The Sleep-Related Effects of Circadian Misalignment on Aviation Shift Workers

Orin Sweetman

X19407024

National College of Ireland

Bachelor of Arts Honours Psychology

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Supervised by Michael Cleary-Gaffney

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Name: Orin Sweetman

Student Number: x19407024

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Abstract

This study aimed to investigate the sleep-related effects of circadian misalignment on aviation shift workers, by first examining if a higher prevalence of sleep disturbance was experienced by shift workers based on their shift disfavor and gender, respectively. It was then examined whether 'morning-type' workers experienced a higher prevalence of sleep disturbance than 'evening-type' workers, before deducing if sleep disturbance was a predictor of a worker's overall life satisfaction, before and after the accountability for sex and age. The sample for the current study consisted of 31 aviation shift workers of a renowned Irish-based airline; the study adopted an experimental, cross-sectional research design with a quantitative statistical approach. An introductory questionnaire accompanied by three pre-established questionnaires were distributed to these participants. Results were of no significance across the board, with the implication that future research needs to be conducted, particularly in the avenue of the predictive relationship between sleep disturbance and overall life satisfaction. Limitations included distribution of study materials to workers of different alternating shift rotas, rather than one definitive rota applicable to all, as well as the consistent gaps in the current knowledge base rendering it difficult for this study to critically evaluate the results it found.

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Introduction

Literature Review

Circadian rhythmicity is essentially defined as the beating of the internalized 24-hour clock that each human brain is comprised of; a clock responsible for regulating cycles of alertness and sleepiness in response to environmental light change (Reddy et al., 2021). This intricate inner clock is not only driven by specific 'clock genes' to adjust bodily homeostasis, but also modulates several physiological processes, such as, the sleep-wake cycle, body temperature, heart rate, and hormone secretion. It is the disruption of this rhythm that can often result in a process known as circadian misalignment, referring to a variety of circumstances, such as, inappropriately timed sleep and wake, a disruption in the alignment of sleep/wake with feeding rhythms, or misaligned central and peripheral rhythms (Baron & Reid, 2014). Sciarra et al. (2020) found that consequently owing to the stress of modern lifestyle, a loss of circadian rhythmicity in the suprachiasmatic nuclei of the brain may impact sex hormone release and, as a result, often affect human fertility. This finding is supported by Mills & Kuohung (2019) who found that alterations in the specific 'rhythm-regulating' genes of the circadian clock can increase infertility and subsequently heighten the risk of suffering a miscarriage. Baron & Reid (2015) provided further support to this finding with their contribution to literature, noting that mutations in these 'clock genes' have been associated with disrupted dietary behaviour and heightened the risk of becoming obese. Obesity was also a topic of interest for Shi et al. (2013) who found that the use of hyperinsulinemic clamps to alter bodily insulin action, disrupted the rhythmic internal environment of insulin-sensitive tissue, thus predisposing oneself to obesity and insulin resistance.

Circadian misalignment is commonly seen in the likes of shift workers, for example, aviation/airline employees, doctors and nurses, and construction workers; though as well as this, this misalignment is often evident in emergency responders and military personnel. It is irrefutable to say that shift work can bring with it a degree of difficulty, due to the fact the human body is not programmed to be alert and fully-functioning in the hours of the night where sleep naturally occurs. As will be further discussed, it has been recognised that physical and mental health effects often arise from shift work, though despite this, the society in which we live is heavily dependent on these shift workers, for example, emergency responders attending to a scene could potentially save a life, or, in the case of this dissertation, an aviation worker in the Flight Operations Department assisting in the planning and smooth running of a passenger's flight from one airport to another based abroad. As previously mentioned, the body's internalised clock produces a circadian rhythmicity driving increased alertness during the daytime and decreased alertness during the night (Dijk & Czeisler, 1994); a process counteracted by a homeostatic pressure for sleep during waking hours (Daan et al., 1984). The synchronicity of these processes occurs during daytime hours when an individual may be working, though these processes are unsynchronised with the environmental light/dark cycle when one is working overnight hours, as it results in one's circadian drive for alertness being low when working and high when they return home in the early morning to sleep (James et al., 2017); the continuum of this unsynchronised process is essentially what results in poor sleep quality and sleep disturbance in these shift workers.

The earliest literature in regard to the presence of circadian misalignment in shift workers dates back to the Czeisler et al. (1990) study of workers' physiologic maladaptation to night-shift work; whereby Czeisler exposed a cohort of participants to bright light at night (approximately

7,000 to 12,000 lux) and more or less total darkness during daytime, resulting in a complete shift in participants' temperature nadir, and incidental shifts in their 24-hour patterns of plasma cortisol concentration and urinary excretion rate. With these shifts resulting in significant improvements in both alertness and cognitive performance, it was concluded that maladaptation of one's circadian system to night-shift work could be treated effectively with gradual exposure to bright light at night and darkness during the day. In contrast, one other early study implemented melatonin administration to its participants in the effort of improving daytime sleep and subsequently combatting circadian rhythm misalignment by improving night-shift alertness and performance. However, this administration only proved effective in preventing the decrease in daytime sleep on the first day of administration, and had no effect in altering the night-shift alertness, performance, or mood of the shift workers (Sharkey et al., 2001). Immediately evident is the lack of area knowledge when it comes to circadian misalignment, that is, Sharkey's study was limited by the participants' minimal tolerance to the sleep-promoting effects of melatonin administration, thus the avenue of melatonin administration would have required a more extensive background research before it was implemented as a potential intervention to circadian misalignment in shift workers.

A number of other more recent studies in literature have maintained the aim of reducing, or altogether preventing, circadian misalignment in shift workers. For example, one study found that the combination of the intermittent use of light boxes in the workplace, and a delayed sleep schedule, successfully reduced a shift worker's circadian misalignment and also demonstrated a reduction in melatonin suppression from light at night which is often related to the risk of cancer (Eastman, 2016). This evidently shows the progression of literature in circadian misalignment in the sense that multiple methods, or a combination of such rather than one single method, may be

required to combat the symptoms of misalignment experienced by shift workers. This study can also be compared to Sharkey's as both have emphasised the additionally important role that melatonin plays whilst circadian misalignment, or the efforts to reduce its occurrence, are being experienced.

Although this particular study assesses the sleep-related effects of circadian misalignment, other studies in literature have adopted a different approach, such as, assessing the mood and emotional effects that misalignment has on the shift worker. One study discovered that misalignment between the circadian system and sleep-wake behaviour adversely affects cortical activity underlying one's mood regulation and that between 25-30% of shift workers are at a higher risk of mental illness development; placing quite the socioeconomic burden upon the workforce (Chellappa, 2020). One other study conducted analyses, anthropometric and molecular in nature, on 40 hospital shift workers, discovering their heightened risk for obesity and diabetes due to increased glucose levels, trigylcerides, and waist circumference (Ferraz-Bannitz, 2021); hence, signifying that sleep complications are not the only health-related effects of circadian misalignment. In comparison to Ferraz-Bannitz's study, it has additionally been mentioned that the risk of both inflammation and cardiovascular complications is heightened by the partaking in shift work, a risk perhaps heightened by a rise in blood pressure, for example, one study notably found an increase of 1.4mmHg in systolic blood pressure and a 0.8mmHg increase in diastolic blood pressure in shift workers who participated in a laboratory protocol simulating night-shift work (Morris et al., 2017). These two studies can be compared in the sense that they emphasise additional physical health difficulties that exist for shift workers, outside of sleep disturbance, owing to the misalignment of their circadian rhythm. Circling back to the mental health aspect, very little studies have been conducted to identify associations between

circadian misalignment, as a result of shift work, and mental illness. However, one South Korean study (Ohayon & Hong, 2006) found a significantly increased prevalence of major depressive disorder (MDD) amongst night workers in comparison to daytime workers. In comparison, Oenning et al. (2018) found a significant link between night shift work and major depressive disorder amongst a cohort of 36,000 Brazilin shift workers, though only in females. Although there are little to no studies conducted to determine a cause-effect relation between circadian misalignment and bipolar disorder (BD), it has been reported that disruption to the circadian clock, in the form of jet lag, can induce bipolar episodes in susceptible individuals travelling across multiple time-zones (Young, 1995). The association discovered between both MDD studies is certainly intriguing and prompts a further endeavour into researching the relation between circadian misalignment and other mental health disorders.

Keeping in mind that this study implements the Bergen Shift Work Sleep Questionnaire (BSWSQ), Flo et al. (2012) found the BSWSQ an adequate model in assessing discrete sleep complications in a sample of 760 nurses. Studies in previous literature have shown that shift workers are far likelier to experience sleep disturbance compared to non-shift workers, for example, Quoc-Thach et al. (2020) found a significantly higher prevalence of sleep disturbance, that is, poor sleep quality, when comparing shift workers to non-shift workers (54.8% vs 36.4%). In addition, Quoc-Thach noted that shift workers had significantly worse scores on the sleep latency subscale than non-shift workers; sleep latency being one of the sub-divisions of sleep disturbance being present on one of this study's questionnaires. Even after adjusting for variables such as, age, sex, gender, caffeine intake, marital status, physical activity, and psychological distress, a robust association remained between shift workers and sleep disturbance. It is the continuity of effect that sleep disturbance has on the participant that is of importance here, even

after controlling for different variables. Additional cross-sectional studies have found the odds to be higher in shift workers experiencing sleep disturbance compared to non-shift workers, particularly in the cases of police officers (Ramey et al., 2012), and nurses (Huth et al., 2013). In contrast to Quoc-Thach's study, other studies have attempted to reduce this sleep onset latency rather than simply detect its occurrence in shift workers, for example, Bahrami et al. (2016) evaluated the efficacy of administering 0.3mg of melatonin to shift workers 30 minutes before night-time sleep for 2 weeks, with results showing that sleep onset latency decreased from 0.27h to 0.20h following melatonin administration. Evidently, the administration of melatonin appears to have a positive impact in reducing sleep onset latency, but does little in aiding night-shift alertness or performance as Sharkey previously speculated. Previous literature contains little information on the association between shift work and the other sleep disturbance sub-divisions on the BSWSQ, that is, premature awakening, wake after sleep onset, and non-restorative sleep. However, despite this, Lauren et al. (2020) found that night workers report significantly more premature awakenings than day workers. As well as this, Holzinger et al. (2019) determined the efficacy of Gestalt therapy-based sleep coaching on non-restorative sleep in Austrian railway shift workers. Although Holzinger's coaching significantly improved subjective sleep quality and reduced diurnal fatigue, it was concluded that additional research and longitudinal designs would be required to establish any long-term effects with regard to non-restorative sleep. It is subsequently hoped in this study that implementing the BSWSQ, an infrequently used questionnaire will inspire more researchers to do the same in the effort of expanding the knowledge base on factors such as, sleep latency, premature awakening, wake after sleep onset, and non-restorative sleep.

Following the Satisfaction with Life Scale (SWLS), the Morningness-Eveningness Questionnaire (MEQ) is the additional questionnaire being implemented into this study, and although little research exists in current literature with this questionnaire being applied to shift workers, it is reportedly believed that a shift worker's morningness-eveningness chronotype (that is, whether one is a 'morning-type' or 'evening-type' individual, that is, their 'circadian profile') relates to the shift worker's ease of adjustment to irregular working patterns (Willis et al., 2008). A study conducted by Folkard & Hunt (2000) found a greater adjustment of evening-type individuals to night work, in comparison to morning-type individuals. However, these researchers particularly emphasised the heightened likelihood of these evening-type individuals experiencing long-term adverse physical health experiences consequential to this shift work. It was further implied that preventative methods previously discussed, such as the use of bright light and melatonin administration, may have short-term benefits for performance but do little in actually preventing potential long-term health problems. Costa (1997) noted that due to the fact adjustment to the night shift necessitates a phase delay of circadian rhythms, evening-type individuals adjust more readily to this shift work. This point is supported by Khaleque (1999) who assessed the quality of sleep of industrial shift workers taking into account their circadian profile. This study not only found that evening-type individuals experience better quality of sleep than their counterpart, but also seem more adapted to the shift work system. These findings combined appear to suggest that, generally, despite potential health complications, evening-type individuals are more adequately suited to shift work and experience a better quality of sleep; thus, experiencing fewer sleep disturbance symptoms than morning-type individuals.

In conclusion, current literature extensively covers the field of circadian misalignment in shift-workers; the processes that occur during such misalignment in the sleep/wake cycle,

potential interventions to prevent or reduce this misalignment (for example, the role of melatonin or the use of bright light), and the additional physical and psychological health complications that exist, outside of sleep disturbance, when it comes to this misalignment. The BSWSQ, SWLS, and Morningness-Eveningness Questionnaire are all adequate scales that can be readily implemented into this study. Evidently, current literature also extensively covers the likes of sleep latency (one of the sub-divisions of sleep disturbance in the BSWSQ), as well as the evidence that individuals with an evening-type circadian profile are more adjusted to the shift work system. Above all, the necessity for this research study owes to the various gaps in existing literature when it comes to the association between circadian misalignment and shift work; for example, regarding to the question as to whether a shift worker's quality of life is depleted based upon the sleep disturbance symptoms they experience as a result of their shift work, or the question as to whether any significant gender differences exist in the experience of these sleep disturbance symptoms. It is thoughts such as these that lead into this research's prominent aims.

Rationale and Research Aims/Hypotheses

With the confident reassurance that sufficient background literature exists for this research to proceed, this study's research question essentially determines what the sleep-related effects of circadian misalignment are on aviation shift workers. Within this particular study five hypotheses exist, as follows: 1.) there will be a higher prevalence of sleep disturbance in workers who typically dislike working a night shift over a day shift than workers who dislike working a day shift over a night shift, 2.) there will be a higher prevalence of sleep disturbance in male workers compared to female workers, 3.) 'morning-type' individuals experience more sleep disturbance than 'evening-type' individuals, 4.) sleep disturbance is a predictor of overall life satisfaction, and 5.) after controlling for sex and age, sleep disturbance will continue to be a

predictor of overall life satisfaction. This study not only aims to contribute to existing knowledge in the field of circadian rhythm, but also to emphasise the health risks, in this case relating to sleep, that misalignment of the body's circadian clock has on shift workers. This study's rationale is also justified in the sense that sleep disturbance as a predictor of life satisfaction in shift workers is an association that has not been previously examined in current literature, thus this study aims to resolve that by expanding the current knowledge base and subsequently adding to it. This study aims to signify the existence of this predictive relationship, thereby paving the way for future research to be conducted potentially into sleep disturbance coaching in order to increase such satisfaction; one such positive implication of this study. This study aims to show how this satisfaction remains unaltered even following the control of additional variables; thus, emphasising the psychological effect of sleep disturbance in shift workers. Another prominent aim would be for this study to achieve results that can be easily replicated to other work domains in which there are shift workers, where currently no literature exists on these workers in association with circadian misalignment, such as finance workers, construction workers, etc. Above all, this study predominantly aims for readers to give more thought to the concept of the circadian clock and its misalignment, as well as, giving a profound understanding into the underpinnings of shift work and the body's subsequent response to this form of work; thus, giving readers the opportunity to become more appreciative for shift workers across various work domains in today's world.

Method

Participants

The sample for the current study consisted of 31 aviation shift-workers (Males: n = 17; Females: n = 14) from a renowned Irish-based airline. This sample was calculated using the Soper (2022) A-priori sample size calculation for the minimum sample of participants required for an effective hierarchical multiple regression analysis to take place (difficulty in obtaining sufficient participants resulted in this study's sample size being four participants less than Soper's recommendation of '35'). Participants ranged in age from 22 to 43, with an average age of 30 (SD = 5.83). This study implemented a non-probability, convenience sampling technique to obtain participants, owing to the convenience of the researcher to recruit participants via online questionnaire administration.

Materials

This study was comprised of an introductory questionnaire (consisting of three demographic questions relating to gender, age, and shift disfavour) (see Appendix I), and three other distinct questionnaires merged together using the Google Forms application:

Bergen Shift Work Sleep Questionnaire *(BSWSQ):* The Bergen Shift Work Sleep Questionnaire, the European version of which was developed by Flo et al. (2013), is typically comprised of seven questions assessing both sleep difficulties and wake-time functioning, however, this study has reduced the questionnaire to assess only sleep difficulties (thus, only four questions are present). The four questions present respectively assess sleep latency, wake after sleep onset, premature awakening, and non-restorative sleep. The potential response options of this questionnaire take a Likert-scale approach of ranging from '0' to '4', with responses being

'never', 'rarely', 'sometimes', 'often', and 'always' (see Appendix II). The internal consistency of the BSWSQ for this study was relatively strong, reflected by the Cronbach's alpha calculation ($\alpha = .81$).

Satisfaction with Life Scale *(SWLS):* Used typically as a measure of subjective well-being (Diener et al., 1985), the Satisfaction with Life Scale comprises of five statements relative to the quality of one's life. Based on the participant's indication of agreement, the statements are responded to using a Likert scale ranging from values 1-7 (i.e. 1 – 'Strongly Disagree', 2 – 'Disagree', 3 – 'Slightly Disagree', 4 – 'Neither Agree or Disagree', 5 – 'Slightly Agree', 6 – 'Agree', and 7 – 'Strongly Agree') (see Appendix III). The internal consistency of the SWLS was strong for this study, indicated by Cronbach's alpha ($\alpha = .87$)

Morningness-Eveningness Questionnaire *(MEQ):* The Morningness-Eveningness Questionnaire (Horne & Ostberg, 1976) was established with the primary aim of assessing whether one's peak cognitive and physical performance/alertness occurred in the morning time, evening time, or in between. The questionnaire presents participants with 19 questions, a handful of which are reverse scored. Following computing each question's corresponding numbers (either '1', '2', '3', or '4'), a participant's total score is calculated; all scores averaging 41 and under indicate an evening-type status (i.e. peak performance during the evening) and all scores averaging 59 and above indicate a morning-type status (i.e. peak performance during the morning). Scores can range between 16 and 86 inclusive; all scores between 41 and 59 indicate a neutral preference (see Appendix IV). The internal consistency of the MEQ for this study was moderate, indicated by Cronbach's alpha ($\alpha = .77$).

Design

This study implemented an experimental, cross-sectional research design with a quantitative approach. For hypothesis one, two variables exist within the independent samples t-test being conducted; the dependent variable being sleep disturbance (as a result of computing four separate variables from the four questions present on the BSWSQ questionnaire), and the independent variable being shift disfavour (two separate groups exist within this variable i.e., 'dislike for night shift over the day shift' and 'dislike for day shift over the night shift', respectively). For hypothesis two, another independent samples t-test was conducted with the dependent variable of sleep disturbance; this time around, the independent variable in question is gender (broken down into the two respective groups of 'males' and 'females'). For hypothesis three, a third and final independent samples t-test was conducted, again with the dependent variable of sleep disturbance, but with the independent variable of morningness-eveningness status (divided into the two groups of 'morning-type participants' and 'evening-type' participants). For hypothesis four, a multiple regression analysis was conducted with the criterion variable of overall life satisfaction, and the predictor variable of sleep disturbance; assessing whether sleep disturbance is indeed a predictor of one's life satisfaction. For the fifth and final hypothesis, a hierarchical multiple regression analysis was conducted with the Block 1 predictor variables of sex and age, the Block 2 predictor variable of sleep disturbance, and the criterion variable of overall life satisfaction.

Procedure

All study participants were recruited via the amalgamated Google Forms questionnaires distributed to them through their work e-mail. A close familial relation of the researcher, working within the airline in question, forwarded an e-mail worded by the researcher to all workers within the Flight Operations Department. Study consent was obtained via a detailed consent form, aligning with the Belmont Report's three constituents of information, comprehension, and voluntariness. Participants were informed of the strict confidentiality and anonymity of all data, as well as their complete right of withdrawal during questionnaire completion and the consistent voluntariness of their participation. Participants were further informed of the maximum 10 minute duration that their participation would take. In addition to the general nature and overall purpose of the study, participants were briefly notified of the ethical guidelines that were being aligned with and how minimal risk of potential psychological vulnerability was present. Participants were provided with further contact details of the researcher and study supervisor, (see Appendix V). This consent form was preceded by a detailed study information sheet that provided the run-down of all that would be involved in the study and how their participation was of importance and held in high regard to the researcher (see Appendix VI). Following successful ticking of the 'I consent' box, participants were first directed to complete the general demographics questionnaire, followed by the Bergen Shift Work Sleep Questionnaire (BSWSQ), the Satisfaction with Life Scale (SWLS), and the Morningness-Eveningness Questionnaire (MEQ). The successful completion of all above questionnaires led participants to the Debriefing component that simply reiterates the helpfulness of the individual's participation, as well as the unidentifiability and anonymity of their data. In addition to this, the Debriefing page updated participants on the confidential online storing of their data on password-protected Microsoft

Excel files, and how after the completion of data analysis all participant data would be disposed of (see Appendix VI).

Results

Descriptive Statistics

The following data is taken from a sample of 31 participants (*n* = 31). This consisted of 54.8% males (*n* = 17) and 45.2% females (*n* = 14). The age of participants ranged between 22 and 43, with an average age of 30 (*SD* = 5.83). The highest occurring age in this dataset was 27, accounting for 16.1% of all participants. In contrast to this, only 9.6% of participants were aged 40 or over. There are three continuous variables in this dataset and they are as follows: sleep disturbance, life satisfaction, and morningness-eveningness. Mean, standard deviation, and range scores for these continuous variables are the values present in Table 1 below.

Table 1

Descriptive statistics for three continuous variables

Variable	*M*	*SD*	Range
Sleep Disturbance	10.48	2.06	8
Life Satisfaction	16.55	4.8	19
Morningness-Eveningness	1.9	0.54	27

Inferential Statistics

An independent samples t-test was conducted to compare the mean sleep disturbance scores of participants who typically dislike working the night shift over the day shift, and participants who typically dislike working the day shift over the night shift. Preliminary analyses were conducted to ensure no violation of the assumptions of normality and homogeneity of variance (Levene's test = .990). The results revealed no statistically significant difference with sleep disturbance scores in those who dislike the night shift over the day shift (M = 10.52, SD = 2.11) and those who dislike the day shift over the night shift (M = 10.4, SD = 2.07), t (29) = .154, p > .001. The magnitude of the differences in the means (mean difference = .124, 95% CI = -1.52, 1.77) was insignificantly small (Cohen's d = .059).

An additional independent samples t-test was conducted to compare the mean sleep disturbance scores of men and women. Preliminary analyses were conducted to ensure no violation of the assumptions of normality and homogeneity of variance (Levene's test = .089). Results again revealed no statistically significant difference with sleep disturbance scores in men (M = 10.41, SD = 2.4) and women (M = 10.57, SD = 1.65), t (29) = -.211, p > .001. The magnitude of the differences in the means (mean difference = -.16, 95% CI = -1.71, 1.39) was similarly insignificantly small (Cohen's d = -.076).

A third and final independent samples t-test was conducted to compare the mean sleep disturbance scores of 'morning-type' participants and 'evening-type' participants. Preliminary analyses were conducted to ensure no violation of the assumptions of normality and homogeneity of variance (Levene's test = .309). The results revealed no statistically significant difference with sleep disturbance scores in morning-type participants (M = 10.7, SD = 1.53) and evening-type participants (M = 10, SD = 0.89), t (7) = -.847, p > .001.

A regression analysis was next conducted to determine whether sleep disturbance was a predictor of one's overall life satisfaction. Preliminary analyses were conducted to ensure no violation of the assumptions of normality, linearity, and homoscedasticity. Additionally ensured was that there was no violation of the assumption of multicollinearity as tests indicated Tolerance and VIF values were in their acceptable ranges. Results revealed that sleep disturbance (M = 10.48, SD = 2.06) was of no statistical significance in predicting one's overall life satisfaction; F (1) = .007, p > .001 and, for this particular sample, accounted for 0% of the variance in life satisfaction scores. Please see below standard multiple regression table for results at each model step.

Table 2

Standard multiple regression table

Variable	R^2	B	SE	β	*t*	*p*
Sleep disturbance	.000	.037	.432	.016	.087	.932

A hierarchical multiple regression analysis was the final test conducted, looking to determine whether sleep disturbance was a predictor of overall life satisfaction, after controlling for the variables of sex and age. Preliminary analyses were conducted to ensure no violation of the assumptions of normality, linearity, multicollinearity, and homoscedasticity. Sex and age were the variables entered at Step 1; this model accounted for 12.6% of the variance in the criterion variable, that is, overall life satisfaction (R-square = .126) but was not statistically significant, $F(2, 28) = 2.02$, p > .001. Sleep disturbance was the variable entered at Step 2,

though did not cause any statistically significant increase in the variance explained by the final regression model; $F(1, 27) = 1.38$, $p > .001$. Accounting for the effects of the Step 1 variables, the final regression model explained 13.3% of the variance in the criterion variable (R-square = .133). Sleep disturbance only accounted for 0.7% of the variance (R-square Change = .007) in the criterion variable and was not statistically significant, $p > .001$. Due to the non-statistical significance of the final regression model, there were no variables that stood out as strong predictors of the variance in the criterion variable. Please see below hierarchical regression table for results at each model step.

Table 3

Hierarchical multiple regression table

Variable	R^2	R^2 *Change*	*B*	*SE*	*β*	*t*	*p*
Model 1	.126						
Sex			1.46	1.68	.154	.872	.390
Age			-.258	.146	-.313	-1.77	.088
Model 2	.133						
Sleep disturbance		.007	-1.99	.435	-0.85	-.457	.652

Discussion

The current study aimed to investigate the sleep-related effects of circadian misalignment on aviation shift workers, in particular, investigating potential differences in workers' sleep disturbance and whether or not sleep disturbance predicts a shift worker's life satisfaction both before and after accounting for their sex and age. This study also aimed to contribute a greater understanding to pre-existing literature on circadian rhythm and the effects of the misalignment of this rhythm on shift workers; a cohort of workers with whom we depend heavily on in today's society. It was hoped that this study's results could be easily replicated in future research studies examining sleep disturbance in other work domains. In contrast to the first hypothesis, results showed no indication of heightened sleep disturbance based on shift disfavour, that is, a worker disliking the night shift over the day. The second hypothesis was also not supported with no indication of heightened sleep disturbance found in male shift workers over female shift workers. In contrast to the third hypothesis, there was no evidence found to suggest that 'morning-type' and 'evening-type' workers differ in their sleep disturbance. The fourth hypothesis was additionally unsupported with results showing that sleep disturbance did not predict a workers' overall life satisfaction. Finally, in contrast to the fifth hypothesis, results showed no significant indication that after controlling for sex and age, sleep disturbance would predict overall life satisfaction.

In an effort to evaluate the first hypothesis, there are a number of reasons as to why sleep disturbance was no more prevalent in those who disliked the night shift over the day in comparison to those who disliked the day shift over the night. Firstly, the participants of this particular sample may have had no preference with their shift disfavour or simply not experience the sleep disturbance symptoms, regardless of their shift work, that this study expected to find.

Secondly, and most importantly, this study did not account for the fact that upon distributing the questionnaire, the participants likely do not have the same alternation of day and night shifts, that is, one worker may only work one night after three day shifts in comparison to the worker who may primarily work day shifts with exception to the occasional night. The former of the two workers above would certainly dislike working the night shift more so than that latter, and likely have more prevalent sleep disturbance symptoms. The above point presents itself as a study limitation due to the fact that if this had been previously rectified, potentially by distributing the questionnaire only to those workers on a fixed rota of alternating shifts, then results may have corroborated with the hypothesis. These results may not match the study's previous expectations, or meaningfully contribute to the previously discussed literature, but do not critique the fact that these workers, alternating between day and night shifts, are at heightened exposure for health risks due to sleep deprivation and mood changes (Books et al., 2020). One of these most prominent health risks is cardiovascular disease, for example, Kawachi et al. (1995) found that women who had worked rotating day and night shifts over a span of six years were at a 51% increased risk of developing coronary heart disease (CHD). Aside from the physical effects, this study's results do not downplay the mental health effects, such as depression, that the night shift is often associated with (Dai et al., 2019).

This study found no heightened prevalence of sleep disturbance symptoms in male workers over female workers, suggesting that there are no gender differences in a worker's tolerance for shift work. This point critiques some of the current available literature, for example, the suggestion that the experience of shift work is perceived worse by women with it permeating over several domains of their life, including health and leisure (Rotenberg et al., 2001). This is not dissimilar to the findings of Tucker et al. (2021) that women's health is more negatively

affected by shift work than men. It is evident that gaps exist here in current literature with no record of studies quantitatively examining sleep disturbance symptoms with regard to gender differences in the experience of shift work. This not only suggests that future research should point in the way of assessing sleep disturbance across male and female shift workers, but also highlights an additional limitation of the current study, that is, the hypothesis could have been altered had a more in-depth analysis of research been conducted into whether or not men and women have differed in sleep disturbance symptoms on the basis of shift work in the past.

As mentioned, in contrast to the third hypothesis, 'morning-type' individuals did not experience more sleep disturbance symptoms than 'evening-type' individuals. Upon further analysis of research, with this study's finding in mind, it appears that an employer determining their employee's 'morningness-eveningnness' chronotype should actually be the first port of call before assessing their suitability to a particular shift assignment (Chung et al., 2009). This suggests that had the airline in question in this study deciphered each shift-working employee's chronotype before the study actually took place, results may have turned out differently. Despite this, future research undoubtedly needs to be conducted into the 'morningness-eveningness' chronotype of shift workers as better understanding of this particular interface gives occupational health experts more information to provide to business management on the potential risks to their staff associated with shift work and sleep disturbance (Hittle & Gillespie, 2018).

This study aimed to establish that a predictive relationship between sleep disturbance and a shift worker's overall life satisfaction exists, using the previously established Satisfaction With Life Scale (SWLS). In contrast to the expectations of the fourth hypothesis, no predictive relationship was found here. Due to no current literature surrounding sleep disturbance and its predictiveness upon life satisfaction, this study, at first glance, has little to compare its findings

too. However, this study could be critiqued in the sense that results may have differed had another criterion variable been used, other than life satisfaction, that still captured a worker's perception of their lives relative to their shift work. For example, upon the implementation of the Medical Outcomes Survey Short Form (SF) – 36 in the Lee et al. (2009) sleep disturbance study, results showed that sleep disturbance is strongly associated with poor health-related quality of life in middle-aged and older adult shift workers. Similarly, Vidya et al. (2019) found, upon implementing the WHO-5 Well-Being Index, that mean scores on both the physical and psychological domains of quality of life (QOL) were significantly lower for rotating shift workers than non-shift day workers. This information points out an additional limitation of the current study, that is, with little to no literature existing in regard to Diener's (1985) SWLS, another established short questionnaire should have been used instead perhaps measuring one's perceived 'quality of life' rather than 'life satisfaction'. Nonetheless, the above reiterates the necessity for future research to endeavour into whether a predictive relationship does indeed exist between sleep disturbance and overall life satisfaction when it comes to shift workers.

In evaluation of the fifth and final hypothesis, although it appeared that following the accountability for a shift worker's sex and age led to their sleep disturbance accounting for a small percentage of the variance in life satisfaction scores, this variance was non-significant and thus unimportant from a statistical perspective. This is not dissimilar to Vidya's (2019) above study which, although noting lower physical/psychological quality of life scores in rotating shift workers, concluded with non-statistically significant findings. However, despite non-statistically significant results, this study can continue to suggest that the resulting variance in life satisfaction scores based on sleep disturbance here could well be due to the effects of sleep impairment based on the misalignment of a worker's circadian clock.

The above findings, although non-significant, have implications for future studies in the sense that a lot more research needs to be conducted into whether or not a predictive relationship exists between sleep disturbance and life satisfaction. The above results show that the SWLS may not be as reliable a questionnaire, as previously anticipated, due to its absence across current literature, and that plenty more research exists on one's perception of physical and psychological 'quality of life' with regard to their shift work. This implies that future research should look into assessing a quality of life or life satisfaction questionnaire that can be specifically used, across various work domains, for shift workers and determining the effects of their sleep disturbance. Possessing one or more questionnaires that are finely established when it comes to looking at shift workers would be hugely beneficial for future studies where results can be continually replicated, subsequently increasing the knowledge base.

Conclusion

In summary, this study sought to determine the sleep-related effects of circadian misalignment on aviation shift workers. The five study hypotheses were ultimately rejected following results that indicated no shift disfavour and gender differences in the prevalence of workers' sleep disturbance, as well as no existence of a significant predictive relationship between sleep disturbance and overall life satisfaction, even after the accountability for sex and age. Study limitations included not distributing the questionnaires to those workers on a specific, fixed alternating shifts rota, and instead distributing them to workers on various different alternating shift rota; shift disfavour answers may have differed had the former of the two decisions occurred. Additional limitations included the consistent gaps in literature, particularly in relation to the SWLS; a more in-depth analysis of the reliability and general usage of the questionnaire should have taken place, had this happened then another questionnaire inspecting perceived 'quality of life' would more than likely have been adopted instead. These limitations ultimately infer that this study's results cannot be replicated in future research or generalised to other work domains, but remains as an important reminder and contributing piece of knowledge that the shift workers of today's heavily dependent society are exposed to the risk of sleep-related disturbances and other health complications; owing to the misalignment of their circadian clock as they continue to work alternating shifts.

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Appendix I

Introductory Questionnaire

The below set of three questions comprise of the following: two questions regarding basic demographic information, and one question regarding your shift disfavour. Please indicate your answers to the below questions as appropriate.

1.) What is your gender?

- Male
- Female

2.) What is your age?

_____ years old

3.) In regard to your shift work in the Operations Control Department, please tick either of the boxes below indicating which particular shift you dislike working more.

- Day Shift
- Night Shift

Appendix II

Bergen Shift Work Sleep Questionnaire (BSWSQ)

The Bergen Shift Work Sleep Questionnaire (BSWSQ) assesses sleep disturbance symptoms in shift workers. The researcher has manipulated the BSWSQ so that it only displays questions relating to sleep complications, and not impaired wake/time functioning. The following 4 questions assess sleep latency, wake after sleep onset, premature awakening, and non-restorative sleep; respectively. Please indicate your answer to each question by writing the number corresponding to the one of the possible answers (listed below), in the lined space below each question.

0 = 'Never'

1 = 'Rarely'

2 = 'Sometimes'

3 = 'Often'

4 = 'Always'

1.) How often has it taken you more than 30 min to fall asleep after the light is switched off?

_____

2.) How often are you awake for more than 30 min during your main sleep period?

_____

3.) How often have you woken up more than 30 min earlier than you wished, without being able to fall back asleep again?

_____

4.) How often have you not felt adequately rested following sleep?

_____

Appendix III

Satisfaction with Life Scale (SWLS)

Developed by Ed Diener Ph.D.

DIRECTIONS: Below are five statements with which you may agree or disagree. Using the 1-7 scale below, indicate your agreement with each item by placing the appropriate number in the line preceding that item. Please be open and honest in your responding.

1 = 'Strongly Disagree'
2 = 'Disagree'
3 = 'Slightly Disagree'
4 = 'Neither Agree or Disagree'
5 = 'Slightly Agree'
6 = 'Agree'
7 = 'Strongly Agree'

_____ 1.) In most ways my life is close to ideal.

_____ 2.) The conditions of my life are excellent.

_____ 3.) I am satisfied with my life.

_____ 4.) So far I have gotten the important things I want in life.

_____ 5.) If I could live my life over, I would change almost nothing.

Appendix IV

MORNINGNESS-EVENINGNESS QUESTIONNAIRE

For each question, please select the answer that best describes you by ticking the answer that best indicates how you have felt in recent weeks.

1. Approximately when would you get up if you were entirely free to plan your day?

[5] 5:00 AM–6:30 AM (05:00–06:30 h)

[4] 6:30 AM–7:45 AM (06:30–07:45 h)

[3] 7:45 AM–9:45 AM (07:45–09:45 h)

[2] 9:45 AM–11:00 AM (09:45–11:00 h)

[1] 11:00 AM–12 noon (11:00–12:00 h)

2. Approximately what time would you go to bed if you were entirely free to plan your evening?

[5] 8:00 PM–9:00 PM (20:00–21:00 h)

[4] 9:00 PM–10:15 PM (21:00–22:15 h)

[3] 10:15 PM–12:30 AM (22:15–00:30 h)

[2] 12:30 AM–1:45 AM (00:30–01:45 h)

[1] 1:45 AM–3:00 AM (01:45–03:00 h)

3. If you usually have to get up at a specific time in the morning, how much do you depend on an alarm clock?

[4] Not at all

[3] Slightly

[2] Somewhat

[1] Very much

4. How easy do you find it to get up in the morning when you are not awakened unexpectedly?

[1] Very difficult

[2] Somewhat difficult

[3] Fairly easy

[4] Very easy

5. How alert do you feel during the first half hour after you wake up in the morning?

[1] Not at all alert

[2] Slightly alert

[3] Fairly alert

[4] Very alert

6. How hungry do you feel during the first half hour after you wake up?

[1] Not at all hungry

[2] Slightly hungry

[3] Fairly hungry

[4] Very hungry

7. During the first half hour after you wake up in the morning, how do you feel?

[1] Very tired

[2] Fairly tired

[3] Fairly refreshed

[4] Very refreshed

8. If you had no commitments the next day, what time would you go to bed compared to your usual bedtime?

[4] Seldom or never later

[3] Less than 1 hour later

[2] 1-2 hours later

[1] More than 2 hours later

9. You have decided to exercise. A friend suggests that you do this for one hour, twice a week, between 7-8 AM (07-08 h). Bearing in mind nothing but your own internal "clock," how do you think you would perform?

[4] Would be in good form

[3] Would be in reasonable form

[2] Would find it difficult

[1] Would find it very difficult

10. Approximately when would you go to bed if you could sleep when you felt like it?

[5] 8:00 PM–9:00 PM (20:00–21:00 h)

[4] 9:00 PM–10:15 PM (21:00–22:15 h)

[3] 10:15 PM–12:45 AM (22:15–00:45 h)

[2] 12:45 AM–2:00 AM (00:45–02:00 h)

[1] 2:00 AM–3:00 AM (02:00–03:00 h)

11. You want to be at your peak performance for a test that you know is going to be mentally exhausting and will last two hours. You are entirely free to plan your day. Considering only your "internal clock," which one of the four testing times would you choose?

[6] 8 AM–10 AM (08–10 h)

[4] 11 AM–1 PM (11–13 h)

[2] 3 PM–5 PM (15–17 h)

[0] 7 PM–9 PM (19–21 h)

12. If you went to bed at 11 PM (23 h), how tired would you be?

[0] Not at all tired

[2] A little tired

[3] Fairly tired

[5] Very tired

13. For some reason you have gone to bed several hours later than usual, but there is no need to get up at any particular time the next morning. Which one of the following are you most likely to do?

[4] Wake up at your usual time, but not fall back asleep

[3] Wake up at your usual time, and doze thereafter

[2] Wake up at your usual time, but fall asleep again

[1] Not wake up until later than usual

14. One night you have to remain awake between 4-6 AM (04-06 h) to carry out a night watch. You have no time commitments the next day. Which one of these alternatives would suit you best?

[1] Stay up until the watch is over

[2] Take a nap before the watch, and sleep after

[3] Have a good sleep before the watch, and nap after

[4] Sleep only before the watch

15. You have two hours of hard physical work. You are entirely free to plan your day. Considering only your internal "clock," which of the following times would you choose?

[4] 8 AM–10 AM (08–10 h)

[3] 11 AM–1 PM (11–13 h)

[2] 3 PM–5 PM (15–17 h)

[1] 7 PM–9 PM (19–21 h)

16. You have decided to exercise. A friend suggests that you do this for one hour twice a week between 10-11 PM (22-23 h). Bearing in mind only your internal "clock," how well do you think you would perform?

[1] Would be in good form

[2] Would be in reasonable form

[3] Would find it difficult

[4] Would find it very difficult

17. Suppose that you can choose your own work hours. Assume that you work a five hour day (including breaks), your job is interesting, and you are paid based on your

performance. At approximately what time would you choose to begin?

[5] 5 hours starting between 4–8 AM (04–08 h)

[4] 5 hours starting between 8–9 AM (08–09 h)

[3] 5 hours starting between 9 AM–2 PM (09–14 h)

[2] 5 hours starting between 2–5 PM (14–17 h)

[1] 5 hours starting between 5 PM–4 AM (17–04 h)

18. At approximately what time of day do you usually feel your best?

[5] 5–8 AM (05–08 h)

[4] 8–10 AM (08–10 h)

[3] 10 AM–5 PM (10–17 h)

[2] 5–10 PM (17–22 h)

[1] 10 PM–5 AM (22–05 h)

19. Are you a "morning type" or an "evening type"?

[6] Definitely a morning type

[4] Rather more a morning type than an evening type

[2] Rather more an evening type than a morning type

[0] Definitely an evening type