduce the risk of over 25 chronic health conditions, including heart disease, stroke, hypertension, breast cancer, colon cancer, type 2 diabetes, and osteoporosis (The Public Health Agency of Canada, 2010). In addition, Shephard (1992) explains that workplace physical activity programs have reduced absenteeism due to illness, injury and occupational stress. It is important to note that exercise will result in the greatest amount of health benefits, however moderate physical activity still leads to increased health benefits. For example, people who exercise will see improvements in cardio-respiratory health and burn more calories for weight loss. In comparison, physical activity will not likely lead to weight loss or large increases in cardio-respiratory fitness, but can still reduce the chronic health conditions discussed earlier (The Public Health Agency of Canada, 2010).

Work Characteristics and Health behaviors

An examination of how workload can affect health behaviors is important to consider because positive health behaviors could potentially influence a person's quality of sleep. Although there is no universal definition, health behaviors can be described as behaviors people carry out to enhance or maintain their health (Cohen, Bowness, & Felix, 1990). Positive health behaviors can include exercising and eating healthy. In contrast, negative health behaviors include smoking or being physically inactive. Health behaviors can develop into health habits, which are firmly established and performed behaviors which occur automatically, without awareness (Cohen, Bowness, & Felix, 1990). For example, a negative health behavior such as sleeping less than 7 hours per night can develop into an ingrained behavior, which turns into a negative health habit. Also, positive health behaviors, such as exercising can turn into automatic habits, which can in turn influence other health behaviors such as improving sleep duration and quality (Atlantis et al., 2006).

The current study investigates what factors can influence physical activity, but it is also necessary to investigate how physical activity can affect other health behaviors and outcomes such as attaining quality sleep. To fully understand all the components that interact with physical activity both the antecedents and consequences of physical activity need to be understood.

Poor perceived health and a lack of physical activity are associated with higher rates of insomnia. Physically fit individuals are also more likely to sleep longer than unfit individuals (Montgomery, Trinder, & Paxton, 1982; Ohida et al., 2001). Daytime sleepiness has been shown to correlate with a sedentary lifestyle and reduced physical activity (Whitney et al., 1998). Kim et al. (2000) also found that insomnia in the general Japanese population was associated with a lack of habitual exercise and psychological distress. However, the effects of physical activity on sleep do not seem to appear unless an individual is consistently physically active. For example, Montgomery et al. (1982) found that individuals who were already physically fit showed longer sleep duration following exercise, but unfit individuals did not show longer sleep duration following exercise.

Control over job scheduling has been linked to employees practicing positive health behaviors (Fenwick & Tausig, 2001), which can include healthy eating, physical activity, and exercise. Further, job strain has been shown to co-occur with negative health behaviors, including physical inactivity. Job control is one antecedent to health behavior practices, however the resulting strain experienced from low job control can also have an impact on health behaviors (Landsbergis et al., 1998). For example, stress can result in strain based on the perceptions of a person, which in turn can increase stress levels. People who are under stress are also less likely to practice positive health behaviors such as exercising (Johansson, Johnson, & Hall, 1991).

A study examining 42,112 Finish public sector workers revealed that high job strain and passive jobs were associated with an increased likelihood of developing adverse health behaviors such as physical inactivity (Kouvonen et al., 2007). Low job control and high job strain have also been linked to increased body mass index (BMI) and increased smoking (Kouvenen, Kivimaki, Cox, Cox, & Vahtera, 2005; Landsbergis et al., 1998). A high body mass index (BMI) can result from many negative health behaviors, including lack of physical activity and exercise. Low job control and high job strain, coupled with shift work can further decrease the likelihood of employees practicing positive health behaviors.

In addition, job demands such as shift work are associated with sedentary behaviors and a lack of physical activity (Johansson, Johnson, & Hall, 1991). Shift work has also been shown to have a negative impact on exercise behaviors. Suskin, Ryan, Fardy, Clarke, and McKelvie (1998) found that decreased sleep duration from shift work rotations resulted in decreased physical activity and aerobic fitness. Shift workers are also more likely to be overweight and their physical activity levels tend to decrease with age (Kivimaki, Kuisma, Virtanen, & Elovainio, 2001).

Shift work may also force employees to carry out their daily activities at different times due to their unique work schedules. For example, people who have jobs with irregular shifts or long shifts may be prone to exercise later at night, after they finish their shift. General sleep hygiene recommendations include exercising around 5-6 hours before going to bed (Morin, Hauri, & Epie, 1999). Exercising and then going directly to bed can increase alertness in individuals, making it difficult to fall asleep. For example, an employee who works consecutive 12-14 hour shifts will not have much spare time in between shifts. The employee would literally have to exercise directly after their shift, and then prepare to go to bed. The problem arises because the employee will be more aroused and alert following exercise, making it difficult to fall asleep (Morin et al., 1999). In addition, the circadian rhythm disruptions from working a night shift will likely cause fatigue (Institute of General Medical Sciences, 2012) making it less likely that an employee will be motivated to exercise following their shift.

Long work hours have also been linked to poor health behaviors among healthcare workers. Bazargan, Makar, Bazargan-Hejazi, Ani, and Wolf (2009) examined the health behaviors of working physicians. Thirty-five percent of the 763 physicians reported that they never or occasionally exercise. The strongest link between work hours and reduced physical activity was found among physicians who worked 65 or more hours per week. Working 51-60 hours a week is associated with increased hypertension and a decrease in leisure physical activity in men (Artazcoz, Cortes, Escriba-Aguir, Cascant, & Villegas, 2009). Artazcoz et al. (2009) found that the negative effect of long work hours on physical activity increases as the hours of work per week increase beyond 51 hours. It is evident from the scientific literature that employees who have a high workload and work shift work are at an increased risk of practicing negative health behaviors.

The current study specifically investigates how a high quantitative workload affects nurses' physical activity behaviors. There is abundant literature on the health behaviors that nurses practice (Chan, 2008; Suskin et al., 1998) however few studies specifically focus on physical activity behaviors. In addition, the literature tends to focus on the health behaviors of nurses, but fails to identify specific antecedents to these behaviors. Also, many studies focus on nurses' health behaviors, and generalize the findings to all nurses without looking at quantitative workload (Bazargan et al., 2009). Examining quantitative workload levels among nurses is important because nurses who have a high quantitative workload will likely suffer from increased sleep disturbances compared to nurses with a lower workload. The current study bridges the gap in the literature and specifically links characteristics of a high quantitative workload to physical activity behaviors among two samples of nurses; nurses who work 10 hour or longer shifts and nurses who work the night shift. This leads into the second hypotheses of the present study.

Hypothesis 2a: High quantitative workload will be negatively associated with physical activity behaviors among nurses who work 10 hour or longer shifts.

Hypothesis 2b: High quantitative workload will be negatively associated with physical activity behaviors among nurses who work the night shift.

Thus far, the effects of a high quantitative workload on sleep have been discussed. In addition, the effects of high quantitative workload on health behaviors such as physical activity and exercise have been examined. In order to understand the complex relationship between quantitative workload, sleep, and physical activity, the effects of physical activity on sleep need to be explored. Before the effects of physical activity on sleep are investigated it is worthwhile to review the effects of exercise on sleep because exercise is a more vigorous form of physical activity, and may have differential effects on sleep.

Effects of Exercise on Sleep Quality

A landmark study by Finnish researchers, Harma, Ilmarinen, Knauth, and Rutenfranz (1988) implemented a 4-month aerobic and resistance physical training intervention for 49 female nurse shift workers, to examine its effects on adaptation to shift work. The intervention increased the nurses' length of sleep each night, and reduced general fatigue during their shift. A follow up study using 75 nurses and nurse aids revealed that a physical training intervention reduced the nurses' night-time fatigue and resulted in changes in their circadian rhythms (Harma et al., 1988). The change in circadian rhythms may have helped shift workers adapt to shift work. In a recent study, Atlantis, Chow, Kirby, and Singh (2006) implemented an exercise intervention to examine its effects on the quality of sleep of Casino workers at an Australian Casino. Participants were assigned to a 3 day a week, moderate-high intensity aerobic workout program for 24 weeks. The intervention significantly improved the subjective quality of sleep for all employees, including the shift work subgroup.

Singh, Clements, and Fiatarone (1997) implemented a 10-week exercise intervention for older adults, to measure its impact on quality of sleep and depressive symptoms. The exercise program significantly improved the participants' quality of sleep, and reduced their depressive symptoms by twice that of the control group.

Group structured exercise can also improve quality of sleep. Naylor et al. (2000) implemented a daily group exercise session for 2-weeks, and found that the frequency of their slow-wave sleep increased compared to a control group. Group structured exercise refers to exercising with a group of people, and this can include cardio classes such as a spinning class or simply exercising with a group of friends.

Driver and Taylor (2000) suggest that the type of exercise has a significant effect on the sleeping patterns of people. Power-trainers tended to have a longer onset to sleep, and shorter sleep duration than endurance trainers. This effect is likely due to the fact that power training evokes a different physiological response compared to endurance training. Power-training involves compound weightlifting exercises (e.g., bench press) with extremely heavy weight for low repetitions. Endurance or aerobic exercise involves any physical activity that raises a person's resting heart rate for a sustained time period (e.g., 30 minutes), and is characterized as a structured activity. Weightlifting is likely to raise a person's heart rate for short periods of time, which trains the anaerobic system, in contrast to endurance exercise which maintains an elevated heart rate for longer time periods, and trains the aerobic system.

Good exercise habits have also been shown to improve quality of sleep by ameliorating breathing problems people suffer from. Peppard and Young (2004) examined the association between exercise frequency and sleep disordered breathing, adjusting for body mass index, skinfold measurements, age and sex. They found that participants who exercised 0 hours per week suffered the most from disordered breathing episodes, and the disordered breathing episodes decreased with greater frequency of exercise. Participants who exercised greater than 7 hours per week had the lowest levels of disordered breathing episodes.

Irwin, Olmstead, and Motivala (2008) demonstrated that Tai Chi is an effective treatment for mild sleep disturbances in older adults. The 16 week Tai Chi program significantly improved sleep quality and reduced reported sleep complaints compared to a group who only received health education training. This indicates that exercise should be considered as a viable alternative to improving sleep quality compared to educating people on how they can improve their sleep. The latter two studies also suggest that low intensity exercise can be as effective as medium-high intensity exercise for treating sleep problems. Serge et al. (2009) found that long-term, vigorous exercise is positively related to adolescents' quality of sleep and psychological functioning. It appears that exercise is both positively related to quality of sleep with the elderly and adolescents.

Effects of Physical Activity on Sleep Quality

Short-term physical activity has been shown to improve subjective sleep quality among elderly individuals living in an assisted care facility (Benloucif et al., 2004). Although the authors defined their intervention as physical activity, only one aspect of the intervention could be considered physical activity; game playing. The intervention included light aerobics as well, which is considered structured exercise. However, given the mean age of participants (74.6), the intensity was likely low enough to compare with general physical activity. Olds, Maher, and Matricciani (2011) also reported that adolescents who go to bed later and sleep in participated in 27 minutes less of daily physical activity compared to adolescents who go to bed earlier and wake up earlier, and are 2.6 times more likely to be obese.

Physical activity has also been used as an alternative treatment to pharmacological drugs for chronic sleep disorders. For example, Sherrill, Kotchou, and Quan (2008) investigated the effect of moderate intensity physical activity on self-reported sleep disorders of adults. The study revealed that moderate intensity physical activity reduced the risk of having any kind of sleep disorder.

Physical activity has also been used as a method to improve the sleep quality of postmenopausal women. Tworoger et al. (2003) examined the effects of physical activity on sleep quality among postmenopausal, obese women, who were not taking hormone replacement therapy. They found that those who were physically active at least 225 minutes per week fell asleep faster than participants who were physically active less than 180 minutes per week. Participants who stretched were also less likely to take sleeping medication and fell asleep faster.

Exercise and physical activity clearly have positive effects on quality of sleep across samples varying in age and gender, as well as in both people suffering from sleep disorders and healthy individuals. Further, it is evident that the form of exercise and physical activity can vary and the positive benefits on sleep still persist. However, there is a strong need for research to examine specifically how physical activity can improve quality of sleep among nurses. The two original studies that examined this relationship among a nurse sample (Harma et al., 1988) were conducted over 20 years ago, and there has not been much progress since then. The current study will add to the investigation about the effects of physical activity and nurses' quality of sleep, and add to the scarce literature on this topic. This leads to the third hypotheses of the current study.

Hypothesis 3a: Physical activity will be positively associated with quality of sleep among nurses who work 10 hour or longer shifts.

Hypothesis 3b: Physical activity will be positively associated with quality of sleep among nurses who work the night shift.

The current study has argued quantitative workload will affect quality of sleep, and physical activity will affect quality of sleep. In addition, there is a gap in the current literature with regards to whether physical activity would reduce the effects of high workload on quality of sleep. Further, it is important to note that this study has made a strong distinction between exercise and physical activity. The current study bridges the gap in the literature about the distinction between exercise and physical activity by defining and using an appropriate measure of physical activity. Finally, there is a need to study nurses who work long shifts and nurses who work the night shift separately because these groups of nurses face uniquely different stressors. For example, night shift nurses are at an increased risk for circadian rhythm disruptions (National Institute of General Medical Science, 2012). The current study links the gap in the current literature, and investigates nurses who work long shifts and nurses who work the night shift separately.

It is also reasonable to expect that a high workload could make it difficult to be physically active because stress and fatigue, which can result from a high workload can reduce the likelihood of being physically active (Suskin et al., 1998). In addition, physical activity has been shown to be positively associated with improved sleep quality (Sherrill et al., 2008). Given the significant relationship between workload and physical activity, in addition to the significant relationship between physical activity and quality of sleep, it appears that physical activity could account for the relationship between quantitative workload and quality of sleep. The rationale is that quantitative workload affects levels of physical activity, which in turn affects sleep quality. This leads to the fourth hypotheses of the current study.

Hypothesis 4a: Physical activity will mediate the relationship between quantitative workload and quality of sleep among nurses who work 10 hour or longer shifts

.*Hypothesis 4b:* Physical activity will mediate the relationship between quantitative workload and quality of sleep among nurses who work the night shift.

In addition to examining the mediating effects of physical activity on the relationship between high quantitative workload and quality of sleep, there is a need for researchers to investigate whether varying levels of physical activity affect the relationship between high quantitative workload and quality of sleep. It is likely that higher levels of physical activity would reduce the negative impact a high quantitative workload has on sleep quality more so than lower levels of physical activity. For example, a nurse who walks daily for 30 minutes, 5 times a week will likely experience greater improvements in sleep quality compared to a nurse who never participates in any leisure physical activity. It may be the case that even low levels of physical activity can improve sleep quality among nurses with a high quantitative workload; however the effect would likely be stronger for nurses who are more physically active. This leads to the fifth hypotheses of the current study.

Hypothesis 5a: Physical activity will moderate the relationship between quantitative workload and quality of sleep among nurses who work 10 hour or longer shifts.

Hypothesis 5b: Physical activity will moderate the relationship between quantitative workload and quality of sleep among nurses who work the night shift.

The relationship between physical activity and quality of sleep may also be affected by other factors. For example, personality traits are associated with poor sleep quality. According to Laar, Verbeek, Pevernagie, Aldenkamp, and Overeem (2010) a common trend displayed by individuals suffering from sleep disorders are signs of neuroticism compared to individuals who do not suffer from sleep disorders. Neuroticism is a personality trait that is associated with negative emotional states such as anxiety, guilt, anger, and a depressive mood. Celucci and Lawrence (1978) found that anxiety was associated with sleep latency, difficulty falling asleep, and nightmares. In addition, Schredl, Landgraf, and Zeiler (2003) further confirmed the link between neuroticism and sleep disruptions, indicating that neurotic individuals are more likely to suffer from intense nightmares.

Interestingly, Rhodes (2006) also suggests that people higher in neuroticism are less likely to be physically active. People higher in neuroticism may not be able to manage their emotions and maintain motivation to participate in physical activity. Hausenblas and Giacobbi (2004) also found that the big five factor model, including neuroticism predicted physical activity behaviors. Further, Potgieter and Venter (1995) reported that neuroticism predicted dropout rates for university students enrolled in a physical activity program. Finally, Korotkov (2008) found that neuroticism moderates the relationship between stress and health behaviors. It is evident that neuroticism affects both sleep patterns and physical activity behaviors.

Research suggests that neuroticism can affect the levels of physical activity people engage in (Rhodes, 2006). Further, the frequency of physical activity participation is positively associated with sleep quality (Tworoger et al., 2003). It is likely that neuroticism interacts with physical activity frequency, which further predicts the quality of sleep a person attains. For example, individuals higher in neuroticism are less likely to be physically active, which contributes to poor sleep quality. This leads to the sixth hypotheses of the current study.

Hypothesis 6a: Neuroticism will moderate the relationship between physical activity and quality of sleep among nurses who work 10 hour or longer shifts.

Hypothesis 6b: Neuroticism will moderate the relationship between physical activity and quality of sleep among nurses who work the night shift.

CHAPTER 2

METHOD

Participants

Participants from research conducted for the Oregon Nursing Retention Project (Sinclair et al., 2009) were used for the current study. There were several goals and aims of this project. The first goal of the Oregon Nursing Retention Project was to describe the critical stressors and positive work experiences that influence nurses' retention. The second goal of the Oregon Nursing Retention Project was to test a new theoretical model that integrates retention research from nursing and organizational psychology with stress research from occupational health psychology. The final goal of the project was to identify specific workplace interventions that, from the perspective of nurses, would address positive and negative work experiences. Refer to the website at www.onrp.webnode.com for more information.

The entire archival data set consisted of 438 nurses in the Wave 1 data collection and 343 nurses in the Wave 2 data collection. The two waves of data collection were separated by a six month time span. The participants' average age was 45.8 years and the majority of the participants were female (93%). Participants ranged in age from 22 years to 70 years. The participants were mostly Caucasian (92%) and 43% had a bachelor's degree in nursing. The majority of the participants were also married (68%). Participants' average hours scheduled per week was 32 hours and they averaged 3.5 shifts per week. The average hours worked per week was 35.2 and voluntary overtime hours per week were 3.8. The average occupational tenure was 17.7 years and the average organizational tenure was 11 years.

Next, a subset of data from the original data set was used, examining nurses who work 10 hour or longer shifts (N = 222). The data was grouped based on shift length because nurses who work longer shifts experience an increase in sleep disturbances (Ribet & Derriennic, 1999). Lockley et al. (2007) recommends that 8 hour shifts for healthcare workers are ideal for reducing fatigue and maintaining good health. Further, little, if any research indicates that shifts shorter than 10 hours in length cause increased fatigue and reduced performance. Finally, choosing the 10 hour shift length cut-off versus a 12 hour shift length allows for a larger sample size, which can improve the power of the statistical analyses.

The demographics of the participants from the 10 hour or longer shift sample were examined. The participants' average age was 43 years and the majority of the participants were female (91%). Participants ranged in age from 22 years to 66 years. The participants were mostly Caucasian (90%) and 45% had a bachelor's degree in nursing. The majority of the participants were also married (64%). Participants' average hours scheduled per week was 33.6 hours and they averaged 3.2 shifts per week. The average hours worked per week was 37 and voluntary overtime hours per week were 4. The average occupational tenure was 15 years and the average organizational tenure was 8.8 years.

Refer to Table 1 for a comparison in demographics between the 10 hour or longer shift nurse sample and the original data set of nurses who work less than 10 hours. The 10 hour or longer shift sample of nurses significantly differed in several demographic variables from the original data set. There were differences in hours scheduled to work per week, number of shifts worked per week, hours actually worked per week, voluntary overtime hours per week, and organizational tenure.

A second subset of data from the original data set was also used, examining nurses who work the night shift (N = 97). Nurses who work the night shift face unique demands; circadian rhythm disruptions, fatigue, and increased sleep disturbances (Waage et al. 2009). Nursing is a high stress occupation, and the addition of working a night shift can increase the occupational stress experienced by nurses (Wu et al., 2009). The night shift sample was examined because these nurses suffer from increased sleep disturbances, and the potential gains in sleep quality through increased physical activity and exercise have important implications for the health of this nursing sample.

The demographics of the participants from the night shift sample were examined. The participants' average age was 40 years and the majority of the participants were female (90%). Participants ranged in age from 22 years to 64 years. The participants were mostly Caucasian (89%) and 50% had a bachelor's degree in nursing. The majority of the participants were also married (63%). Participants' average hours scheduled per week was 32.7 hours and they averaged 3.4 shifts per week. The average hours worked per week was 36 and voluntary overtime hours per week were 4. The average occupational tenure was 10.8 years and the average organizational tenure was 6.5 years.

Refer to Table 2 for a comparison in demographics between the night shift sample of nurses and the original sample of nurses who do not work the night shift. The night shift sample of nurses significantly differed in one demographic variable from the original data set. There were differences in organizational tenure.

Measures

Quantitative Workload Scale. The Quantitative Workload Scale was used to measure nurses' work-schedule demands (See Appendix A). This is a 9-item subscale, taken from the Expanded Nurse Stress Scale, created by French, Lenton, Walters, and

Eyles (2000). The overall internal reliability of the Expanded Nurse Stress Scale (ENSS) is reported to be extremely high ($\alpha = .96$), in addition to the internal reliability of the Quantitative Workload Subscale ($\alpha = .86$).

All 9 items of the scale measure one factor, which is Quantitative Workload. A sample item is, "I worked too many hours in a shift". The response format is a 1-4 Likert type scale, with 0 as an option for "does not apply to me". An Exploratory Factor Analysis also revealed that one factor explained 60.57% of the variance. Factor loadings ranged from .56 to .88. A Scree plot also confirmed this finding, indicating one factor past the point of inflection. In the present study the Cronbach's alpha of the Quantitative Workload subscale is .86

Sleep Quality. A single-item measure was used to measure quality of sleep. The item is, "Thinking about the past 30 days, in a typical week, how many days did you get adequate sleep"? The response to the item involves the participant to list the number of days. In the current study a one-item measurement is appropriate, and has been deemed effective for measuring sleep quality. For example, Kuppermann et al. (1993) concluded that a single question about quality of sleep can serve as an accurate measure of sleep quality and underlying sleep disorders. Further, this item measures perceived sleep quality over a 30 day time-span, which can overcome the potential issues concerning weekly fluctuations in sleep patterns.

Physical Activity. A single-item measure was used to measure physical activity behavior. The item is, "Thinking about the past 30 days, on how many days in a typical week did you engage in aerobic or physical activity, such as walking, jogging, or cycling? The response format involves the participants to list the number of day per week.

For the current study, a one-item measurement of physical activity is appropriate because physical activity frequency is being assessed. Physical activity encompasses both exercise and more general activities that result in an increased energy expenditure. If exercise were to be specifically examined the differentiation between exercise and physical activity would need to be made clear, because exercise does not encompass unstructured physical activity, such as gardening. In contrast, if physical fitness were to be measured it would require more items to measure the domain because it consists of several separate components such as endurance, strength, and body composition just to name a few (Caspersen, Powell, & Christenson, 1985). In addition, Courneya, Plotnikoff, Hotz, and Birkett (2000) note that most studies in the domain of exercise research have used single-item measures of exercise.

Neuroticism. Neuroticism was measured with 5 items, with a 5-point likert response scale, ranging from 1 "Strongly Disagree" to 5 "Strongly Agree". An example item is, "Sometimes I feel depressed". Items 1, 3, and 5 are reversed scored. (See Appendix B) An average of the 5 items was computed to create a measure of neuroticism. The neuroticism scale also demonstrated strong internal reliability ($\alpha = .73$). In addition, an Exploratory Factor Analysis confirmed that the scale is measuring one factor, accounting for 38.38% of the variance. Factor loadings ranged from .47 to .70. A Scree plot also confirmed this finding, indicating one factor past the point of inflection.

Control Variables. Age and occupational tenure will be added as control variables in the current study. First, shift work, and quantitative workload likely have differential influences on a person's quality of sleep, based on age. Monk (2005) explains that there are age related changes in circadian rhythms, which affect a person's sleep patterns, and how they react to sleep disturbances. Age related changes in circadian rhythms include amplitude declines in rhythm, earlier rhythm phases, and shortened free-running periods (Monk, 2005). This can lead to changes in sleep patterns. For example, on average, people go to bed earlier and awake earlier as they advance in age. Further, older adults are less tolerant to circadian phase shifts such as jet lag, compared to younger adults (Vitiello, 2006).

Age can also influence a person's physical activity levels. For example, young adults' physical activity levels tend to drop compared to adolescents, whereas middle adulthood (30-64) is characterized by relatively stable patterns of physical activity (Caspersen, Pereira, & Curran, 2000). In this situation, stable patterns of physical activity are not necessarily positive for middle aged adults if they have a stable pattern of low physical activity. Importantly, older adults tend to have lower levels of self-efficacy towards exercise participation, and also perceive fewer benefits to physical activity compared to younger adults (Netz & Raviv, 2004). Age related differences in exercise self-efficacy help explain the differing levels of exercise among different age groups.

Secondly, occupational tenure will be added as a control variable because over time, an individual's circadian system will begin to adapt to new work schedules (Kerkhof, 1985). This suggests that nurses who have been working in the field for a number of years may have adapted to night shifts compared to nurses who are just beginning their career. In addition, nurses who have worked night shifts for longer periods of time may be less likely to be physically active (Kivimaki, Kuisma, Virtanen, & Elovainio, 2001).

Neuroticism will also be controlled for in this study for Hypotheses 1 to 5. Laar et al. (2010) found a positive association between neuroticism and sleep disturbances. In addition, Schredl, Landgraf, and Zeiler (2003) further confirmed the link between neuroticism and sleep disruptions, indicating that neurotic individuals are more likely to suffer from intense nightmares. Interestingly, Rhodes (2006) also suggests that people higher in neuroticism are less likely to be physically active. It is evident that neuroticism can affect both sleep quality and physical activity frequency.

Procedures

Refer to Figure 2 for an overview of the ONRP Research Overview. A focus group was held with 8 experienced nurses to estimate the time needed to complete the survey, obtain feedback on survey items, and further develop positive nursing events. A second focus group with 6 experienced nurses was held to estimate the time it takes to complete the weekly work experience survey, and obtain feedback.

A survey was conducted to asses nurses' personal and organizational resources, as well as the retention pathway and outcome measures. Next, nurses completed a weekly work experience survey for 12 consecutive weeks. Finally, participants completed a follow-up survey in order to assess changes in retention outcomes.

Participants were recruited from conferences sponsored by the Oregon Nurses Association (ONA) and by the ONA, circulating information regarding the study through newsletters and additional postcard mailings. In addition, participants were invited to register online for the study throughout the recruitment process. Upon registration, participants gave their consent to complete demo questions at this time. Participants received $20 in compensation for completing the Wave 1 survey, $10 for the Wave 2 survey, and $5 for the weekly surveys. Each participant was also entered into a raffle for several $50 prizes. Refer to the Final Report of the Oregon Nurse Retention Project Website for the full procedures used to collect the data: www.onrp.webnode.com.

CHAPTER 3

RESULTS

Data Screening

The data were split into 2 separate samples; nurses who work 10 plus hour shifts (N = 222) and nurses who work the night shift (N = 97). All statistical analyses were conducted using SPSS 16.0. Before beginning the analyses, the data were standardized and examined for outliers with z-scores above or below three. Case ID 10528 was removed from the 10 hour or longer shift length data analysis because the z-score for the sleep variable was above three standard deviations. This reduced the data set to 221 cases. No cases were deleted from the night shift sample. Next, multivariate outliers were examined for Hypotheses 1a and 1b through 6a and 6b, examining Standardized residuals, Cook's Distance, and Standardized DfBetas. Case ID 10650 was removed from the 10 hour or longer shift sample because the Standardized residual was below the cut-off of 3 standard deviations. This reduced the sample size of the data set to 220. No extreme cases were identified in the night shift sample. Due to missing data, pairwise deletion was used in all subsequent analyses for both data sets.

Descriptive Statistics of the Measured Variables

Means and standard deviations for the 10 hour or longer shift sample scales are presented in Table 3. The descriptive statistics for the 10 hour or longer shift sample were computed. The mean score for quantitative workload was 2.85, with a standard deviation of .88. The mean days of physical activity per week among nurses was 3.93 days, with a standard deviation of 1.92. The mean score for neuroticism was 2.56, with a standard deviation of .67. In addition, nurses averaged 5.61 days of adequate sleep per week, with a standard deviation of 1.47.

For the 10 hour or longer shift sample, on average, women (M = 2.86, SD = .88) did not significantly differ in quantitative workload compared to men (M = 2.79, SD = .62), $t(213) = .31$, $p > .05$. In addition, women (M = 3.88, SD = 1.89) did not significantly differ in physical activity frequency per week compared to men (M = 4.47, SD = 2.30), $t(184) = -1.13$, $p > .05$. Further, women (M = 2.56, SD = .68) did not significantly differ in neuroticism compared to men (M = 2.54, SD = .59), $t(211) = 0.10$, $p > .05$. Finally, women (M = 5.60, SD = 1.47) did not significantly differ in days of quality of sleep per week compared to men (M = 5.67, SD = 1.54), $t(184) = -.18$, $p > .05$. The results indicate that men and women perceive similar workloads and participate in comparable levels of physical activity. Men and women also demonstrate comparable levels of neuroticism, and attain similar levels of quality sleep per week.

Means and standard deviations for the night shift sample scales are presented in Table 4. The descriptive statistics for the night shift sample were computed. The mean score for quantitative workload was 2.68, with a standard deviation of .86. The mean days of physical activity per week among nurses was 3.48 days, with a standard deviation of 1.86. The mean score for neuroticism was 2.53, with a standard deviation of .70. In addition, nurses averaged 5.41 days of adequate sleep per week, with a standard deviation of 1.38.

For the night shift sample, on average women (M = 2.70, SD = .88) did not significantly differ in quantitative workload compared to men (M = 2.54, SD = .62), $t(93) = .54$, $p > .05$. Interestingly, women (M = 3.27, SD = 1.69) significantly differed in physical activity frequency per week compared to men (M = 5.38, SD = 2.33), $t(77) = -3.22$, $p < .05$. Further, women (M = 2.52, SD = .72) did not significantly differ in neuroticism compared to men (M = 2.56, SD = .56), $t(92) = -.16$, $p > .05$. Finally, women (M = 5.38, SD = 1.36) did not significantly differ in days of quality of sleep per week compared to men (M = 5.62, SD = 1.69), $t(77) = -.47$, $p > .05$. The results indicate that men and women perceive similar workloads, demonstrate comparable levels of neuroticism, and attain similar levels of quality sleep per week. Interestingly, men participated in greater levels of physical activity per week compared to females in the night shift sample. Further, physical activity levels differed among men and women only within the night shift sample, suggesting that the night shift may have a greater impact on physical activity levels for women than for men.

Correlation Analyses

Hypotheses 1-6 were examined for the 10 hour or longer shift sample. Table 3 presents the correlations among the variables. Hypotheses 1a and 3a were supported, and Hypotheses 2a, 4a, 5a, and 6a were not supported. In support of Hypothesis 1a, quantitative workload at time 1 was negatively related to sleep quality at time 2, $r = -.15$, $p < .05$, which indicates a high workload is associated with poor quality of sleep. Failing to support Hypothesis 2a, quantitative workload at time 1 was not significantly related to physical activity at time 1, $r = .11$, $p > .05$, which indicates that workload is not associated with physical activity participation. In support of Hypothesis 3a, physical activity at time 1 was significantly related to sleep quality at time 2, $r = .29$, $p > .01$, which signifies that higher levels of physical activity is associated with improved sleep quality. The mediation analyses for Hypothesis 4a were partially supported. Quantitative workload was not significantly related to physical activity; however physical activity was significantly related to sleep. In addition, quantitative workload was significantly related to sleep, fulfilling one of the requirements for mediation.

Hypotheses 1b, 2b, 3b, 4b, 5b, and 6b were examined for the night shift sample. Table 4 presents the correlations among the variables. Hypothesis 1b was supported, and hypotheses 2b-6b were not supported. In support of Hypothesis 1b, quantitative workload at time 1 was negatively related to sleep quality at time 2, $r = -.29$, $p < .05$, indicating that a high workload is related to reduced quality of sleep. Failing to support Hypothesis

2b, quantitative workload at time 1 was not significantly related to physical activity at time 1, $r = -.10$, $p > .05$, which suggests that workload does not affect physical activity levels. Failing to support Hypothesis 3b, physical activity at time 1 was not significantly related to sleep quality at time 2, $r = .12$, $p > .05$, signifying that physical activity is not associated with improved sleep quality. The mediation analyses for Hypothesis 4b were partially supported. Quantitative workload was not significantly related to physical activity, and physical activity was not related to sleep. However, quantitative workload was significantly related to sleep, fulfilling one of the requirements for mediation.

Regression Analyses

Regression analyses were conducted for the sample of nurses who work 10 hour or longer shifts to test Hypotheses 1-3. The results from the linear regression analyses for Hypotheses 1a, 2a, and 3a are presented in Table 5. The linear regression analyses supported Hypothesis 1a, in which quantitative workload significantly predicted quality of sleep among nurses, controlling for age, occupational tenure and neuroticism, $B = -.23$, $t(179) = -1.90$, $p < .05$. The results for Hypothesis 1a indicate that a high workload is associated with reduced quality of sleep. Quantitative workload and the control variables also explained a significant proportion of variance in quality of sleep, $R^2 = .11$, $F(4, 183) = 5.68$, $p < .01$. The linear regression analysis did not support Hypothesis 2a, in which quantitative workload did not significantly predict physical activity among nurses, controlling for age, occupational tenure, and neuroticism, $B = .13$, $t(179) = .81$, $p > .05$. Interestingly, the full model with quantitative workload and the control variables did explain a significant proportion of variance in physical activity, $R^2 = .05$, $F(4, 179) =$

2.48, $p < .05$. The results from Hypothesis 2a signify that a high workload is not related to a decrease in physical activity. The linear regression analysis supported Hypothesis 3a, in which physical activity significantly predicted quality of sleep among nurses, controlling for age, occupational tenure, and neuroticism, $B = .19$, $t(179) = 3.42$, $p < .01$. In addition, physical activity and the control variables explained a significant proportion of variance in quality of sleep, $R^2 = .15$, $F(4, 179) = 7.91$, $p < .001$. The results from Hypothesis 3a indicate that increased levels of physical activity are associated with improved sleep quality.

Regression analyses were conducted for the sample of nurses who work the night shift. The results from the linear regression analyses for Hypotheses 1b, 2b, and 3b are presented in Table 6. The linear regression analysis supported Hypothesis 1b, in which quantitative workload significantly predicted quality of sleep among nurses, controlling for age, occupational tenure and neuroticism, $B = -.45$, $t(72) = -2.49$, $p < .05$. Quantitative workload and the control variables also explained a significant proportion of variance in quality of sleep, $R^2 = .14$, $F(4, 72) = 2.83$, $p < .05$. The results for Hypothesis 1b indicate that a high workload is associated with reduced quality of sleep. The linear regression analysis did not support Hypothesis 2b, in which quantitative workload did not significantly predict physical activity among nurses, controlling for age, occupational tenure, and neuroticism, $B = -.23$, $t(72) = -.89$, $p > .05$. In addition, the full model with quantitative workload and the control variables did not explain a significant proportion of variance in physical activity, $R^2 = .02$, $F(4, 72) = .36$, $p > .05$. The results from Hypothesis 2b signify that a high workload is not related to a decrease in physical activity. The linear regression analysis did not support Hypothesis 3b, in which physical activity did not significantly predict quality of sleep among nurses, controlling for age, occupational tenure, and neuroticism, $B = .09$, $t(72) = 1.05$, $p > .05$. In addition, physical activity and the control variables did not explain a significant proportion of variance in quality of sleep, $R^2 = .08$, $F(4, 72) = 1.47$, $p > .05$. The results of Hypothesis 3b indicate that increased physical activity is not associated with improved quality of sleep.

Moderation and Mediation Analyses

The results for the moderation analysis for the sample of nurses who work 10 hour or longer shifts are presented in Table 9. First, quantitative workload and physical activity, along with the control variables were entered as predictors of the dependent variable, quality of sleep. The results indicated that there was a direct effect for quantitative workload on quality of sleep, $B = -.25$, $t(177) = -2.17$, $p < .05$. The addition of the interaction term between quantitative workload and physical activity did not significantly add to the prediction of quality of sleep, *F Change* = .19, $p > .05$, failing to support Hypothesis 5a. (See Figure 3 for simple slopes plot)

The results for the mediation analysis for the sample of nurses who work 10 hour or longer shifts are presented in Table 7. The script from Preacher and Hayes (2008) was used to perform a bootstrap analysis, in order to test whether physical activity mediates the relationship between quantitative workload and quality of sleep. The indirect effect is .122*.190 = .023. The indirect effect divided by the total effect (.023/.226 = .102), indicates that 10.2% of the relationship between quantitative workload and quality of sleep could be accounted for by physical activity; however the confidence intervals contained zero. This indicates that the indirect effect is not significantly different from zero. Also, the results indicated that the bootstrap indirect effect was not significantly different from the calculated indirect effect (.024 - .023). Taken as a whole, the results indicate that the bootstrapping method yielded the same results as the calculated method of the indirect effect, and the confidence intervals signify that physical activity does not significantly mediate the relationship between quantitative workload and quality of sleep. The results failed to support Hypothesis 4a.

A moderation analysis was conducted in order to test Hypothesis 6a for the sample of nurses who worked 10 hour or longer shifts. The results of the moderation analysis are presented in Table 10. First, physical activity and neuroticism, along with the control variables age and occupational tenure were entered as predictors of the dependent variable, quality of sleep. The results indicated that there was a direct effect for physical activity on quality of sleep, $B = .24$, $t(181) = 3.40$, $p < .05$. The addition of the interaction term between physical activity and neuroticism did not significantly add to the prediction of quality of sleep, *F Change* = .11, failing to support hypothesis 6a. (See Figure 4 for simple slopes plot)

The results of the moderation analysis for the sample of nurses who work the night shift are presented in Table 11. First, quantitative workload and physical activity, along with the control variables were entered as predictors of the dependent variable, quality of sleep. The results indicated that there was a direct effect for quantitative workload on quality of sleep, $B = -.44$, $t(70) = -2.37$, $p < .05$. The addition of the interaction term between quantitative workload and physical activity did not significantly add to the prediction of quality of sleep, *F Change* = .17, $p > .05$, failing to support Hypothesis 5b. (See Figure 5 for simple slopes plot)

Next, the script from Preacher and Hayes (2008) was used to perform a bootstrap analysis, in order to test whether physical activity mediates the relationship between quantitative workload and quality of sleep. The results are presented in Table 8. The indirect effect is -.249*.062 = -.015. The indirect effect divided by the total effect (-.015/-.487 = .031), indicates that 3.1% of the relationship between quantitative workload and quality of sleep could be accounted for by physical activity. However, the results indicated that the bootstrap indirect effect was not significantly different from the calculated indirect effect (.024 - .023), and the confidence intervals contained zero. This indicates that the indirect effect is not significantly different from zero. Taken as a whole, the results indicate that the bootstrapping method yielded the same results as the calculated method of the indirect effect, and the confidence intervals signify that physical activity does not significantly mediate the relationship between quantitative workload and quality of sleep. The results failed to support Hypothesis 4b.

A moderation analysis was conducted in order to test Hypothesis 6b for the sample of nurses who worked the night shift. The results of the moderation analysis are presented in Table 12. First, physical activity and neuroticism, along with the control variables age and occupational tenure were entered as predictors of the dependent variable, quality of sleep. The results indicated that there was not a direct effect for physical activity on quality of sleep, $B = .12$, $t(75) = 1.05$, $p > .05$. The addition of the interaction term between physical activity and neuroticism did not significantly add to the prediction of quality of sleep, *F Change* = .83, failing to support Hypothesis 6b. (See Figure 6 for simple slopes plot)

CHAPTER 4

DISCUSSION

To the best of this author's knowledge the current study is the first to examine both the effects of quantitative workload and physical activity on quality of sleep among two separate samples of nurses; nurses who work 10 hour or longer shifts and nurses who work the night shift. The remainder of this section will first discuss the results, then identify the implications for theory, next explore organizational implications, and finally discuss strengths, limitations, and future research.

Summary of Results

First, bivariate relationships were examined among the measured variables for the two samples of nurses; nurses who work 10 hour or longer shifts and nurses who work the night shift. For both samples, quantitative workload was negatively associated with quality of sleep, supporting Hypotheses 1a and 1b. For both samples of nurses, quantitative workload was not associated with physical activity, failing to support Hypotheses 2a and 2b. Physical activity was positively associated with quality of sleep for the 10 hour shift sample but not the night shift sample, supporting Hypothesis 3a, and failing to support Hypothesis 3b.

Next, the relationship between quantitative workload and quality of sleep was further examined for both samples of nurses; the 10 hour or longer shift sample and the night shift sample. Quantitative workload was negatively associated with nurses' quality of sleep, controlling for age, occupational tenure, and neuroticism for both samples. These findings further supported Hypotheses 1a and 1b.

The relationship between quantitative workload and physical activity was further examined, including the control variables. The results indicated that quantitative workload was not associated with physical activity levels, failing to support Hypotheses 2a and 2b. Although the prediction was that a high workload would reduce physical activity frequency, some studies have found that job workload is not associated with exercise or other health behaviors (Kageyama et al., 1998; Park et al., 2001).

The relationship between physical activity and quality of sleep was also tested, including the control variables. The results indicated that physical activity was positively associated with nurses' quality of sleep for the 10 hour or longer shift sample but not the night shift sample. These findings supported Hypothesis 3a and failed to support Hypothesis 3b. Although it was expected that physical activity frequency would be related to quality of sleep across both samples, previous studies have failed to support this hypothesis across different samples of participants (Alessi et al., 1995) In addition, the sleep promoting effects of physical activity on normal populations has not been consistently established in empirical studies (Driver & Taylor, 2000).

Next, physical activity was examined as a mediator between the relationship of quantitative workload and quality of sleep for both samples of nurses; the 10 hour or longer shift sample and the night shift sample. The analyses indicated that physical activity did not mediate the relationship between quantitative workload and quality of sleep, failing to support Hypotheses 4a and 4b. Since the initial bivariate relationships between the IV-Mediator, and the Mediator-DV were found to be non-significant, these findings were expected.

Physical activity was also examined as a moderator between the relationship of quantitative workload and quality of sleep for both samples of nurses; the 10 hour or longer shift sample and the night shift sample. The results indicated that physical activity did not moderate the relationship between quantitative workload and quality of sleep, failing to support Hypotheses 5a and 5b.

Finally, neuroticism was examined as a moderator for the relationship between physical activity and quality of sleep for both samples of nurses; the 10 hour or longer shift sample and the night shift sample. The results indicated that neuroticism did not moderate the relationship, failing to support Hypotheses 6a and 6b.

Theoretical Implications

In order to discuss the theoretical implications of the findings in the current study, the expected relationship between quantitative workload and quality of sleep is first investigated. Previous research supports that a high workload is negatively related to quality of sleep among shift-working nurses (Arora et al., 2008., Nakata et al., 2007), and the current study extended these results across two samples of nurses; nurses who work 10 hour or longer shifts and nurses who work the night shift.

However, support was not found for physical activity acting as a mediator or moderator between the relationship of quantitative workload and quality of sleep. Although studies have found that physical activity can affect quality of sleep (Atlantis et al., 2006.; Harma et al., 1988) few studies have specifically examined physical activity as a mediator or moderator between workload and quality of sleep.

The findings from the current study suggest that physical activity does not affect the relationship between quantitative workload and quality of sleep. An explanation for the inability of the current study to find an effect for physical activity on the relationship between quantitative workload and quality of sleep can be explained by the distinction between physical activity and exercise. First, physical activity and exercise have different physiological effects on the human body because the intensity of physical exertion is dissimilar. Exercise results in a higher, sustained increase in heart rate, as well as a greater amount of calories consumed by the human body compared to general physical activity (Caspersen, Powell, & Christenson, 1985). General physical activity may not be at a high enough intensity to elicit a physiological response sufficient to have an impact on sleep. This differentiation between physical activity and exercise can aid in the explanation of why exercise shows more consistent effects on improving sleep compared to general physical activity (Driver & Taylor, 2000).

In addition to the differentiation between exercise and physical activity, other factors can affect the relationship between quantitative workload and quality of sleep. Overall health status could affect sleep quality. For example, obesity and high blood pressure have been linked to sleep disturbances (Strohl et al., 1994). Further, Type 2 diabetes is related to sleep disturbances, after controlling for obesity and age (Vgontzas, Bixler, & Chrousos, 2003). The effects of health status may have a stronger impact on sleep than physical activity behaviors, which explains why physical activity did not impact sleep quality for night shift workers.

The negative impact that stress has on sleep quality has been discussed. In addition, the literature on how unhealthy individuals are at a greater risk for developing sleep disturbances has been reviewed. Taking this information into account, it is likely that a person who is unhealthy and experiences job stress from a high workload would be at an increased risk for poor sleep quality. For example, obesity and stress are both predictive of cortisol levels, which can affect an individual's sleep (Bjorntorp & Rosmond, 2000; Dahlgren, Kecklund, & Akerstedt, 2005). The common denominator may be that both stress and poor health status increase cortisol and suppress the immune system, which disrupts the sleep cycle. In the current study, stress may have a stronger impact on sleep quality than physical activity. Further, a nurses' ability to cope with stress may have a larger impact on sleep quality than physical activity behaviors. It is plausible that if nurses' ability to cope with stress was controlled for in the current study, the effects of physical activity on sleep quality would have been stronger.

Further, quantitative workload was not associated with physical activity frequency among nurses. Many studies examine and combine several health behaviors together with one score, such as the study by Suskin et al. (1998), instead of examining physical activity separately. The individual effect of workload on physically activity may not be as strong when physical activity is not part of a comprehensive health behaviors questionnaire.

Physical activity was not associated with sleep quality among nurses who work the night shift. Although these results may seem surprising, many studies examine exercise instead of physical activity (Harma et al., 1988; Atlatis et al., 2006). As previously discussed, physical activity and exercise differentially affect sleep quality because exercise is more physiologically arousing than general physical activity (Casperson et al., 1985). Therefore, general physical activity may not be vigorous enough to elicit a strong enough response to affect sleep quality for the night shift sample.

Interestingly, physical activity was positively associated with sleep quality among nurses who work 10 hour or longer shifts. This finding suggests that physical activity has differential effects on sleep quality for nurses who work 10 hour or longer shifts compared to nurses who work the night shift. Circadian rhythm disruptions that night shift workers face are extremely detrimental to sleep quality (Gold et al., 1992). Physical activity is not as physiologically arousing as exercise, and may not have a strong enough effect to improve sleep quality among nurses who suffer from circadian rhythm disruptions. It is also important to note that the 10 hour or longer shift sample (N =222) was substantially larger than the night shift sample (N = 97), which may explain why physical activity was not associated with sleep quality for the night shift sample. The relationship may exist between physical activity and quality of sleep; however the sample may not have been large enough to find a significant effect. The low power of the night shift sample can make it difficult to find a significant relationship between physical activity and quality of sleep. However, the correlation between physical activity and sleep for the 10 hour shift or longer sample (r = .29) was larger than the night shift sample (r = .12) irrespective of significance. The correlations suggest that a larger sample size for the night shift sample may not increase the probability of a significant relationship between physical activity and sleep.

Finally, neuroticism did not moderate the relationship between physical activity and quality of sleep for both samples of nurses; the 10 hour or longer shift sample and the night shift sample. Neuroticism has been shown to be associated with both physical activity and sleep (Laar et al., 2010; Rhodes, 2006); however research has not focused on neuroticism acting as a moderator between physical activity and sleep. It is also difficult to determine whether neurotic individuals have sleep problems, or whether sleep problems cause neuroticism. Finally, neuroticism may not influence the relationship between physical activity and sleep, although a grouping of personality characteristics might have a stronger effect on physical activity and sleep. For example, a combination of personality traits such as neuroticism and conscientiousness may influence physical activity. People who are both emotionally stable and are able to plan and organize their time may be better equipped to maintain physical activity over longer periods of time, which could improve sleep.

Organizational Implications

The current study has several important implications for organizations and has several applied applications. First, the current study goes beyond examining how a high workload can affect quality of sleep, and focuses on nurses who work 10 hour or longer shifts and nurses who work the night shift. The differentiation between hours worked and shift type worked is important to consider because nurses are facing two kinds of stressors at work; work schedule demands and workload demands. Therefore it is critical to examine and search for methods that can be implemented to help nurses improve their sleep, and allow them to fulfill their job duties.

Importantly, physical activity was related to improved sleep quality among the 10 hour or longer shift sample. The effects of physical activity on sleep for the 10 hour or longer shift sample suggests that physical activity promotion is a viable method for improving nurses' quality of sleep. The implications of the current study for nurses are clear; hospitals need to promote physical activity among their nurses who work long shifts. Hospitals can promote physical activity by providing nurses with easy access to fitness programs, personal trainers, and organized group activities such as walking clubs before or after work, or during a lunch break. Further, hospitals need to reduce nurses' daily work hours so they can have more time to attain adequate sleep and participate in physical activity behaviors. Interestingly, there has been discussion about creating federal and state regulations to cap the amount of hours nurses' work (U.S. Department of Labor, 2012).

Further, exercise has been shown to be a viable method for improving quality of sleep, and decrease sleep disturbances (Atlantis et al., 2006., Irwin et al., 2008). Although this study did not find affects for physical activity on sleep quality for the night shift sample, physical activity promotion is still important. For example, it is not wise for an individual who is inactive to jump right into a demanding exercise program because this could lead to injuries. Physical activity promotion can be used as an intermediate step between being inactive and participating in an exercise program, in order to prepare a person's body for more demanding exercise. Promoting physical activity as an intermediate step to exercise for workplace initiatives is important because an employer does not want to deal with lawsuits from injured employees. For example, a corporate exercise promotion program could lead to injury among unhealthy employees who are not ready to perform vigorous exercise. Physical activity is a solution to slowly introducing employees to an exercise program, reducing the likelihood of an injury.

Physical activity can also be a cost effective method for improving quality of sleep, and can be implemented in an applied setting, such as an organization. Physical activity promotion is a practical intervention for improving sleep because it does not require the use of pharmacological drugs or complex evaluations to be implemented. Physical activity promotion can start with something as simple as getting employees to go for group walks during lunch, and can become progressively more intense as the employees' fitness and endurance levels improve. Physical activity can be used as a stepping stone for inactive employees to participate in vigorous exercise programs. The key is to set small attainable goals, and continue to progress to more intense physical activity.

Strengths of the Current Study

One of the key strengths of the current study is that it examines the antecedents to health behaviors, which opens up discussion for methods to promote physical activity and exercise in the workplace. Understanding the antecedents to physical activity is essential for the successful implementation and maintenance of any physical activity or exercise intervention in the workplace. For instance, certain factors can make it difficult to engage in physical activity and exercise, such as working long hours, shift work, or a high workload. Methods for promoting physical activity and exercise need to be considered to overcome these obstacles. Methods for promoting physical activity can include improving employee exercise self-efficacy, providing access to fitness centers which are open 24 hours a day, or something as simple as providing bicycle racks to promote physical activity (Mackinnon et al., 2001.,Oldenburg, Sallis, Harris, & Owen, 2002).

A second strength of the current study is the examination of two separate and unique samples of nurses; nurses who work 10 hour or longer shifts and nurses who work the night shift. The demands of night shift work and long work hours can have a differential impact on physical activity behaviors and sleep. For example, the current study found that physical activity was related to quality of sleep among the 10 hour or longer shift sample but not the night shift sample. A plausible explanation for the differential effects of physical activity on sleep quality between the two samples of nurses is that night shift workers face greater circadian rhythm disruptions. Physical activity may not have a strong enough physiological affect on the human body to reduce circadian rhythm disruptions, reducing the positive effects of physical activity on sleep.

The current study also made a strong distinction between workload and quantitative workload. Although many studies have linked workload to quality of sleep (Gander, Van den Berg, and Signal, 2008), few studies have specifically examined the association between quantitative workload and quality of sleep. In addition, there is limited research examining the affects of quantitative workload on sleep among nurses. The current study bridges the gap in the literature, and links quantitative workload to sleep among two unique samples of nurses.

A final strength of the current study is that the data is longitudinal, and the data collection points were separated by 6 months. Longitudinal data takes into account changes over time, in contrast to cross-sectional designs, where all the data is collected at 1 time point. Further, a separation of 6 months between data collection points is reasonable because it allows enough time to capture changes within participants. In addition, if the separation between data collection time points was too long, the design may not capture changes in behavior that occur more rapidly, including the acute effects of physical activity on stress and sleep.

Limitations

There are some potential problems with the current study. One criticism could be that a single item measure is not sufficient to capture the multidimensional construct of sleep. However, Cappelleri et al. (2009) found that a single-item measure of sleep sufficiently captured a measure of sleep disturbances. The single item measure of sleep used in the Cappelleri et al. (2009) study also demonstrated convergent validity with other scales used to measure sleep. The single item measure of sleep also demonstrated strong test-retest reliability.

In addition, researchers may argue that the single item measure of physical activity is not adequate to capture the full spectrum of physical activity behaviors.

However, many studies successfully employ a single item measure of physical activity (Courneya et al., 2000). Further, the goal of the current study was to measure an overall frequency of physical activity; it was not the goal of the current study to differentiate between various forms of physical activity. A multi-item measure is more appropriate when the goal of a study is to compare or differentiate between different forms of physical activity.

The current study looked specifically at nurses who work 10 hour or longer shifts and nurses who work the night shift, without examining nurses who work a day shift or shorter shifts. A comparison between nurses with differing shift schedules could provide information on the magnitude of the effects of shift work schedules on quality of sleep. It could be the case that workload has a greater negative impact on sleep for nurses who work rotating shifts or long shifts (Berger & Hobbs, 2005).

Finally, the findings from the current study may not generalize to non-nurse samples of employees. Nurses are a unique sample of employees, who deal with many stressors not typical of a regular job; dealing with infectious diseases and injured patients, shift work is the norm, and the job can be physically demanding, including lifting patients onto beds (McKenzie-Green & Shofer, 2007). The current study was also limited to nurses who work in Oregon, U.S. Hospitals and the work environment for nurses may vary by State, or by Country. Work demands may be lower in countries where long work hours are not a norm, such as the Netherlands (OECD, 2012).

Future Research

It is important to consider the impact that job control has on nurses' quality of sleep. Nurses who have more control over their work schedule and shifts may not experience as much stress or reduced sleep quality. This rationale can be linked to the job-demand-control model (JDC), proposed by Karasek (1979). The JDC model posits that occupational stress is a function of how demanding a person's job is and how much control a person has over their job. Job demands can include time pressures, conflicting demands, or demanding job schedules. Job control can include factors such as having freedom to decide how to complete job tasks, having a say in which shifts to work, or having creative latitude in one's job (Karasek, 1979). Nursing is a high stress occupation, however nurses who choose to work a night shift may have a greater sense of control over their work schedule compared to nurses who were scheduled for night shifts without any choice. It is a reasonable prediction that nurses who have more control over their work schedules and have more freedom in how to complete their job tasks will have lower stress, which in turn can improve sleep quality.

It is also important to consider the role that resources have on job stress and sleep quality. The Job-Demand-Resource Model by Demerouti, Bakker, Nachreiner, and Schaufeli (2001) categorizes employee working conditions into demands and resources. Job demands for nurses can include shift work, time pressures, and high patient acuity. Resources can be described as factors which help nurses cope with workplace stressors, and help them attain job goals and personal growth. Resources can include role clarity, career opportunities, or social support from peers (Schaufeli & Bakker, 2004). The JDR Model posits that job resources help buffer the impact that job demands have on strain and occupational stress. Given the evidence that stress reduces sleep quality (The National Sleep Foundation, 2009), it is apt to predict that nurses who attain and maintain their resources will be less affected by workplace stressors, and reap the benefits of improved sleep quality.

One interesting factor to consider for future research is that nurses tend to have physically active jobs. For example, the duties of a nurse can include a lot of walking, bending, stretching, standing, and lifting objects or patients (Bureau of Labor Statistics, 2012). The main issue is whether occupational physical activity should be considered when examining the physical activity levels of nurses. The distinction between occupational physical activity and leisure physical activity could be made if the goal of a future study is to examine both forms of physical activity separately. The other option would be to include both occupational and leisure physical activity into one measure of general physical activity. Finally, if the goal was to examine the individual effects of leisure physical activity on quality of sleep, occupational physical activity could be controlled for to account for varying levels of occupational physical activity among nurses.

Future research could also compare the effects of quantitative workload on quality of sleep between nurses who work different shifts. The current study compared nurses who work 10 hour or longer shifts to nurses who work the night shift; however there are several different kinds of shift work that could be examined. Shift work can include rotating shifts and the speed and direction of the rotation (Gold et al. 1992). In addition, shift work can include day, evening, and night shifts. Different kinds of shift work likely have differential impacts on sleep quality, so it is important to determine which kinds of shifts are least detrimental to nurses' sleep quality. For example, nurses who work the night shift tend to report greater sleep disturbances than nurses who work the day shift (Atlantis et al., 2006).

Further, studies could use a multi-item measure of sleep quality. Although the current study made a strong argument for the use of a single item measure of sleep there are some well validated and reliable multi-item measures of sleep. For example, the Pittsburgh Sleep Quality Index (PSQI) is a widely used and well validated measure of sleep (Smyth, 2012). The PSQI measures seven domains of sleep; subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction over the last month. The PSQI measures a wide domain of sleep patterns, and has strong internal reliability ($\alpha = .83$) (Smyth, 2012). The current study measured subjective sleep quality; however the PSQI is appropriate for studies which set out to measure several domains of sleep.

Future studies could examine measures of exercise instead of using a 1-item measure of physical activity. Physical activity is not as intense and physiologically arousing as exercise (Casperson et al., 1985), which may explain why the current study found an association between physical activity and sleep for the 10 hour or longer shift sample but not the night shift sample. Exercise may have a stronger relationship with quality of sleep because exercise is performed at a greater intensity than general physical activity, and exercise may be physiologically arousing enough to ameliorate circadian rhythm disruptions among night shift workers.

In addition, studies could evaluate the effects of different forms of exercise (weightlifting vs endurance training) for improving quality of sleep among employees. Weightlifting trains the anaerobic system and the endurance exercises train the aerobic system. Both weightlifting and endurance exercise train the human body via different physiological routes. Therefore, the physiological differences in training mechanisms between different forms of exercise may have differential impacts on sleep quality. Future studies that compare the effects of various forms of exercise on sleep quality will aid in the development of exercise interventions targeted at improving sleep quality.

Studies could also branch into other occupations that require employees to work shift work. Future studies could compare the effects of workload on quality of sleep between differing occupations, and examine if exercise has similar effects on quality of sleep for both groups. For example, the effects of quantitative workload on quality of sleep among white collar occupations could be compared to more physically demanding jobs such as nursing or construction. A comparison between jobs with differing levels of occupational physical activity is important because high quantitative workload for nurses may involve more physical activity than someone employed as a secretary. The implications for the comparison across different occupations is clear; employees who work less physically demanding jobs may benefit more from exercise programs than employees who are already getting high levels of physical activity from performing their job.

Finally, it is often difficult to convince organizations to implement exercise or physical activity programs because organizations are not convinced that these interventions will have any benefit. Studies linking or demonstrating the potential benefits to the employees and organization in terms of financial gain are critical for gaining organizational support for a physical activity or exercise program.

Conclusions

In conclusion, some novel relationships were established in this study. High quantitative workload was related to decreased quality of sleep among two separate samples of nurses; nurses who work 10 hour or longer shifts and nurses who work the night shift. Further, higher levels of physical activity were related to higher levels of sleep quality among nurses who work 10 hour or longer shifts. Organizations need to recognize the negative impact a high quantitative workload can have on quality of sleep, and promote physical activity and exercise as a possible factor for improving quality of sleep among employees.

APPENDICES

APPENDIX A

Quantitative Workload Scale

Please indicate how often you have experienced each of the following in your primary job over the past 30 days.

5-Point Response Scale: never-almost never-sometimes-often-very often

1) I worked too many hours in a shift.
2) I worked too many shifts in a week.
3) I missed rest/meal breaks.
4) I did not have enough time to provide emotional support to my patients.
5) I did not have enough time to complete all of my nursing tasks.
6) I had too many non-nursing tasks required, such as clerical work.
7) I did not have enough time to respond to the needs of my patients' families.
8) Patient acuity was too high.
9) Care intensity was too high.

APPENDIX B

Items Measuring Neuroticism

5-Point Response Scale: strongly disagree-disagree-neutral-agree-strongly agree

1) Sometimes I feel depressed*
2) I am capable of coping with most of my problems
3) There are times when things look pretty bleak and hopeless to me*
4) I have frequent mood swings
5) I am not easily bothered by things*

*Reverse scored items

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FIGURE 1

Moderation and Mediation

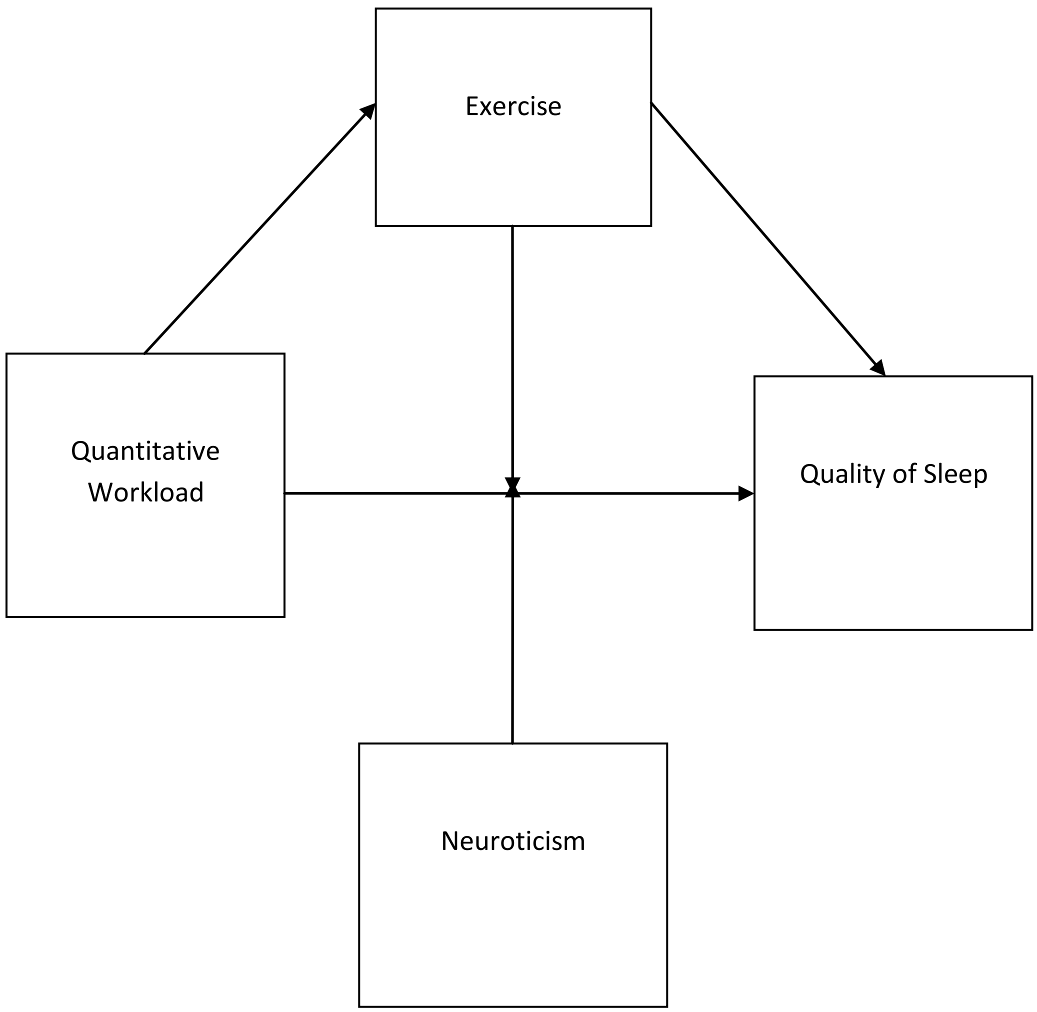

FIGURE 2

ONRP Research Overview

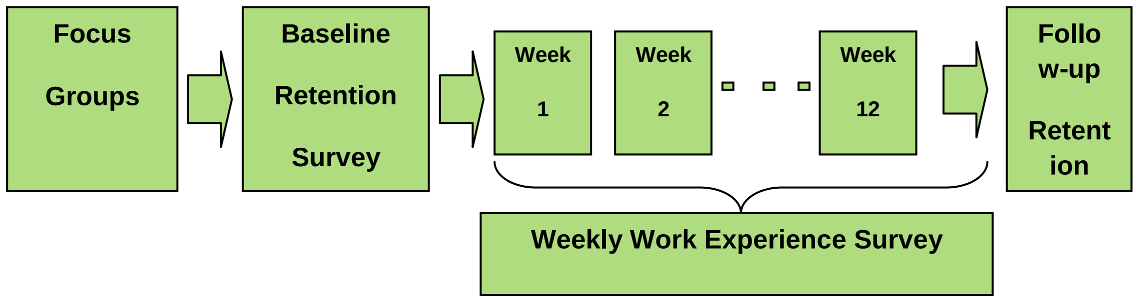

FIGURE 3

Simple Slopes of the Interaction between Quantitative Workload and Physical Activity

for the 10 Hour or Longer Shift Sample

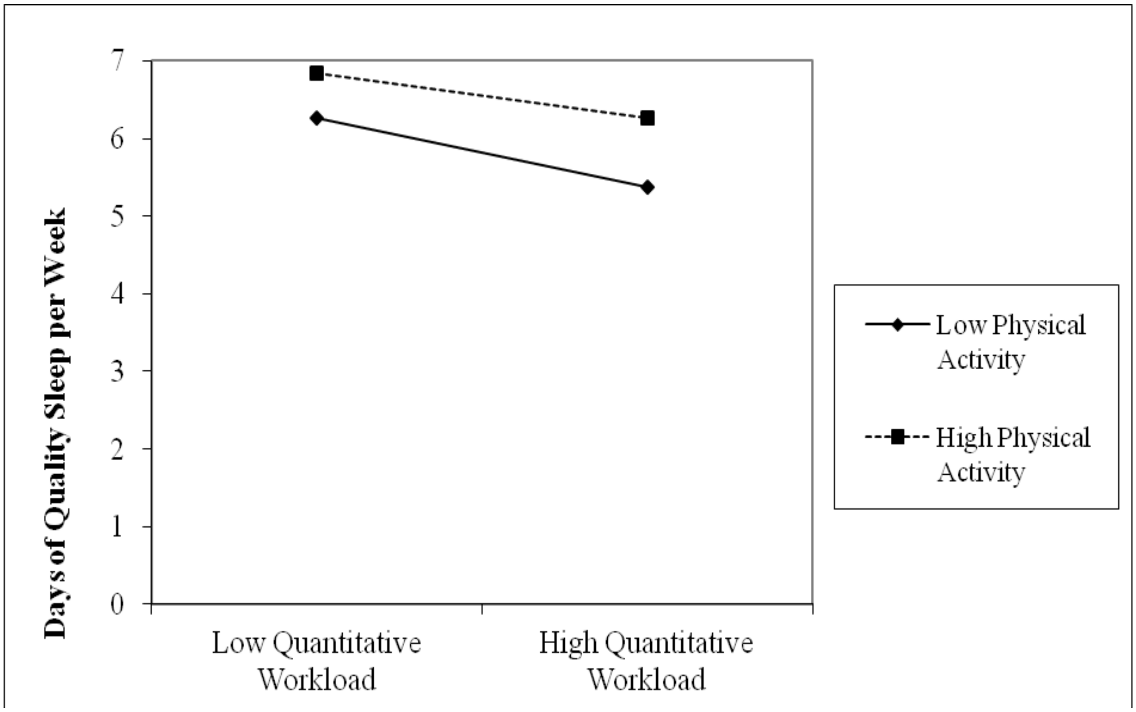

FIGURE 4

Simple Slopes of the Interaction between Physical Activity and Neuroticism for the 10 hour or Longer Shift Sample

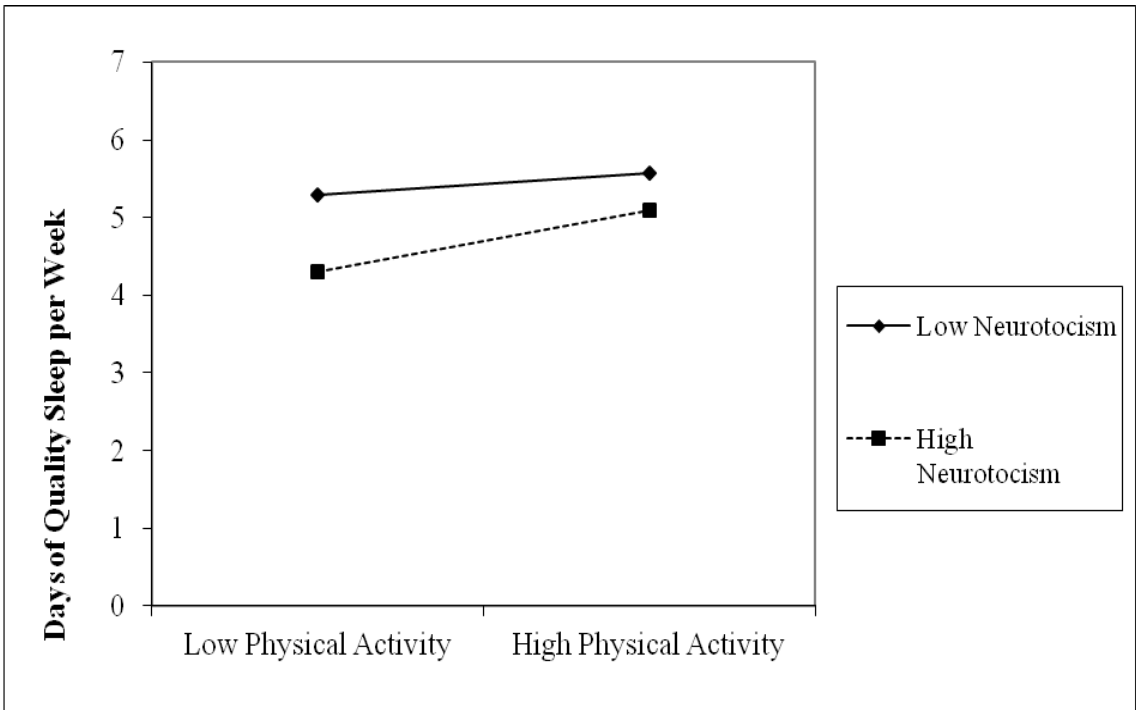

FIGURE 5

Simple Slopes of the Interaction between Quantitative Workload and Physical Activity for the Night Shift Sample

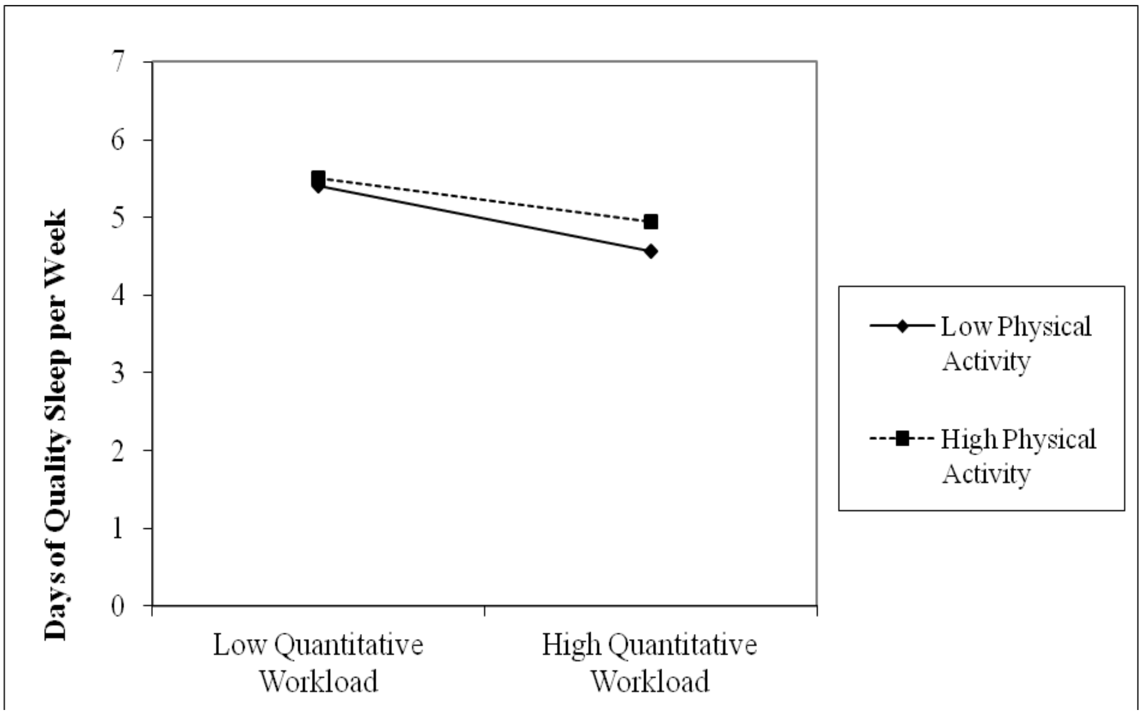

FIGURE 6

Simple Slopes of the Interaction between Quantitative Workload and Physical Activity for the Night Shift Sample

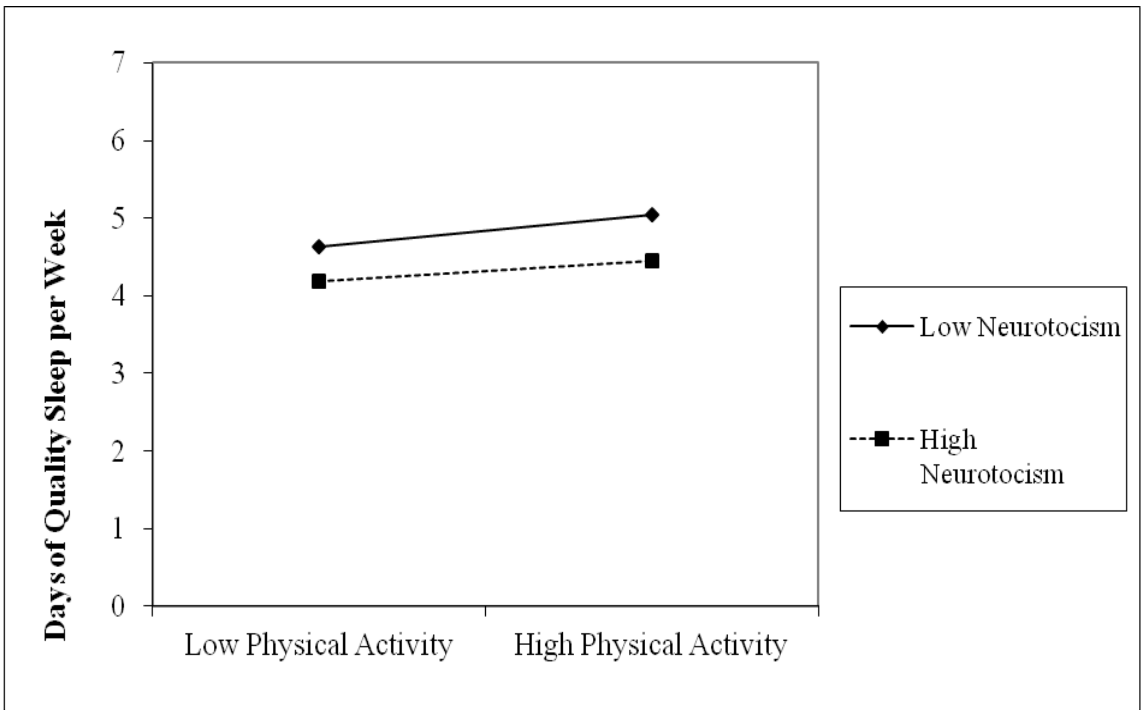

TABLE 1

Demographic Differences in Means for 10 Hour sample and Original Sample

Demographics	10 Hour Sample Means	Original Sample Means	*df*	*t value*
Age	43.20	48.90	394	5.14
	(11.25)	(10.58)		
Hour Scheduled per Week	33.57	30.28	397	-4.07***
	(5.89)	(10.07)		
Shifts per Week	3.25	3.81	389	4.41***
	(1.16)	(1.35)		
Hours Worked per Week	37.19	33.11	396	-4.03***
	(8.24)	(11.86)		
Voluntary Overtime Hours	4.11	3.47	384	-1.21**
	(5.68)	(4.44)		
Occupational Tenure	14.81	21.27	400	5.49
	(11.94)	(11.51)		
Organizational Tenure	8.77	13.66	399	5.42**
	(8.29)	(9.78)		

* = $p < .05$; ** = $p < .01$; *** = $p < .001$. Standard deviations appear in parentheses below means.

TABLE 2

Demographic Differences in Means for the Night Shift Sample and Original Sample

Demographics	10 Hour Sample Means	Original Sample Means	*df*	*t value*
Age	39.69	47.80	382	6.36
	(11.09)	(10.73)		
Hour Scheduled per Week	32.71	31.66	383	-1.08
	(8.98)	(8.08)		
Shifts per Week	3.37	3.54	376	1.08
	(1.21)	(1.33)		
Hours Worked per Week	35.96	34.86	383	-.89
	(10.47)	(10.46)		
Voluntary Overtime Hours	4.01	3.74	372	-.43
	(5.23)	(5.18)		
Occupational Tenure	10.83	19.98	388	6.79
	(11.24)	(11.58)		
Organizational Tenure	6.54	12.63	387	5.82***
	(7.40)	(9.38)		

* = $p < .05$; ** = $p < .01$; *** = $p < .001$. Standard deviations appear in parentheses below means.

TABLE 3

Means, Standard Deviations, and Correlations of Measured Variables for the 10 Hour or Longer Shift Sample

	Variable	Mean	SD	1	2	3
1	Quantitative Workload	2.85	.88			
2	Physical Activity	3.93	1.92	.05		
3	Neuroticism	2.56	.67	.11	-.15*	
4	Sleep	5.61	1.47	-.15*	.29**	-.29**

* = $p < .05$; ** = $p < .01$ (two-tailed)

TABLE 4

Means, Standard Deviations, and Correlations of Measured Variables for the Night Shift Sample

	Variable	Mean	SD	1	2	3
1	Quantitative Workload	2.68	.86			
2	Physical Activity	3.48	1.86	-.10		
3	Neuroticism	2.53	.70	.21*	-.04	
4	Sleep	5.41	1.38	-.29*	.12	-.16

* = $p < .05$; ** = $p < .01$ (two-tailed)

TABLE 5

Linear Regression Analyses for the 10 Hour or Longer Shift Sample

Three Separate Regressions	Unstand. B	SE	DF	t-value	F	R^2
1:QW-Sleep	-.23	.12	179	-1.90*	5.68***	.11
2:QW-PA	.13	.16	179	.81	2.48*	.05
3:PA-Sleep	.19	.05	179	3.42**	7.91***	.15

QW = Quantitative Workload; PA = Physical Activity

* = $p < .05$; ** = $p < .01$; *** = $p < .001$

TABLE 6

Linear Regression Analyses for the Night Shift Sample

Three Separate Regressions	Unstand. B	SE	DF	t-value	F	R^2
1:QW-Sleep	-.45	.18	72	-2.49*	2.83*	.14
2:QW-PA	-.23	.26	72	-.89	.36	.02
3:PA-Sleep	.09	.09	72	1.05	1.47	.08

QW = Quantitative Workload; PA = Physical Activity

* = $p < .05$; ** = $p < .01$; *** = $p < .001$

TABLE 7

Physical Activity as a Mediator of the Relationship between Quantitative Workload and Quality of Sleep for the 10 Hour or Longer Shift Sample

Model	Unstand. B	SE	DF	t-value	Bias Corrected Confidence Intervals
IV-M Direct Effect: QW-PA	.12	.16	181	.75	
IV-DV Direct Effect: QW-Sleep	-.25	.12	181	-2.11*	
M-DV Direct Effect: PA-Sleep	.19	.05	181	3.45***	
IV-DV Total Effect: QW-Sleep	-.23	.12	176	-1.86	Lower: -.03 Upper: .10

QW = Quantitative Workload; PA = Physical Activity; DV = Dependent Variable; IV = Independent Variable; M = Mediator

* = $p < .05$; ** = $p < .01$; *** = $p < .001$

Model Summary: $R^2 = .17$, $F(5, 176) = 7.14$, $p < .001$

TABLE 8

Physical Activity as a Mediator of the Relationship between Quantitative Workload and Quality of Sleep for the Night Shift Sample

Model	Unstand. B	SE	DF	t-value	Bias Corrected Confidence Intervals
IV-M Direct Effect: QW-PA	-.25	.27	75	-.93	
IV-DV Direct Effect: QW-Sleep	-.49	.19	75	-2.63*	
M-DV Direct Effect: PA-Sleep	.06	.08	75	.75	
IV-DV Total Effect: QW-Sleep	-.49	.19	70	-2.63*	Lower: -.13 Upper: .02

QW = Quantitative Workload; PA = Physical Activity; DV = Dependent Variable; IV = Independent Variable; M = Mediator

* = $p < .05$; ** = $p < .01$; *** = $p < .001$

Model Summary: $R^2 = .15$, $F(5, 70) = 2.46$, $p < .05$

TABLE 9

Analyses of Physical Activity as a Moderator between Quantitative Workload and Quality of Sleep for the 10 Hour or Longer Shift Sample

Variable	Unstand. B	SE	DF	t-value	R^2	R^2 Change	F Change
Model 1:					.17	.17	7.37
QW-Sleep	-.25	.17	177	-2.17*			
PA-Sleep	.19	.05	177	3.57**			
Model 2:					.17	.00	.19
QW-Sleep	-.35	.26	176	-1.35			
PA-Sleep	.12	.19	176	.61			
QW x PA	.03	.06	176	.43			

QW = Quantitative Workload; PA = Physical Activity

* = p < .05; ** = p < .01

TABLE 10

Analyses of Neuroticism as a Moderator between Physical Activity and Quality of Sleep for the 10 Hour or Longer Shift Sample

Variable	Unstand. B	SE	DF	t-value	R^2	R^2 Change	F Change
Model 1:					.15	.15	7.82**
PA-Sleep	.19	.06	177	3.40**			
NE-Sleep	-.54	.15	177	-3.49**			
Model 2:					.16	.01	2.66
PA-Sleep	-.15	.21	176	-.70			
NE-Sleep	-1.05	.35	176	-3.01**			
PA x NE	.13	.08	176	1.63			

PA = Physical Activity, NE = Neuroticism

* = $p < .05$; ** = $p < .01$

TABLE 11

Analyses of Physical Activity as a Moderator between Quantitative Workload and Quality of Sleep for the Night Shift Sample

Variable	Unstand. B	SE	DF	t-value	R^2	R^2 Change	F Change
Model 1:					.14	.14	2.36*
QW-Sleep	-.44	.18	70	-2.37*			
PA-Sleep	.07	.08	70	.83			
Model 2:					.14	.00	.17
QW-Sleep	-.57	.37	69	-1.55			
PA-Sleep	-.06	.32	69	-.18			
QW x PA	.05	.11	69	.42			

QW = Quantitative Workload; PA = Physical Activity

* = $p < .05$; ** = $p < .01$

TABLE 12

Analyses of Neuroticism as a Moderator between Physical Activity and Quality of Sleep for the Night Shift Sample

Variable	Unstand. B	SE	DF	t-value	R^2	R^2 Change	F Change
Model 1:					.08	.08	1.45
PA-Sleep	.09	.09	71	1.05			
NE-Sleep	-.34	.23	71	-1.50			
Model 2:					.08	.00	.04
PA-Sleep	.17	.39	70	-.44			
NE-Sleep	-.26	.44	70	-.60			
PA x NE	-.03	.14	70	-.21			

PA = Physical Activity; NE = Neuroticism

* = p < .05, ** = p < .01