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Nurse Health: The Influence of Chronotype and Shift Timing

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Abstract

Extreme chronotype and circadian disrupting work hours may increase nurse disease risks. This national, cross-sectional study of nurses (*N* = 527) had three hypotheses. When chronotype and shift times are incongruent, nurses will experience increased likelihood of (1) obesity, (2) cardiovascular disease/risk factors, and (3) obesity or cardiovascular disease/risk factors when theoretically linked variables exist. Chronotype mismatched nurses' (*n* = 206) average sleep (6.1 hours, *SD* = 1.2) fell below 7–9 hours/24-hours sleep recommendations. Proportion of male nurses was significantly higher chronotype mismatched (12.3%) than matched (6.3%). Analyses found no direct relationship between chronotype match/mismatch with outcome variables. Exploratory interaction analysis demonstrated nurses with mismatched chronotype and above average sleep quality had an estimated 3.51 times the adjusted odds (95% CI 1.52,8.17; *p* = .003) of being obese. Although mechanism is unclear, this suggests sleep quality may be intricately associated with obesity. Further research is needed to inform nurses on health risks from disrupted sleep, chronotypes, and shift work.

Keywords

chronotype; obesity; cardiovascular disease; shift work; healthcare workers; sleep

Obesity affects 38.9% of the United States adult population (National Center for Health Statistics, 2018). Additionally, Americans are suffering from hypertension (33.4%), type 2 diabetes (12.6%), and cardiovascular disease (CVD) (21.6% of adults aged 65 years and over). Health care workers are not immune, as they experience a rise in obesity (Gu et al., 2014) and cardiovascular disease risk factors prevalence (Shockey et al., 2016).

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Simultaneously, 38% of nurses and other healthcare workers regularly experience short sleep (≤ 6 hours/24-hour period; Luckhaupt et al., 2010) and decreased sleep quality (Caruso et al., 2017). Insufficient sleep duration and quality increases the risk for developing cardiovascular disease, metabolic syndrome, diabetes, obesity, and other chronic health conditions (Luyster et al., 2012). Recent evidence suggests altered sleep/wake cycles resulting from circadian rhythms and individualized chronotype misaligned with shift work timing is associated with increased disease development (Vetter et al., 2015a). Considering these associations between sleep, shift work, and adverse health outcomes, the risks to nurses needs to be examined.

Sleep Preferences, Shift Timing, and Nurse Health

Long shifts, overtime, rotating shifts, and work hours that disrupt circadian rhythms (work occurring outside the time of 7am to 6pm [Drake & Wright, 2017]) are all occupational characteristics contributing to nurses' insufficient sleep (Caruso, 2014). Individual factors, such as chronotype, also can influence sleep duration and quality. Chronotype is an individual's preferred time for sleeping (Adan et al., 2012). For example, late chronotypes prefer to wake up later in the morning and go to sleep later in the evening. Conversely, early chronotypes prefer to wake up early in the morning and go to sleep earlier in the evening. When work hours conflict with these personal sleep preferences, nurses can experience a misalignment between time available for sleep and their natural circadian rhythms, resulting in shorter sleep duration and decreased sleep quality (Lee et al., 2015).

Circadian rhythms regulate many body systems, including hormone secretions, body temperature, and digestion processes (Czeisler & Buxton, 2017). Circadian rhythms' control center, located in the hypothalamus, acts as a conductor for these various physiological functions, coordinating the timing of the processes over a roughly 24-hour cycle. Circadian misalignment occurs when these 24-hour cycles are not synchronized with the sleep–wake cycle (Revell & Eastman, 2005). This most commonly occurs with shift workers and individuals traveling across time zones and can result in fragmented and shorter sleep duration (Czeisler & Buxton, 2017). Validated chronotype surveys confirm individuals scoring as late chronotypes have delayed circadian rhythms, manifesting in natural later sleep/wake times than individuals who are intermediate and early types (Adan et al., 2012). When social constraints, such as work start/end times, dictate when an individual must be awake, those with extreme chronotypes (early and late) and/or individuals working atypical work hours (such as night shift) are at risk for circadian misalignment (Wittman et al., 2006). Furthermore, evidence suggests this mismatch of chronotype and shift hours leads to a greater risk for adverse health outcomes (Vetter et al., 2015a). Therefore, examining shift times and chronotype may indicate which shift workers will be most at risk for circadian misalignment, short sleep, and disease development.

Epidemiological evidence suggests when individuals suffer from circadian misalignment, an association exists between their short sleep and obesity (Roenneberg et al., 2012). In a meta-analysis, Cappuccio et al. (2008) determined short sleep increased the risk for obesity in adults by 55% (pooled calculated OR 1.55, 95% confidence interval [CI] 1.43–1.68, $p < .0001$). When the researchers conducted a pooled regression analysis, they found a loss of one hour of sleep per day was associated with a 0.35 kg/m^2 increase in body mass index (BMI) (Cappuccio et al., 2008). Circadian misalignment causes biological changes implicated in obesity development, such as decreased leptin, and increased blood glucose and insulin levels (Scheer et al., 2009). Additionally, a sleep restricted brain causes individuals to desire higher caloric foods, with one study demonstrating an approximately 1-kg weight gain over the 5-day study period (Spaeth et al., 2013). Examining how chronotype interacts with obesity, late chronotypes have been reported to have higher incidences of obesity (Lucassen et al., 2013), a trend also found in shift worker populations (Wong et al., 2015).

Researchers conducting a meta-analysis of 15 prospective studies report short sleep is associated with an almost 50% higher risk (RR 1.48, 95% CI 1.22–1.80) of developing or dying from cardiovascular disease and a 15% higher risk (RR 1.15, 95% CI 1.00–1.31) of stroke (Cappuccio et al., 2011). Melatonin is suspected to function as an endothelial protector, reducing inflammatory processes associated with cardiovascular disease (Strohmaier et al., 2018). Based on a review of the literature, Strohmaier et al. (2018) present support for a causal association between decreased melatonin levels, due to circadian rhythms disruption, and the increased risk of cardiovascular disease and stroke in sleep deprived individuals. Short sleep in workers has been associated with an increased risk for cardiovascular disease (St-Onge et al., 2016). Barger et al. (2017) followed a cohort of workers (N = 13,036), two years of post-acute coronary syndrome, to explore the association of poor sleep health and cardiac health. Study participants who screened positive for sleep apnea had a 12% increased risk of a recurrent major cardiac event and those who worked night shift had a 15% increased risk. Participants who reported short sleep had 29% increased risk, strengthening the evidence between short sleep and cardiovascular disease.

Additionally, short sleep and circadian misalignment is linked to various known contributors to cardiovascular disease, including hypertension and diabetes (St-Onge et al., 2016). Laboratory studies have implicated short sleep and circadian disruption in elevated glucose levels (Buxton et al., 2012), increased blood pressure, and increased inflammatory markers such as C-reactive protein (Morris et al., 2016). Low melatonin levels contribute to endothelial oxidation and vessel inflammation in the peripheral vascular system, a condition associated with hypertension (St-Onge et al., 2016; Strohmaier et al., 2018). Low melatonin levels also are associated with altered insulin secretion from the pancreas, promoting glucose intolerance and insulin resistance in workers experiencing circadian disruption (Peschke, 2008). Although research findings are helping to connect the pathophysiological relationship between the circadian system, short sleep, and cardiovascular health, the gaps in the literature were recognized by the American Heart Association, prompting a call for further research (St-Onge et al., 2016).

When examining how chronotype may predict cardiometabolic health, a cross-sectional study (N = 439,933) demonstrated early chronotypes, coupled with seven to eight hours of sleep in 24-hour period, had less cardiovascular risk factors than other chronotypes (Patterson et al., 2017). When examining nurses' chronotype and incidence of newly developed type 2 diabetes, Vetter et al. (2015a) reported nurses who identified as being late chronotypes and working dayshift had a 50% higher risk of developing diabetes, compared to intermediates. Conversely, early chronotypes had a lower risk of diabetes when working day shift. Wong et al. (2015) found dayshift workers (N = 447) identifying as a late chronotype were more likely to have higher triglycerides and lower HDL cholesterol levels. These findings suggest workers with a chronotype incongruent with their shift timing may be at greater risk for disease. Research is needed to examine how these individual differences increase the risks of shift workers developing obesity and cardiometabolic diseases.

Purpose

The purpose of this study is to investigate the relationship of shift work timing (morning, evening, or night shift) and chronotype (early, intermediate, or late chronotype) on obesity and cardiovascular disease/risk factor outcomes in registered nurses. Three hypotheses were tested:

1. When registered nurse chronotype is incongruent with shift timing, nurses will experience increased likelihood of obesity (BMI ≥ 30).
2. When registered nurse chronotype is incongruent with shift timing, nurses will experience increased likelihood of suffering from cardiovascular disease (heart attack, angina, or cardiac arrhythmias) and/or cardiovascular disease risk factors (diabetes, high blood pressure, hypercholesterolemia, or diabetes mellitus).
3. When registered nurse chronotype is incongruent with shift timing, nurses will experience more disease (obesity or cardiovascular disease risk factors) when theoretically linked variables are present.

Method

Study Design, Sample, and Setting

This study is a secondary analysis of a de-identified dataset from the National Institute for Occupational Safety and Health (NIOSH) study titled, *Health and Safety Outcomes Related to Work Schedules in Nurses*. The main study purpose was to investigate the associations between hospital-based registered nurses’ work schedules and their health and safety outcomes. Registered nurses were recruited from 15 hospitals in the United States. The hospitals were participating in the American Nurses Association’s National Database of Nursing Quality Indicators program and remained anonymous to NIOSH staff. Inclusion criteria included full-time employment at the hospital; providing direct patient care a minimum of 50% of work hours; work on medical, surgical, step-down, or intensive care units; and work for 6-month minimum at current schedule. Registered nurses were recruited to complete a 276-item self-report survey based on a theoretical model by Barton et al. (1995). Survey items were taken from various sources, including the Standard Shiftworker Index (Barton et al., 1995) and National Health and Nutrition Examination Survey (Center for Disease Control and Prevention [CDC], 2003–2004). Data were collected in the spring of 2004 and 2005. Responses from 527 registered nurses were included in this analysis. Approval was received through the NIOSH Institutional Review Board.

Measures

Variables known to increase risk for CVD were included as confounding variables, including alcohol intake, tobacco use, obesity, and sleep disorders (CDC, 2015). Drinking alcohol in excess of one drink per day for women and two drinks per day for men increases risk for CVD (CDC, 2015). Female respondents indicating drinking more than seven drinks per week and male respondents drinking more than 14 drinks per week were coded as "elevated alcohol risk for CVD." All others were coded as "minimal alcohol risk for CVD." For tobacco use, when individuals have quit using tobacco products for greater than 15 years, their CVD health risks are similar to individuals who have never smoked (American Heart Association, 2015). Therefore, respondents indicating they never used tobacco and those who had quit for greater than 15 years were coded into "never smoked equivalent," with remaining respondents coded as "tobacco CVD risk factor." BMI was calculated from self-report height and weight, with calculated BMIs ≥ 30 kg/m^2 considered obese (American Heart Association, 2015) and divided into "obese" or "not obese" groups. Additionally, because sleep apnea is associated with CVD development (St-Onge et al., 2016), the diagnosis of sleep disorders was considered. Respondents were coded into a dichotomous variable based on their report of being diagnosed with a sleep disorder.

The original study asked respondents to report sleep duration and sleep quality for five types of shifts: 8- to 10-hour day shift, 8- to10-hour evening shift, 8- to 10-hour night shift, 12-hour day shift or 12-hour night shift. Sleep duration was measured in hours and minutes, with respondents instructed to answer questions specific to shifts they regularly worked (i.e., "How many hours of sleep per 24-hour period are you actually getting on average, when you work the 8- to 10-hour day shift?"). Sleep quality was subjectively reported as excellent, good, average, below average, or poor. In some cases, participants provided sleep duration times for multiple shifts. For example, a nurse may usually work a 12-hour day shift but occasionally also work an 8- to 10-hour evening shift. Thus, the participant may have reported sleep duration for both the 12-hour day shift and the 8- to 10-hour evening shift. Answers were compared to the participants' report of what shift they usually worked. For bivariate analyses, all responses reported by participants for sleep duration while working various shift lengths and times (e.g., sleep duration when working 8- to 10-hour evening shift) were included in the analysis (Table 3). For the multiple logistic regression models (Tables 4 and 5), the variable "sleep duration" represents the sleep duration reported during the shift most usually worked (e.g., 12-hour day shift).

To determine chronotype and shift timing congruency, a new variable was constructed. This variable was based on two questions, one related to Morningness–Eveningness tendencies and another regarding the predominant shift worked. For the Morningness–Eveningness question, participants were provided a question from the shortened version of the Standard Shiftworker Index to determine chronotype tendencies (Tucker et al., 1998). The question inquires "Are you the sort of person who feels at their best early in the morning and tends to feel tired earlier than most people in the evening." Responses were on a Likert scale of 0–8, with 0 indicating the respondent is definitely not an early morning person and 8 indicating the respondent is definitely a morning person. Although chronotype exists on a continuum, to create a variable to match chronotype with shift timing required a determination of what constitutes a late, intermediate, and early chronotype. After discussion with experts in the field, 0–1 was identified as late chronotype, 2–6 as intermediate, and 7–8 as early chronotype. Predominant shift worked was divided into dayshift (8 and 12 hours), evening shift (8 and 12 hours), night shift (8 and 12 hours), two shift rotations (day/evening or day/night), and three shift rotations (day, evening, and night). Shift timing break off points were as follows: day shifts included shifts beginning and ending within 6am and 7pm, evening shifts included shifts beginning and ending between 11am and 12am, and night shifts included shifts beginning and ending between 7pm and 8am.

Once chronotype and predominant shift worked were determined, the two were combined to create the independent variable of "chronotype match." This dichotomous variable indicated whether a worker's shift timing (dayshift, evening shift, night shift, or rotating shift) aligned with sleep preferences (chronotype). When early chronotypes are working day shift, their sleep preference matches what time they need to be awake for work, therefore, "matching" chronotype with shift timing. When early chronotypes must work night shift, their preference for going to bed early in the evening and waking up early in the morning is incongruent with working night shift. Therefore, early chronotype would be a "mismatch" to night shift. In this analysis, chronotype match and mismatch was determined as follows: late chronotypes were matched when working evening shift or night shift, intermediate chronotypes were matched when working dayshift or evening shift, and early chronotypes were matched when working day shift. All other pairings were marked as mismatched.

Obesity and CVD risk factor/disease were the dichotomous dependent variables. Obesity was defined as a BMI ≥ 30 kg/m^2 (CDC, 2017a) and coded accordingly into a dichotomous variable of "obese" or "not obese." Because only a few participants reported being diagnosed with CVD or conditions that are risk factors for CVD, it was decided to make a combined variable of CVD risk factor/disease. These conditions are all either a form of CVD (e.g., heart attack) or are risk factors for CVD (e.g., diabetes mellitus; CDC, 2017b). Six health outcomes were included in this variable: angina, heart attack, high blood pressure, cardiac arrhythmia, hypercholesterolemia, and diabetes mellitus. Respondents who self-reported at least one of these conditions were coded yes "1," and those without were coded "0."

Data Analysis

Data were analyzed using IBM SPSS Statistics V25. Chisquare test of independence was used to compare the distribution of categorical variables (gender, race, marital status, alcohol intake, tobacco use, sleep quality, presence of sleep disorder, BMI, and CVD risk factors/disease) by chronotype match/mismatch (Table 2). The independent samples *t*-tests were performed to compare means of continuous characteristics (age, years employed as a nurse, hours per week worked, and sleep duration) by chronotype match/mismatch (Table 3). Alpha was set at 0.05. Logistic regression was used to estimate the odds ratio (OR) and 95% CI of obesity and CVD risk factors/disease associated with chronotype match/mismatch (Tables 4 and 5). Multivariable logistic regression models included covariates suggested by the literature. Exploratory analysis with logistic regression was conducted to explore interactions with chronotype match/mismatch. This exploratory analysis is meant to elucidate potential subgroup specific effects that could be studied further in future studies.

Results

Sociodemographic Descriptive Statistics

The mean age of study participants was 40.6 years (*SD* = 10.3) and the majority were female (91.4%), white (86.7%), and partnered in marital status (69.6%; see Table 1). Other races (Asian, Black, Other races or Multiracial) each accounted for less than 7% of the sample. The average years of employment as a registered nurse was 13.1 years (*SD* = 9.9) and the average hours of work per week were 39.8 hours (*SD* = 6.8). A majority of the participants (60.6%) were above the CDC's guideline for normal BMI. Nearly 30% self-reported at least one CVD risk factor or disease, with high blood pressure being the most frequent risk factor reported (16.1%).

Comparison of Variables among Chronotype Match/Mismatch

Among the variables compared between chronotype match/mismatch, gender, sleep duration, and sleep quality demonstrated significant differences (Tables 2 and 3). Higher percentage of males reported chronotype mismatch relative to females (p = .017), indicating a relationship between chronotype match/mismatch and gender. Both chronotype match and mismatch groups reported average sleep duration (6.4 hours, *SD* = 1.0 and 6.1 hours, *SD* = 1.2, respectively) below the 7-hour level recommended by experts (Hirshkowitz et al., 2015), but respondents with chronotype mismatch reported even less sleep than those with chronotype match (p = .004). However, when sleep duration was compared for each shift timing/length separately, no significant differences were observed by chronotype match/mismatch (Table 3). Differences in sleep quality were noted between chronotype match versus mismatch (p = .019). The proportion of respondents who reported at least average sleep quality was higher for those with chronotype match. Those self-reporting below average or poor sleep were proportionally higher in the chronotype mismatch group (p = .017).

Chronotype Match and Obesity (Hypothesis 1)

Unadjusted logistic regression analyses of chronotype match/mismatch with obesity did not demonstrate a significant association (p = .611). When all the variables (chronotype match, sleep quality, sleep duration, age, gender, and race) were added to a multiple logistic regression model, the model was statistically significant (p = .001). However, based on Nagelkerke R^2 the model only accounts for 9.1% of the variance. The full model had an accuracy of 70%, while the null model (intercept only model) had an accuracy of 70.7%, indicating the full model did not successfully predict obesity. When examining each independent variable in the model, two variables, age and race, did demonstrate statistically significant differences and contributions to the model (Table 4). This is not surprising as variances in obesity prevalence is noted among various age brackets and races (CDC, 2019).

Chronotype Match and Cardiovascular Disease Risk Factors (Hypothesis 2)

Logistic regression results of chronotype match/mismatch on CVD risk factor/disease were not significant (X^2 [1, n = 527] = 1.252, p = .263). Subsequently, all variables of interest (chronotype match, sleep quality, sleep duration, sleep disorder presence, age, gender, race, BMI, alcohol intake, and tobacco) were added to a multiple logistic regression model. Statistically significant results were obtained (X^2 [15, n = 464] = 85.84, p < .001), with the model accounting for 24% of the variance (Nagelkerke R^2 = .24). The full model had an accuracy rate of 76.3%, while the null model (intercept only model) had an accuracy of 70.7%. Although an improvement is noted, this is most likely in part due to the significance of age and BMI in the model (Table 5).

Exploratory Interaction Effect Analysis

After the main hypotheses were found insignificant, an exploratory interaction analysis was conducted. Each factor for each dependent variable was tested for an interaction effect with chronotype match/mismatch. (For obesity, the variables included sleep quality, sleep duration, race, gender, and age. For CVD/CVD related risk factors, the variables included sleep quality, sleep duration, sleep disorders, tobacco use, alcohol intake, BMI, gender, age, and race). Results indicated a potential interaction between sleep quality and chronotype match/mismatch with obesity as the outcome variable. To investigate this interaction further, sleep quality was condensed from five categories to three: “Excellent” and “good” quality sleep were combined to “above average” sleep quality, “average” sleep remained as is, and “below average” and “poor” sleep were combined to “below average” sleep quality (Table 6). The results of interaction effects with this three-level sleep quality variable demonstrated nurses with mismatched chronotype and above average sleep quality had an estimated 3.51 times the adjusted odds (95% CI 1.52,8.17; p = .003) of being obese compared to nurses with matched chronotype and above average sleep quality.

Discussion

The purpose of this analysis was to investigate the impact of nurse chronotype match/mismatch on the prevalence of obesity and CVD/CVD related risk factors. The results indicate that chronotype match/mismatch did not impact disease outcomes independently, but interesting findings were still noted. Nurses with chronotype mismatch were composed of significantly higher proportion of men (12.3%) compared to male nurses with chronotype match (6.3%). Research investigating chronotype and sex differences support men tend to report a later chronotype than women from approximately 20 to 40 years of age (Fischer et al., 2017). Additionally, a slightly higher percentage of men versus women work shifts alternative to day shift (Alterman et al., 2013). Hormonal and developmental changes are thought to explain some of these sex-based variations, although domestic gendered roles may also influence differences in tolerance (Ritonja et al., 2019). Further investigation into sex and gender differences in shift work timing is warranted.

Nurses with chronotype match had a sleep duration that was 18-minutes longer compared to those with chronotype mismatch, a result consistent with reports from previous studies (Van de Ven et al., 2016). Because chronotype mismatch could be indicative of circadian misalignment, shortened sleep duration would be anticipated given these workers are attempting to sleep while the circadian system is signaling the body to be awake. Unfortunately, both chronotype match and mismatch groups are already sleeping below the daily recommended sleep requirement of 7–9 hours of sleep in a 24-hour period (Hirshkowitz et al., 2015). Curiously, the average hours of sleep per day between chronotype match/mismatch was not significantly different when compared by shift lengths and shift timing. This is likely due to the multiple respondents who provided more than one answer, including answers for shifts they were not working consistently. Therefore, it is possible these additional responses prevented sleep duration related to worked hours from presenting as significant, resulting in a Type II error. Of note, the lowest sleep duration for both groups was reported during both 8-to10-hour night shifts (for chronotype matched) and 12-hour night shifts (for chronotype mismatched).

When comparing the study population description to national averages, the gender differences were comparable with 90.7% of the study population being females and 92.2% of registered nurses reporting as female in 2004 (U.S. Bureau of Labor Statistics, 2005). Slight differences between the study population and national averages for registered nurses existed by race. Race distribution across the national registered nurse workforce has been reported as 80.4% White, 9.9% Black, and 7.9% Asian (U.S. Bureau of Labor Statistics, 2008). In comparison, the study population was 86.7% White, 4.8% Black, 6.6% Asian, and 1.9% Other races or Multiracial. Despite these differences, the odds of being obese among Asian Americans was 93% smaller compared to odds of being obese among Whites (OR = 0.07; 95% CI 0.01, 0.55, $p = .01$). Asian Americans have trended nationally in the United States to have lower BMIs than White, Black, or Hispanic Americans (Hales et al., 2017).

Because several risk factors increase risk for obesity and CVD, theoretically linked variables were included into multiple logistic regression models to assess the influence of these variables, along with chronotype match/mismatch, on each outcome variable. When evaluating the CVD risk factor/disease dependent variable, it was determined any significance found in the model was driven by age and obesity. This is not surprising, considering both are well known risk factors for heart disease and other CVD risk factor diseases (American Heart Association, 2018). Lack of statistical significance noted for other well-established risk factors, such as sleep disorder history and alcohol intake could be due to the low number of study participants who were positive for any of these health issues.

Of interest in the exploratory analysis was an interaction effect noted for registered nurses experiencing chronotype mismatch with above average sleep quality on the outcome of obesity. Sleep quality has previously been found to improve when chronotype was matched with shift timing (Vetter et al., 2015b). Therefore, above average sleep quality and chronotype mismatched to shift timing was not anticipated to be associated with obesity. These results may just give a glimpse of the intricacy of the issue, because the relationship between shift work, sleep, and obesity is a complex picture. Broussard and Van Cauter (2016) reflect on how circadian desynchrony causes not only elevated ghrelin levels, which increases appetite, but also a disruption to the gut microbiome resulting in increased caloric uptake in the gut. Additionally, Markwald and Wright (2012) describe how the eating habits of workers experiencing short sleep, poor sleep quality, and circadian misalignment are compounded not only by biological influences, but also obesity-contributing behavioral and emotional eating habits (higher sugar intake, anxiety eating, etc.) that occur when working night shift. These same behavioral and emotional eating habits, along with decreased physical activity, are found in late chronotype workers (Mota et al., 2016). As poor sleep creates not only biological changes leading to obesity, it appears behavioral actions also contribute. Chronotype mismatch may just compound the issue.

There are several limitations to this study. The data included in this secondary analysis were collected in 2004–2005. Although this can be considered a limitation, evidence suggests prevalence of short sleep duration among United States' adults has drifted upwards from 2004 to 2017, demonstrating the persistent issue of sleep in the United States (Sheehan et al., 2019) and thus providing baseline evidence for this trend. Self-reported sleep duration is not always reported accurately, when compared to actigraphy, and sleep quality has been challenging to objectively quantify due to varying definitions (Blunden & Galland, 2014; Johnson et al., 2019). Additionally, the study population had a lower representation of Black nurses in comparison to the national registered nurse population. This lack of representation could have prevented some results from accurately reflecting the experience of this sub-group of registered nurses. This under-representation was a limitation in our ability to detect subgroup specific effect in our exploratory interaction analysis as well as weaken our confidence in the subgroup specific effects we did find. Larger studies with appropriate sample size for under-represented subgroups are needed. Due to the relatively young age of study participants (mean 40.6 years, *SD* 10.3) in relation to average CVD risk factor/disease onset, it is possible the full impact of shift work hours and chronotype match/mismatch on CVD disease and related risk factors is not yet realized. A longitudinal study investigating this phenomenon would give more insight. Finally, not all measurements were conducive to the statistical analysis, including the chronotype match/mismatch variable, necessitating some variables to be developed, collapsed and potentially losing some nuances in the data. A more accurate assessment of circadian misalignment would be to collect biological measures (such as temperature) from nurses during their shifts, which was not feasible in this cross-sectional study, and may have resulted in misclassification of chronotype match/mismatch.

Understanding how chronotype specifically interacts with shift work and timing would allow workers to easily identify individualized risk factors for diseases associated with circadian disruption from shift work. Although this study presented a complicated picture of the impact of chronotype match/mismatch, it did indicate a statistically significant interaction between sleep quality and obesity for chronotype mismatched nurses. Further investigation into this interaction is needed in a larger study before greater conclusions can be made about its meaning and interpretation. Other researchers have supported the hypothesis that a mismatch of chronotype and shift timing is associated with more disease for shift workers. Because of this research and the findings of this study, further research investigating this phenomenon is important. Understanding the complexity of how working night and rotating shifts intersects with individual sleep differences would allow registered nurses to further arm themselves with educated decisions about the risks they are taking when working specific shifts. Additionally, occupational health practitioners and other healthcare providers would be more equipped to counsel individuals working against their natural circadian rhythms.

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Table 1.

Participant Sociodemographics Data ($N = 527$).

Variable	*N* (%)
Gender[a]	
Female	478 (91.4)
Male	45 (8.6)
Race[a]	
Asian	34 (6.6)
Black or African American	25 (4.8)
Other races or Multiracial	10 (1.9)
White	450 (86.7)
Marital status[a]	
Not partnered	80 (15.3)
Partnered	364 (69.6)
Previously partnered	79 (15.1)
Shift scheduled	
8- to10-hour day shift	41 (7.8)
12-hour day shift	227 (43.1)
8- to12-hour evening shift	15 (2.8)
8- to10-hour night shift	80 (15.2)
12-hour night shift	114 (21.6)
2-shift rotation between days and evenings	25 (4.7)
2-shift rotation between days and nights	23 (4.4)
3-shift rotation between days, evenings, and nights	2 (0.4)
Education[a]	
Diploma in nursing	64 (12.3)
Associate degree in nursing	173 (33.1)
Completed Baccalaureate degree in another discipline	14 (2.7)
Baccalaureate degree in Nursing	257 (49.2)
Complete graduate degree (Master's or Doctorate)	14 (2.7)

Note.

[a]Participants with missing values for gender, race, marital status, and education were four, eight, four, and three, respectively.

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Table 2.

Bivariate Comparison of Variables between Chronotype Match and Chronotype Mismatch (Categorical Variables).

Variable	Chronotype Mismatch (n = 206) *N* (%)	Chronotype Mismatch (n = 206) *N* (%)	*p*
Gender[a]			.017
Female	299 (93.7)	179 (87.7)	
Male	20 (6.3)	25 (12.3)	
Race[a]			.996
Asian	20 (6.3)	14 (6.9)	
Black or African American	15 (4.8)	10 (4.9)	
Other races or Multiracial	6 (1.9)	4 (2.0)	
White	274 (87.0)	176 (86.2)	
Marital status[a]			.221
Not partnered	42 (13.1)	38 (18.7)	
Partnered	229 (71.6)	135 (66.5)	
Previously partnered	49 (15.3)	30 (14.8)	
ETOH intake[b]			.439
Minimal risk	302 (94.1)	197 (95.6)	
Elevated risk for CVD	19 (5.9)	9 (4.4)	
Tobacco use[c]			.762
Never used tobacco equivalent	233 (72.6)	152 (73.8)	
Tobacco CVD risk factor	88 (27.4)	54 (26.2)	
Sleep disorder diagnoses			.707
Positive for sleep disorder	18 (5.6)	10 (4.9)	
Negative for sleep disorder	303 (94.4)	196 (95.1)	
Sleep quality[a]			.019
Excellent	17 (5.4)	9 (5.4)	
Good	77 (24.3)	31 (18.6)	
Average	146 (46.2)	64 (38.3)	
Below average	58 (18.4)	53 (31.7)	

Variable	Chronotype Mismatch (n = 206) *N* (%)	Chronotype Mismatch (n = 206) *N* (%)	*p*
Poor	18 (5.7)	10 (6.0)	
BMI			.611
BMI < 30	231 (72.0)	144 (69.9)	
BMI ≥ 30	90 (28.0)	62 (30.1)	
CVD risk factors/disease[d]			.265
No disease	224 (69.8)	153 (74.3)	
Positive CVD risk factor/disease	97 (30.2)	53 (25.7)	

Note.

[a]Participants with missing values for gender, race, marital status, and sleep quality were 4, 8, 4, and 44, respectively.

[b]Minimal risk defined as less than 7 drinks per week for female respondents and 14 drinks per week for male respondents.

[c]Never used tobacco equivalent is defined by individuals who have never smoked or have quit using tobacco products for greater than 15 years.

[d]Participants who responded yes to at least one of the following: angina, cardiac, arrhythmia, diabetes mellitus, heart attack, and high blood pressure. Some respondents were positive for more than one risk factor and/or disease.

Table 3.

Bivariate Comparison of Variables between Chronotype Match and Chronotype Mismatch (Continuous Variables).

	Chronotype Match (n = 321)	**Chronotype Mismatch (n = 206)**	
Variable	**Mean (*SD*)**	**Mean**	***p***
Age[a]	41.2 (10.3)	39.7 (10.3)	.098
Years employed as nurse[a]	13.7 (10.0)	12.2 (9.8)	.098
Hours worked per week[a]	39.4 (7.3)	40.4 (5.8)	.085
Sleep duration[a]	6.4 (1.0)	6.1 (1.2)	.004
Sleep duration when working:[b]			
8–10-hour day shift	6.8 (1.1)	6.7 (1.1)	.954
8–12-hour evening shift	6.8 (1.3)	6.8 (1.6)	.991
8–10-hour night shift	5.9 (1.7)	6.1 (1.6)	.645
12-hour day shift	6.3 (1.0)	6.5 (1.1)	.134
12-hour night shift	6.0 (1.3)	5.9 (1.3)	.735

Note.

[a]Participants with missing values for age, years employed as an RN, hours worked per week, and sleep duration were 5, 8, 7, and 48, respectively.

[b]Some participants answered for multiple shifts.

Table 4.

Multiple Logistic Regression Results (Dependent Variable: Obesity) $N = 527$.

		95.0% CI for Odds Ratio		
	Odds Ratio	**Lower**	**Upper**	***p*-Value**
Chronotype mismatch	0.80	0.51	1.24	.32
Sleep quality (Poor-reference)				
Excellent	0.42	0.10	1.70	.22
Good	0.62	0.23	1.66	.32
Average	0.89	0.36	2.18	.79
Below average	0.90	0.36	2.25	.82
Sleep duration	0.96	0.78	1.20	.73
Age	1.03	1.00	1.05	.01
Gender (Female-reference)	1.53	0.75	3.11	.25
Race (White-reference)				
Asian	0.07	0.01	0.55	.01
Black or African American	1.80	0.75	4.33	.19
Other races or Multiracial	1.44	0.32	6.40	.64

Table 5.

Multiple Logistic Regression Results (Dependent Variable: CVD Risk Factor and/or Disease) $N = 527$.

		95.0% CI for Odds Ratio		
	Odds Ratio	**Lower**	**Upper**	***p*-Value**
Chronotype mismatch	1.39	0.84	2.31	.20
Sleep quality (Poor-reference)				
Excellent	2.14	0.46	9.98	.33
Good	1.55	0.41	5.77	.52
Average	1.70	0.48	5.96	.41
Below average	2.34	0.66	8.32	.19
Sleep duration	1.23	0.98	1.55	.07
Positive sleep disorder history	1.69	0.58	4.92	.34
Age	1.09	1.06	1.11	.00
Gender (Female-reference)	1.88	0.86	4.11	.11
Race (White-reference)				
Asian	0.78	0.29	2.13	.63
Black or African American	1.72	0.63	4.67	.29
Other races or Multiracial	1.34	0.27	6.66	.72
BMI	1.08	1.04	1.11	.00
Alcohol intake	1.54	0.52	4.54	.43
Tobacco use	1.10	0.65	1.84	.73

Table 6.

Crosstabulation of Chronotype, Sleep Quality, and Obesity.

	Chronotype Match (n = 317)		Chronotype Mismatch (n = 167)	
Sleep Quality	**Obese (n = 88)**	**Not Obese (n = 229)**	**Obese (n = 55)**	**Not Obese (n = 112)**
Below average	28 (31.8%)	48 (21.0%)	21 (38.2%)	42 (37.5%)
Average	45 (51.1%)	102 (44.5%)	18 (32.7%)	46 (41.1%)
Above average	15 (17.1%)	79 (34.5%)	16 (29.1%)	24 (21.4%)