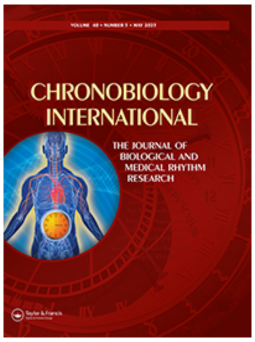

Taylor & Francis
Taylor & Francis Group

Chronobiology International
The Journal of Biological and Medical Rhythm Research

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/icbi20

An evaluation of morningness and schedule misfit using the revised Preferences Scale (PS-6): Implications for work and health outcomes among healthcare workers

Janet L. Barnes-Farrell, Rick A. Laguerre & Lee V. Di Milia

CHRONOBIOLOGY INTERNATIONAL
2023, VOL. 40, NO. 5, 612–625
https://doi.org/10.1080/07420528.2023.2193272

Taylor & Francis
Taylor & Francis Group

ORIGINAL ARTICLE

An evaluation of morningness and schedule misfit using the revised Preferences Scale (PS-6): Implications for work and health outcomes among healthcare workers

Janet L. Barnes-Farrell [a], Rick A. Laguerre [b], and Lee V. Di Milia [c]

[a]Department of Psychological Sciences, University of Connecticut, Storrs, Connecticut, USA; [b]Department of Psychology, Montclair State University, Montclair, New Jersey, USA; [c]School of Business and Law, Central Queensland University, Rockhampton, Australia

ABSTRACT

The last several decades of shift work tolerance and circadian misalignment research has had mixed results regarding the adverse impact of shift work on work and health outcomes. This inconsistency is, in part, due to the circadian typology measure employed and the study methodology. Based on models of shift work and health, the present study examined associations between circadian misalignment, end-of-day strain, and job- and health-related outcomes using the revised Preferences Scale (PS-6). A sample of 129 healthcare workers (76.7% female) from the United States (67%) and Australia (34.1%) aged 22 to 64 responded to a self-report questionnaire on work schedules, work stressors, and well-being. Multiple regression analysis found that the preferences for cognitive activity subscale of the PS-6 moderated the association between shift work and strain ($b = -.36$, $p < .001$). Those who worked nights experienced more strain if their preferences for cognitive activity were misaligned, whereas no differences in strain were observed among day workers. Moderated-mediation analyses, on the basis 95% confidence intervals, found that shift work had a conditional indirect effect on work-family conflict, job satisfaction, and health-related quality of life, via strain, and the effect was moderated by preferences for cognitive activity. Findings provide additional evidence for the criterion and external validity of the PS-6, and importantly, the present study establishes further support for models of shift work and health. Overall, the analyses highlight the importance of exploring the interactions between shift work and different dimensions of morningness in shift work tolerance research.

ARTICLE HISTORY
Received 25 October 2022
Revised 21 February 2023
Accepted 15 March 2023

KEYWORDS
Morningness-eveningness; shift work; healthcare; chronotype; sleep; well-being; stress

Introduction

Shift work, broadly defined as hours of employment that fall outside of the standard day schedule of 09:00–17:00 h during the week (Costa 2003), has been a topic of interest for chronobiologists, occupational health psychologists, ergonomists, and policy-makers for some time. Nearly 18% of the U.S. workforce consists of shift workers, and the most common shift worked is 14:00–00:00 h (McMenamin 2007). Many of the problems surrounding the health and well-being of shift workers stem from a disturbance of the circadian rhythm as a result of working at night (Berger and Hobbs 2006; Costa 1996). Measures of circadian typology (Ctypo) have been crucial to quantifying the impact of shift work. Measurement of Ctypo variables may be performed through objective and/or subjective methods. Wrist actigraphy and melatonin secretion are valid objective methods, but it is important to note that the relationship between melatonin onset (a reliable circadian phase marker) and chronotype can be suppressed with artificial light (Lewy et al. 1980; Zeitzer et al. 2000). Thus, depending on the population, chronotype may or may not reflect a circadian phase, highlighting the fact that objective methods have their limitations.

Subjective self-report measures of Ctypo are increasingly used due to their ease-of-administration and non-invasiveness (Gomes et al. 2011). Research suggests that morningness-eveningness (M-E) preferences scales – self-report Ctypo assessments – can be used as proxies of circadian misalignment, since they are not able to measure circadian misalignment itself (Adan et al. 2012; Saksvik et al. 2011; Tucker and Knowles 2008). Given that M-E preferences scales correspond to individual differences in the circadian clock (Bhatti et al. 2014; Duffy et al. 2001; Simpkin et al. 2014; Wright et al. 2013), we conceptualize circadian misalignment as a misalignment between a worker's M-E preferences and their actual shift worked (Majumdar and Sahu 2020). Those with stronger morningness preferences tend to function optimally in the morning hours, whereas those with stronger eveningness preferences perform best during the afternoon and evening (Di

CONTACT Rick A. Laguerre Laguerrer@montclair.edu Department of Psychology, Montclair State University, 1 E Normal Ave, Montclair, NJ 07043, USA

Milia et al. 2008). For decades, researchers have drawn from stress-strain frameworks to depict models of shift work and health (e.g., Barton et al. 1995; Olsson et al. 1990; Taylor et al. 1997; Tucker and Knowles 2008). Typically, shift work is viewed as a stressor that produces adverse consequences through disturbances to sleep, health, family life, and social life (Smith et al. 1999). Personal factors (e.g., chronotype) and work environment characteristics (e.g., lack of autonomy) are often proposed as key moderators of the stress-strain relationship (Taylor et al. 1997; Tucker and Knowles 2008).

Although correlations have provided support for the conceptual pathways of shift work adjustment, there are surprisingly few empirical tests of models of shift work and health that include moderation and/or mediational examinations (Adan et al. 2012; Saksvik et al. 2011; Tucker and Knowles 2008). Further, the few tests of shift work tolerance mechanisms yield results that are not always in agreement, and they have sometimes found contradictory effects of circadian misalignment on health and well-being (Saksvik et al. 2011). There is evidence, however, that the inconsistent associations between circadian misalignment and shift work tolerance are, in no small part, due to the measures themselves.

Researchers commonly assess M-E via the Morningness-Eveningness Questionnaire (MEQ; Horne and Östberg 1976), its derivative the reduced Morningness-Eveningness Questionnaire (rMEQ; Adan and Almirall 1991), the Composite Scale of Morningness (CSM; Smith et al. 1989), or the diurnal type scale (DTS; Torsvall and Åkerstedt 1980). Despite their popularity, these measures of M-E preferences have traditionally been criticized for being culturally biased and for referring to the timing of activities that may not be applicable to respondents with non-traditional schedules (Smith et al. 1991; Zickar et al. 2002). In a review, Saksvik et al. (2011) identified 16 shift work tolerance studies that examined morningness and found that a misalignment between chronotype and shift produced mixed results. We evaluated these 16 publications and identified that they can be placed into two broad measurement categories: a) those that used single-item, nominal measures of morningness, and b) those that utilized the popular M-E scales, such as the CSM or MEQ, and consisted of people who worked irregular or rotating shifts (e.g., Khaleque 1999; Petru et al. 2005; Smith et al. 1999; Takahashi et al. 2005). Taken together, we infer that the ongoing inconsistencies in associations between circadian misalignment and shift work tolerance are partly due to the use of different scales, methodological limitations in each study, and study subjects being from different countries and occupations.

Although the use and applicability of an M-E assessment in shift work research depends on the nature of the design, there is no gold standard. Smith et al. (2002) developed the Preference Scale (PS) in response to criticisms of contemporary M-E instruments, which eliminated references to time of day for the purpose of being inclusive of work schedules and cultural differences. Di Milia (2005) revised the PS by establishing a two-factor 6-item structure, and subsequent research has validated the revised version of the scale, resulting in the PS-6 (Di Milia et al. 2008). To date, no direct, systematic examination of the relations between dimensions of the PS-6 and shift work tolerance have been conducted (Adan et al. 2012; Saksvik et al. 2011; Tucker and Knowles 2008); therefore, the aim of this study is to assess the relevance of the PS-6 for shift work tolerance research. Consistent with models of shift work and health, the major hypotheses are; explored herein is shift work circadian misalignment, as assessed by the PS-6, directly effects the experience of end-of-day strain at work (i.e., *moderation*), and the experience of strain mediates the relationship between circadian misalignment and important work and health outcomes (i.e., *moderated-mediation*).

Method

Participants

The sample included a total of 129 healthcare workers; of these, 85 (67%) were from the United States and 44 (34.1%) were from Australia. All workers had fixed shift schedules, where 74.4% worked the day shift and 25.6% worked nights. They were aged 22–64 years ($M = 41.96$, $SD = 9.96$) of which 76.7% were female and 22.5% male. The marital status of the participants was as follows: 73.6% married/partnered, 10.9% divorced or separated, and 14.7% single. Nearly half (48.8%) of them had children.

Measures

Independent variables

Shift work. The *shift work* variable was derived from reported shift start and end times and through asking participants to respond yes or no to the question "*are these the only hours of the day that you work on a regular basis?*" This information was used to categorize respondents as working: a fixed (non-rotating) day shift, or a fixed (non-rotating) afternoon/evening shift, resulting in a dichotomous dummy variable.

Revised Preferences Scale (PS-6). The two factor, six-item version of the revised Preferences Scale (PS-6; Di Milia 2005; Di Milia et al. 2008) was used to assess morningness. The first factor was conceptualized as a readiness for cognitive activity (e.g., *When would you prefer to take an important three-hour examination?*), and the second factor pertained to preferences for starting the day (e.g., *When would you prefer to get up?*). The PS-6 uses a 5-point scale (1= *much earlier than most people;* 5 = *much later than most people*). Lower scores represent a higher morningness orientation.

Work-related dependent variables

Strain. A 3-item adaptation of the International Healthcare Professionals (IHP) Survey (Barnes-Farrell et al. 2008) was used to assess end-of-day strain (*When you leave work at the end of a normal work day, how mentally tired do you usually feel?*). This measure uses a 4-point scale (1 = *not at all*; 4 = *extremely*).

Work-family conflict. A composite of two items adapted from Frone et al. (1992) was used to assess work-family conflict (*how often does your job or career interfere with your home life?*). This measure uses a 6-point scale (1 = *never*; 6 = *5+ days per week*).

Job satisfaction. A 2-item adaptation of the Global Job Satisfaction measure (Ganzach 2003) was used to assess job satisfaction (*how satisfied are you with your job?*). This measure uses a 4-point scale (1 = *very dissatisfied*; 4 = *very satisfied*).

Turnover intentions. A 3-item adaptation of the measure developed by Hanisch and Hulin (1990) was used to assess turnover intentions (*how often have you thought about leaving your job?*). This measure uses a 4-point scale (1 = *never/almost never*; 4 = *often*).

Health-related dependent variables

Health-related quality of life. Finally, a comprehensive collection of 9 distinct indicators of health were assessed as measured by the US Centers for Disease Control Healthy Days measure (CDC 2001). The CDC designed this measure to globally capture the minimum number of unhealthy days for the purpose of making it transparent for policy-makers – thus, the recommendation is to keep these items separate (Moriarty et al. 2003). The measure is divided into 4 core scales and 5 additional scales. For the core scale, this measure assesses general health (e.g., *would you say that in general your health is . . .*) using a 5-point scale (1 = *poor*; 5 = *excellent*). The remaining indicators assessed the number of days during the past 30 days that respondents were unhealthy. The items used a similar stem as physical health (*Thinking about your physical health, which includes physical illness and injury, for how many days during the past 30 days was your physical health not good?*), but each subsequent index used different language to capture different aspects of life, as is the case with mental health (*Thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good?*), and activity level (*During the past 30 days, for about how many days did poor physical or mental health keep you from doing your usual activities, such as self-care, work, or recreation?*). The additional scales assessed pain (*During the past 30 days, for about how many days did PAIN make it hard for you to do your usual activities, such as self-care, work, or recreation?*), depression (*During the past 30 days, for about how many days have you felt SAD, BLUE, or DEPRESSED?*), anxiety (*During the past 30 days, for about how many days have you felt WORRIED, TENSE, or ANXIOUS?*), sleep (*During the past 30 days, for about how many days have you felt you did not get ENOUGH REST or SLEEP?*), and energy (*During the past 30 days, for about how many have you felt VERY HEALTHY AND FULL OF ENERGY?*—reverse coded).

Control variables

We controlled for *nation*, *chronological age*, *job tenure*, and *work demands* using the physical (3-items; *My job requires a lot of physical effort*) and psychological (3-items; *My job requires working very fast*) demands subscales of the Job Content Questionnaire (JCQ; Karasek et al. 1998). The JCQ uses a 4-point scale (1 = *strongly disagree*; 4 = *strongly agree*). We opted to control for nation due to differences between the U.S. and Australia in terms of their productivity norms and the level of support provided to working women (Bardoel et al. 2011), which is an important consideration for this study since our sample contains mostly female shift workers. Further, controlling for nation allowed us to account for the unequal distribution of U.S. and Australian shift workers in our design, and to ensure that demographic differences in one country did not substantially bias results.

Procedure

The healthcare workers were volunteers for an international collaborative questionnaire, the Survey of Work and Time for Healthcare Workers (SWAT-Healthcare), which includes the PS-6 and multi-item assessments of work schedule, work stressors, and work and personal well-being (see also Barnes-Farrell et al. 2008).

Researchers from both countries received approval from their University's Institutional Review Board to recruit convenience samples of volunteers. All ethical requirements established by the Journal to conduct research on human subjects were adhered to (Portaluppi et al. 2010).

Statistical analysis

Analyses were conducted using SPSS Version 25. We used hierarchical multiple regression to test for moderation, then we employed the PROCESS macro for SPSS (Hayes 2013; Preacher et al. 2007), which utilizes bias-corrected bootstrapping for estimating confidence intervals (CI), to test for moderated-mediation. To operationalize circadian misalignment, we created interaction terms for shift work and each morningness dimension of the PS-6, (a) preferences for cognitive activity and (b) preference for starting the day. This means that one series of analyses operationalized circadian misalignment on the basis of shifts that are a misfit with preferences for cognitive activity, and another set of tests framed circadian misalignment as a misfit between shifts and preferences for starting the day. We then regressed end-of-day strain on these interaction terms (in separate models) to test for moderation. Given that the PS-6 assesses two distinct aspects of morningness, modeling the morningness dimensions separately allows us to evaluate which aspect has greater associations with important work and health outcomes.

Next, we tested for moderated-mediation using the PROCESS macro by assessing whether shift work had a direct and conditional indirect effect on work (e.g., job satisfaction, work-family conflict, and turnover intentions) and health (e.g., CDC healthy days) outcomes, via strain. This model evaluated whether end-of-day strain (i.e., physical and mental fatigue) is a suitable explanatory variable for the associations between shift work and the work and health outcomes in our design. In other words, we evaluated circadian misalignment by testing whether the observed mediations between shift work and outcomes were moderated by the PS-6 morningness subscales (i.e., moderated-mediation). Collectively, these analyses allowed us to evaluate the role of the PS-6 in a manner consistent with models of shift work and health.

Results

Descriptive statistics, bivariate correlations, and reliability coefficients (Cronbach's alpha) for all study variables are summarized in Table 1. On average, participants reported that the preferences for cognitive activity ($M = 2.6$; $SD = .80$) and preferences for starting the day ($M = 2.8$; $SD = .95$) were *a-little-earlier* to *about-the-same* as most people. Consistent with prior research, higher chronological age was associated with preferences for starting the day that were earlier than most people ($p < .05$). Women worked more night shifts than men ($p < .05$), and those who worked nights tended to report that their work was more physically demanding ($p < .05$). Moreover, shift work was positively associated with strain ($p < .01$) and work-family conflict ($p < .05$). With the exception of the physical job demands subscale ($\alpha = .56$), the Cronbach's alphas for the measures were adequate, ranging from .75 to .85. For a comprehensive summary of the descriptive characteristics of the study population, sorted by nation, see Table 2.

Moderation results

We tested the first hypothesis – that circadian misalignment was associated with more strain – using multiple regression (see Table 3). Age, nation, tenure, and job demands, were introduced as control variables (Table 3, step 1) before doing the core analyses. In the linear model predicting strain (Table 3, step 2), shift work was associated with greater strain ($b = .46$, $p < .01$), such that night workers had an average increase of .46 on strain scores than day workers. The interaction between shift and preferred cognitive activities timings (Table 3, step 3) was significantly associated with strain ($b = -.36$, $p < .001$). In contrast, the interaction between shift and preferences for starting the day (Table 3, step 4) was not significant ($b = -.20$, *ns*). We inferred partial support for the first hypothesis and plotted the significant interaction following the procedures given by Aiken et al. (1991). As seen in Figure 1, preferences for cognitive activity have no effect on strain experiences for day workers, but night workers experience more strain if their preferences were much earlier than others and less strain if their preferences were much later than others.

Moderated-mediation results

In order to test the second hypothesis, we conducted moderated-mediation analyses, with circadian misalignment predicting worsened work and health outcomes via strain, using the PROCESS macro for SPSS (see Figure 2).

Overall, the analyses revealed that circadian misalignment, as assessed by the preferences for cognitive activity subscale of the PS-6, had a significant indirect effect on the majority of the job- and health-related outcomes. With shift work as the independent variable, a test of the conditional indirect effect examines whether the mediational pathway from shift work → strain →

Table 1. Means, standard deviations, Cronbach's alphas, and Pearson's correlation coefficients of demographic characteristics and psychological measures ($n = 129$).

	Variable	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Age	41.96	9.96	-																					
2	Gender	n/a	n/a	.09	-																				
3	Tenure	7.77	7.94	.46**	.14	-																			
4	Nation	n/a	n/a	.07	.24**	.16	-																		
5	JD Physical	2.78	0.64	−.19*	−.25**	−.19*	−.11	(.56)																	
6	JD Psychological	2.59	0.76	−.28**	−.05	−.08	.17	.30**	(.75)																
7	Shift	n/a	n/a	−.05	−.19*	−.09	−.16	.19*	−.08	-															
8	Strain	2.58	0.70	−.16	−.19*	−.07	.01	.27**	.34**	.29**	(.77)														
9	PS-6 Cog. activity	2.63	0.80	−.13	.03	.01	−.18*	−.04	.10	.20*	−.03	(.75)													
10	PS-6 Start day	2.84	0.95	−.22*	−.20*	−.08	−.20*	.06	.03	.35**	.14	.52**	(.82)												
11	WFC	3.07	1.30	−.15	−.04	.05	.00	.30**	.37**	.21*	.50**	.01	.18*	(.85)											
12	Job sat	2.81	0.73	.15	.07	.07	−.11	−.09	−.41**	−.02	−.37**	−.10	.02	−.19*	(.82)										
13	Turnover	2.21	0.85	−.16	.07	−.19*	.22*	.04	.32**	−.04	.16	.12	−.09	.21*	−.51**	(.84)									
14	General health	3.33	0.94	−.20*	−.08	−.07	−.13	.08	.06	−.15	−.22*	−.02	−.01	.03	.00	−.02	-								
15	Physical health	2.40	4.44	.15	−.19*	.00	−.06	−.02	.07	.18*	.24**	.14	.10	−.04	.04	−.06	−.35**	-							
16	Mental health	4.44	6.26	.00	−.06	−.10	−.15	.10	.26**	.11	.37**	.13	.11	.21*	−.21*	.19*	−.22*	.31**	-						
17	Activity limit	1.29	2.80	.14	−.06	.03	−.03	−.01	.11	.17	.25**	.06	.06	.07	.02	−.04	−.34**	.69**	.41**	-					
18	Pain	2.55	5.53	.19*	−.22*	.05	−.13	−.08	−.09	.09	.27**	.02	.06	.01	−.11	.03	−.31**	.38**	.30**	.25**	-				
19	Depression	4.15	6.38	.00	−.07	.02	−.03	−.03	.29**	−.03	.34**	.05	.06	.16	−.26**	.24**	−.28**	.17	.73**	.31**	.30**	-			
20	Anxiety	5.99	7.76	−.01	−.10	.00	−.11	.04	.27**	.06	.44**	.13	.07	.19*	−.43**	.37**	−.12	.24**	.51**	.33**	.34**	.57**	-		
21	Sleep	9.17	8.98	−.15	−.13	−.11	−.07	.02	.19*	.21*	.42**	.01	.11	.21*	−.49**	.29**	−.04	.03	.34**	.13	.10	.36**	.56**	-	
22	Lack of Vitality	18.44	10.35	−.07	.01	−.09	−.12	−.01	.15	.26**	.41**	.23**	.23**	.10	−.34**	.15	−.37**	.15	.38**	.22*	.15	.39**	.42**	.46**	-

Gender coding 1=female, 2=male; Nation coding 1=US, 2=Australia; JD Physical= physical job demands; JD Psychological= psychological job demands; Shift coding 0=day, 1=night; PS-6 Cog. Activity = preference scale cognitive activity subscale; PS-6 start day = preference scale starting day subscale; WFC = work-family conflict; Job sat = job satisfaction; Physical health = physically unhealthy days; Mental health = mentally unhealthy days; activity limit = activity limitation days; pain = pan days; depression = depression days; Anxiety = anxiety days; Sleep = sleepless days; Lack of Vitality = lack of vitality days; * = $p < .05$; ** = $p < .01$. Values in the diagonal are Cronbach's alpha (reliability) estimates.

Table 2. Summary of descriptive characteristics by nation.

	Full Sample: United States + Australia (*N* = 129)				United States (*n* = 85)				Australia (*n* = 44)			
Characteristic	*N*	(%)	*M*	*SD*	*n*	(%)	*M*	*SD*	*n*	(%)	*M*	*SD*
Age (in years, range 22–64)			41.96	9.96			41.44	10.22			42.98	9.49
22–29	20	(16%)			15	(18%)			5	(11%)		
30–39	28	(22%)			19	(22%)			9	(20%)		
40–49	52	(40%)			32	(38%)			20	(45%)		
50–59	24	(19%)			15	(18%)			9	(20%)		
60+	5	(4%)			4	(5%)			1	(2%)		
Gender												
Male	29	(22%)			13	(15%)			16	(36%)		
Female	99	(77%)			71	(84%)			28	(64%)		
missing	1	(1%)			1	(1%)			0	(0%)		
Shift worked												
Day	96	(74%)			59	(69%)			37	(84%)		
Night	33	(26%)			26	(31%)			7	(16%)		
Day Shift: Stratified by age												
22–29	13	(14%)			8	(14%)			5	(14%)		
30–39	22	(23%)			13	(22%)			9	(24%)		
40–49	39	(41%)			24	(41%)			15	(41%)		
50–59	17	(18%)			10	(17%)			7	(19%)		
60+	5	(5%)			4	(7%)			1	(3%)		
Night Shift: Stratified by age												
22–29	7	(21%)			7	(27%)			0	(0%)		
30–39	6	(18%)			6	(23%)			0	(0%)		
40–49	13	(39%)			8	(31%)			5	(71%)		
50–59	7	(21%)			5	(19%)			2	(29%)		
60+	0	(0%)			0	(0%)			0	(0%)		
Day Shift: Stratified by gender												
Male	26	(27%)			12	(20%)			14	(38%)		
Female	69	(72%)			46	(78%)			23	(62%)		
missing	1	(1%)			1	(2%)			0	(0%)		
Night Shift: Stratified by gender												
Male	3	(9%)			1	(4%)			2	(29%)		
Female	30	(91%)			25	(96%)			5	(71%)		
missing	0	(0%)			0	(0%)			0	(0%)		
Revised Preferences Scale (PS-6)												
Preferences for cognitive activity			2.63	0.80			2.73	0.80			2.43	0.76
Preferences for starting the day			2.84	0.95			2.97	1.00			2.58	0.77
Work Demands												
Physical demands			2.78	0.64			2.82	0.65			2.68	0.63
Psychological demands			2.59	0.76			2.50	0.77			2.77	0.71
Tenure			7.77	7.94			6.89	7.70			9.48	8.21

work and health outcomes are conditional on levels of morningness (i.e., the PS-6). Significant results, as evidenced by confidence intervals that exclude zero, would mean that the mediational process is optimal in the presence of circadian misalignment. The results of our analyses are presented in Table 4, which provides effect size estimates and confidence intervals for the conditional indirect effects. Results in the third column of Table 4 show that, with preferred cognitive activity timings as the moderator, shift work had a conditional indirect effect on job satisfaction, work-family conflict, and all personal health variables via end-of-day strain. As shown in Table 4, shift work did not have a conditional indirect effect on turnover intentions. Results in the fifth column of Table 4 show that, with preferences for starting the day as the moderator, there were no significant conditional indirect effects of shift work on the dependent variables.

For the job-related outcomes (see Table 5), the regression analyses revealed that shift work had no significant direct effect on work-family conflict ($b = .65$, *ns*), job satisfaction ($b = .03$, *ns*), and turnover intentions ($b = -.03$, *ns*). Further, we observed similar results using nine distinct indicators of health as assessed by the Center for Disease Control Healthy Days measure. As seen in Tables 6 and 7, the direct effect of shift work on all personal health variables were non-significant.

Although shift work did not independently predict worsened work and health outcomes, the impact of strain did, which explains why circadian misalignment had an indirect association with work- and health-related outcomes. As shown in the dependent variable models of Table 5, strain had a significant direct effect on work-family conflict ($b = .65$, $p < .001$) and job satisfaction ($b = -.30$, $p < .01$); however, strain was not associated with turnover intentions ($b = .09$, *ns*). Moreover, strain was related to a worsening of all personal health variables. The unstandardized coefficients for these personal health variables, except

Table 3. Regression results for strain.

Model	b	SE	t	R^2
Step 1. Strain predicted by:				0.15
Constant	1.56**	0.45	3.47	
Age	0.00	0.01	−0.53	
Nation	−0.02	0.13	−0.12	
Tenure	0.00	0.01	0.06	
Physical job demands	0.19	0.10	1.98	
Psychological job demands	0.25**	0.09	2.94	
Step 2. Strain predicted by:				0.23
Constant	1.48**	0.43	3.46	
Age	0.00	0.01	−0.48	
Nation	0.03	0.12	0.26	
Tenure	0.00	0.01	0.17	
Physical job demands	0.13	0.10	1.36	
Psychological job demands	0.28**	0.08	3.46	
Shift	0.46**	0.13	3.51	
Step 3. Strain predicted by:				0.28
Constant	1.53***	0.42	3.64	
Age	0.00	0.01	−0.63	
Nation	0.02	0.12	0.16	
Tenure	0.00	0.01	0.50	
Physical job demands	0.10	0.09	1.07	
Psychological job demands	0.31	0.08	3.79	
Shift	0.56***	0.13	4.20	
Preferred cognitive activities timings	0.01	0.09	0.09	
Shift × Preferred cognitive activities timings	−0.36***	0.15	−2.41	
Step 4. Strain predicted by:				0.24
Constant	1.45**	0.43	3.34	
Age	0.00	0.01	−0.38	
Nation	0.05	0.12	0.40	
Tenure	0.00	0.01	0.54	
Physical job demands	0.12	0.10	1.26	
Psychological job demands	0.29**	0.08	3.58	
Shift	0.52***	0.15	3.43	
Preferred start day timings	0.08	0.08	1.05	
Shift × Preferred start day timings	−0.20	0.15	−1.36	

n = 129. Regression coefficients are unstandardized.
*$p < .05$; **$p < .01$; ***$p < .001$.

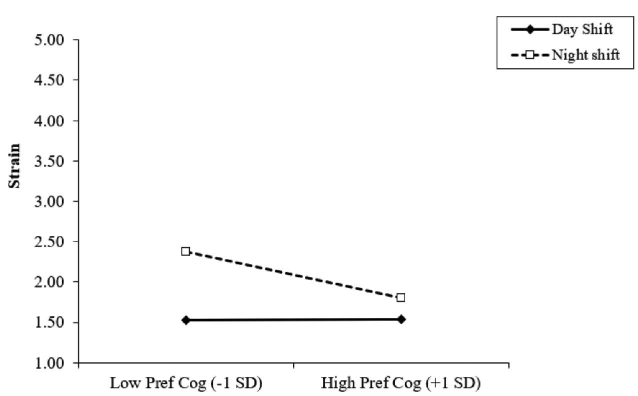

Figure 1. Interaction of shift work and preferences for cognitive activity predicting strain.
Note: Low pref cog = preferences for cognitive activity that is earlier than most people; High pref cog = preferences for cognitive activity that are later than most people.

general health, correspond to *unhealthy* days out of a 30-day period. This means that, for example, if b = 3.00, a one-unit increase in strain accounts for a three-day increase in reported health problems over the course of a month. To this regard, Tables 6 and 7 reveal that strain was significantly associated with physically unhealthy days ($b = 1.42$, $p < .05$), mentally unhealthy days ($b = 2.93$, $p < .05$), activity limitation days ($b = .90$, $p < .05$), pain days ($b = 2.96$, $p < .001$), depression days ($b = 3.13$, $p < .001$), anxiety days ($b = 4.76$, $p < .001$), sleepless days ($b = 4.94$, $p < .001$), lack of vitality days ($b = 5.70$, $p < .001$), and general health ($b = -.35$, $p < .01$).

Discussion

In this study, we examined a model of shift work tolerance that addressed two major gaps in the literature on circadian typology and theory on adaptation to shift work. First, we tested the efficacy of the revised preferences scale (PS-6) in predicting outcomes important for shift work and occupational health researchers. To our knowledge, we are the first study to provide evidence of criterion validity for the PS-6 within a shift work tolerance framework, going beyond the scope of methodological articles that used the measure before (e.g., Di Milia et al. 2011; Marques et al. 2017). Second, we found support for our hypothesized model regarding conditional indirect effects of shift work on work

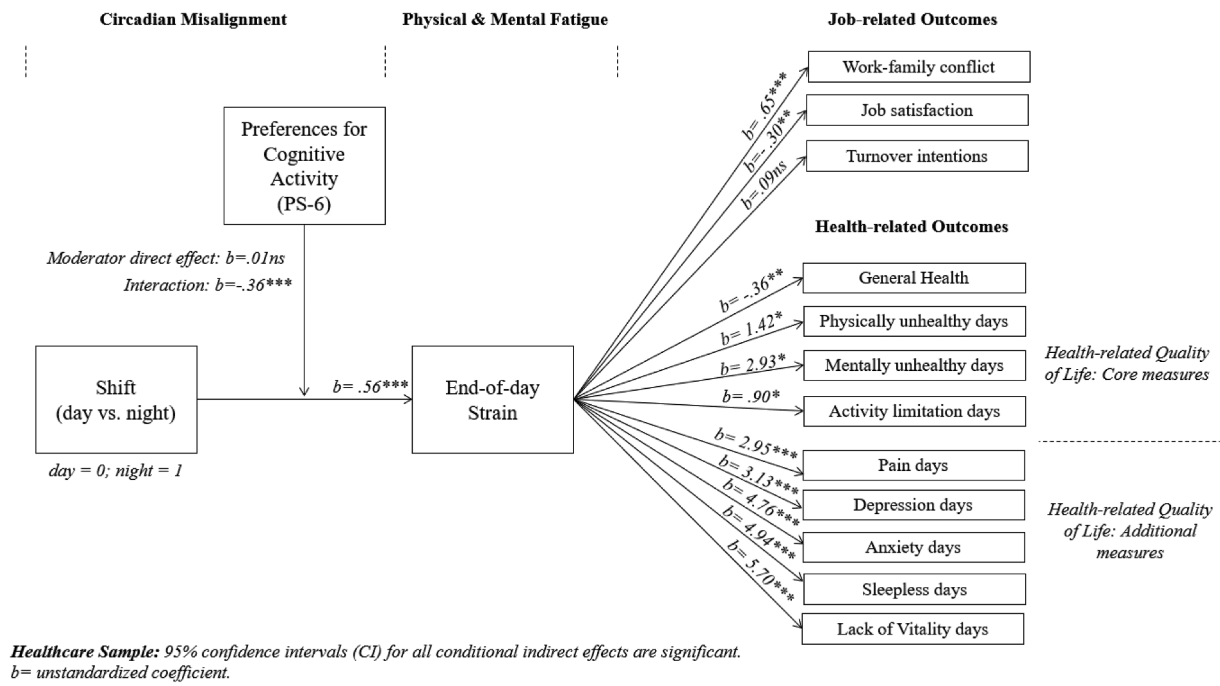

Figure 2. Conditional indirect effect of shift work on job- and health-related outcomes, via strain (controlling for age, nation, tenure and job demands). Note: * = $p < .05$; ** = $p < .01$; ***= $p < .001$

Table 4. Circadian misalignment as assessed by two aspects of PS-6 morningness: confidence intervals and estimates for the conditional indirect effect of the interaction between shift work and morningness on various work and health outcomes, via strain (controlling for age, nation, tenure and job demands).

	PS-6 Moderator			
	Preferences for cognitive activity		Preferences for starting the day	
Dependent Variable	Estimate	Confidence Interval (CI)	Estimate	Confidence Interval (CI)
Job-related				
Work-family conflict	−0.2381	95% CI [−0.4833, −0.0534]	−0.1313	95% CI [−0.4161, 0.082]
Job satisfaction	0.1085	95% CI [0.0240, 0.2549]	0.0555	95% CI [−0.0464, 0.1801]
Turnover intentions	−0.0319	95% CI [−0.1704, 0.0342]	−0.0163	95% CI [−0.1412, 0.0191]
Health-related				
General health	0.1279	95% CI [0.0323, 0.3110]	0.0654	95% CI [−0.0396, 0.2464]
Physically unhealthy days	−0.6029	95% CI [−1.7082, −0.619]	−0.2551	95% CI [−1.2278, 0.1307]
Mentally unhealthy days	−1.2385	95% CI [−2.6704, −0.4391]	−0.524	95% CI [−1.7945, 0.4405]
Activity limitation days	−0.3585	95% CI [−1.0163, −0.0364]	−0.1609	95% CI [−0.7640, 0.0911]
Pain days	−1.172	95% CI [−2.3883, −0.4544]	−0.5312	95% CI [−1.8292, 0.4281]
Depression days	−1.2446	95% CI [−2.67986, −0.4001]	−0.5641	95% CI [−1.9648, 0.4303]
Anxiety days	−1.8392	95% CI [−3.6501, −0.6012]	−0.7871	95% CI [−2.574, 0.9071]
Sleepless days	−1.9601	95% CI [−3.9854, −0.7217]	−0.9154	95% CI [−2.8567, 0.8449]
Lack of vitality days	2.2434	95% CI [0.6782, 4.5835]	0.9744	95% CI [−0.9721, 3.4159]

PS-6 = revised preferences scale.

Table 5. Regression results for job-related outcomes.

Model	b	SE	t	R^2
WFC predicted by:				.34
Constant	−.18	.77	−.24	
Age	−.01	.01	−.86	
Nation	−.07	.21	−.33	
Tenure	.03	.01	1.95	
Physical job demands	.27	.16	1.66	
Psychological job demands	.37*	.15	2.47	
Shift	.32	.24	1.33	
Strain	.65***	.16	4.16	
Job satisfaction predicted by:				.24
Constant	4.04***	.47	8.63	
Age	.00	.01	.23	
Nation	−.07	.13	−.55	
Tenure	.00	.01	.40	
Physical job demands	.10	.10	1.03	
Psychological job demands	−.31***	.09	−3.48	
Shift	.03	.14	.21	
Strain	−.30**	.09	−3.21	
Turnover predicted by:				.18
Constant	1.57**	.56	2.78	
Age	.00	.01	−.09	
Nation	.35*	.15	2.26	
Tenure	−.02*	.01	−2.17	
Physical job demands	−.10	.12	−.80	
Psychological job demands	.30**	.11	2.74	
Shift	−.03	.17	−.15	
Strain	.09	.11	.78	

n = 129. Regression coefficients are unstandardized.
$^*p < .05$; $^{**}p < .01$; $^{***}p < .001$.

and health outcomes, via strain. In the next paragraphs, we discussion the practical and theoretical implications of our results and identify future directions for research.

Findings of our study, which was based on a sample of healthcare professionals from the U.S. and Australia, make several contributions to existing knowledge. By separately modeling two dimensions of the PS-6, preferred cognitive activities timings and preferences for starting the day, we determined that these morningness dimensions have differential effects on strain. We found that the relationship between shift work and strain was moderated by the preferred cognitive activities dimension; however, no such moderation occurred for the dimension corresponding to preferences for starting the day. These findings suggest that employers should go beyond broad categorizations of chronotype when attempting to match employees with an appropriate shift. Specifically, it is more important to know a person's preferences for cognitive activity (i.e., whether it is much earlier than others vs. much later than others), rather than knowing how people respond to other aspects of morningness (e.g., preference for sleeping-eating, whether one considers themselves a morning or evening person, etc.) when determining person-job fit.

Further, when plotting the interaction between shift and cognitive activity preferences (Figure 1), we observed that night workers, in particular, experienced more strain when their cognitive preferences were misaligned with their shift. This is in contrast to day workers, who experienced no differences in strain when their preferences for cognitive activity were misaligned with their shift. One explanation for the nature of the interaction could be found in Olsson et al.'s (1990) model of shift work adaptation. According to the model, shift work is one of several occupational stressors (e.g., lack of autonomy, monotony, time pressure) that drain an individual of resources (Olsson et al. 1990). This model assumes that people consider a multitude of occupational stressors in the work environment when appraising their ability to manage work stress, and these occupational stressors interact with personal characteristics to produce adverse outcomes (Olsson et al. 1990). Because work environmental characteristics can vary drastically across shifts (Costa 1996), it is possible for workers to operate under environmental conditions that compensate for strain depending on their schedule. Thus, when a personal factor such as preferences for cognitive activity misaligns with one's shift, environmental factors may buffer against strain. With regard to our results, this would mean that aspects of the environment (e.g., more autonomy, less time pressure) may have served to alleviate strain among day workers who worked misaligned shifts. Night workers, on the other hand, may have had less work environmental supports. A future study should investigate the degree to which contextual features differ among day and night workers, and whether these features reduce or exacerbate strain.

Table 6. Regression results for health-related outcomes using the core CDC health-related quality of life measures.

Model	b	SE	t	R^2
General health predicted by:				0.14
Constant	4.58***	0.63	7.22	
Age	−0.02	0.01	−2.22	
Nation	−0.27	0.17	−1.53	
Tenure	0.01	0.01	0.46	
Physical job demands	0.15	0.13	1.11	
Psychological job demands	0.09	0.12	0.72	
Shift	−0.24	0.20	−1.24	
Strain	−0.36**	0.13	−2.80	
Physically unhealthy days predicted by:				0.12
Constant	−4.96	3.10	−1.60	
Age	0.11*	0.05	2.33	
Nation	−0.56	0.85	−0.66	
Tenure	−0.05	0.05	−0.84	
Physical job demands	−0.74	0.66	−1.13	
Psychological job demands	0.58	0.59	0.98	
Shift	1.42	0.96	1.48	
Strain	1.42*	0.63	2.27	
Mentally unhealthy days predicted by:				0.21
Constant	−8.76*	4.15	*-2.11*	
Age	0.10	0.06	1.67	
Nation	−2.44*	1.14	−2.14	
Tenure	−0.09	0.07	−1.24	
Physical job demands	−0.78	0.88	−0.89	
Psychological job demands	1.93*	0.79	2.44	
Shift	0.17	1.28	0.13	
Strain	2.93*	0.84	3.48	
Activity limitation days predicted by:				0.13
Constant	−3.72	1.92	−1.93	
Age	0.06*	0.03	2.26	
Nation	−0.25	0.54	−0.46	
Tenure	−0.02	0.03	−0.50	
Physical job demands	−0.47	0.41	−1.14	
Psychological job demands	0.49	0.37	1.33	
Shift	0.91	0.61	1.50	
Strain	0.90*	0.39	2.30	

n = 129. Regression coefficients are unstandardized.
$^*p < .05$; $^{**}p < .01$; $^{***}p < .001$.

A similar framework that may inform the role of contextual factors important for shift work tolerance is the Job Demands-Resource model (JD-R; Demerouti et al. 2001). The JD-R model is a theoretical framework that occupational health psychology researchers have used for decades to better understand how work characteristics influence individual performance and well-being. It diverges from Olsson et al.'s (1990) model of shift work tolerance by emphasizing the psychosocial benefits of having support from colleagues at work. According to the JD-R model, *job resources* (e.g., co-worker support, supervisor support, job control) are aspects of the work environment that facilitate the management of energy and job performance, while *job demands* are aspects of work that drain a person physically and mentally (e.g., doing the actual work, working very fast, or doing tasks that require sustained concentration). In our study, we controlled for *job (i.e., work) demands* in order to account for variability in the difficulty of work among respondents; however, we did not assess for *job resources*, which would serve to increase the energy people have at work. Research has found that supervisor support, co-worker support, and schedule control contribute to the well-being of shift workers (Pisarski et al. 1998). Perhaps, differences in *job resources* between shifts can explain why day workers with misaligned cognitive preference timings were more resistant to strain than night workers in our study.

Shift work did not have a direct effect on work and health outcomes. This is consistent with shift work tolerance research because exposure to night work may not always be a direct indicator of adverse outcomes (Saksvik et al. 2011). Results from our moderated-mediation analyses revealed that shift work had an indirect effect on work-family conflict, job satisfaction, and personal health via strain, and the indirect effect was conditional on levels of preferred cognitive activity timings. Specifically, when preferences for cognitive activity are misaligned for night workers, higher rates of strain were reported, and these workers experienced worsened personal health and job-related outcomes. To strengthen our conclusion, we tested for simple mediation and found that shift work still had an indirect effect on the same work and health outcomes, via strain. Full

Table 7. Regression results for health-related outcomes using the additional CDC health-related quality of life measures.

Model	b	SE	t	R^2
Pain days predicted by:				0.17
Constant	−4.49	3.70	−1.21	
Age	0.1187*	0.05	2.19	
Nation	−1.63	1.02	−1.60	
Tenure	−0.02	0.07	−0.29	
Physical job demands	−1.07	0.79	−1.36	
Psychological job demands	−0.71	0.70	−1.01	
Shift	−0.23	1.16	−0.20	
Strain	2.95***	0.76	3.90	
Depression days predicted by:				0.21
Constant	−6.25	4.19	−1.49	
Age	0.06	0.06	0.97	
Nation	−1.66	1.16	−1.44	
Tenure	0.00	0.08	0.01	
Physical job demands	−1.84*	0.89	−2.07	
Psychological job demands	2.23**	0.80	2.80	
Shift	−1.40	1.31	−1.07	
Strain	3.13***	0.86	3.66	
Anxiety days predicted by:				0.26
Constant	−9.67	4.96	*-1.95*	
Age	0.08	0.07	1.07	
Nation	−2.78*	1.39	−2.01	
Tenure	0.00	0.09	−0.02	
Physical job demands	−1.65	1.07	−1.55	
Psychological job demands	2.25*	0.94	2.38	
Shift	−0.81	1.56	−0.52	
Strain	4.76***	1.01	4.70	
Sleepless days predicted by:				0.22
Constant	2.30	5.89	0.39	
Age	−0.06	0.09	−0.66	
Nation	−1.51	1.63	−0.93	
Tenure	−0.05	0.11	−0.45	
Physical job demands	−2.26	1.26	−1.78	
Psychological job demands	1.18	1.14	1.03	
Shift	2.18	1.85	1.18	
Strain	4.94***	1.23	4.03	
Lack of Vitality days predicted by:				0.24
Constant	7.55	6.64	1.14	
Age	0.04	0.10	0.38	
Nation	−2.84	1.84	−1.54	
Tenure	−0.09	0.12	−0.76	
Physical job demands	−3.24*	1.41	−2.30	
Psychological job demands	1.62	1.27	1.28	
Shift	3.91	2.07	1.89	
Strain	5.70***	1.36	4.20	

n = 129. Regression coefficients are unstandardized.
$^*p < .05$; $^{**}p < .01$; $^{***}p < .001$.

results are available from the corresponding author, however, in summary, the interpretation remains the same and circadian misalignment appreciably impacts work and health.

Strengths and limitations

A major contribution of this study is that it is one of the few examinations of shift work tolerance and circadian misalignment that systematically assesses for moderated-mediation. The methodological approach of this study aligns with the core principles of models of shift work and health (Taylor et al. 1997; Tucker and Knowles 2008), and thus, provides empirical support for shift work theories at large. This study substantially disentangles the mixed results in shift work tolerance research by using a measure of morningness (i.e., the PS-6) that addresses the criticisms levied against traditional M-E instruments.

Although the present study makes significant contributions to the literature, there are some limitations. First, the cross-sectional design of the study limits inferences of causality. Second, there were unequal proportions of day and night shift workers, which means that the night workers in our study may not have been represented as well as the day workers with respect to M-E preferences and other outcomes; therefore, a future study should seek to increase the number night workers when evaluating the PS-6. Of note, however, to help counteract this limitation, we used bias-corrected bootstrapped confidence intervals to stabilize the interpretation of results and minimize the impact of sample size differences between shifts (Hayes 2013; Preacher et al. 2007). Third, self-report measures are susceptible to common method bias, and despite the advantages of the PS-6 over contemporary Ctypo instruments, there are aspects of it that are worth further consideration. One criticism of the PS-6 is that respondents may not be able to accurately perceive sleep habits of "most people" when comparing themselves to others (Kripke et al. 2008). The nature of the response scale is susceptible to systematic bias which would be difficult to control for without having estimates of workers' perceptions of population activity timings. Even though the present study uses self-report and cross-sectional data, it uses samples from two countries which, notably, provides evidence for using the PS-6 among different nationalities in chronobiological and occupational health psychological research. Lastly, given that this study used subjective data to evaluate the PS-6 among healthcare workers, a future study should incorporate objective measures of shift work adaptation and health when utilizing the PS-6.

These limitations notwithstanding, there are far reaching implications. The present analyses lay the foundation for future longitudinal research. For instance, by utilizing the Centers for Disease Control measures of health-related quality of life, the present study provides initial support for larger-scale, cross-national studies of shift work and health. Given the brevity of the PS-6, we propose that it should be a frontrunner for additional research in work settings.

Another major strength of the present study lies in the sample itself. The current results are based on working adults in healthcare settings, which supports the external validity of the PS-6 because prior studies with this measure consisted of college students. Healthcare workers are consistently challenged by the impact of shift work, and because these shifts facilitate the 24-hour care of patients, the adverse impact of shift work on employee well-being and performance cannot be understated (Lee and Lipscomb 2003). The strain and fatigue experienced by healthcare professionals during shift work impairs their performance (Ganesan et al. 2019), which is why patient care and safety standards decline at night (Lee and Lipscomb 2003). Compared to other occupations, healthcare workers are at greater risk of burnout and work-life balance problems than the general population (Shanafelt et al. 2012). Thus, our results should be particularly beneficial to healthcare professionals, who are more vulnerable to disruptions in their functioning at work. For instance, this can inform employee selection and placement procedures by having decision-makers consider a specific dimension of circadian type in the hiring process (e.g., preferences for cognitive activity).

Conclusions

In conclusion, the results of our study support the hypotheses that circadian misalignment, as assessed by the PS-6, is associated with end-of-day strain at work, and the experience of strain mediates the associations between circadian misalignment and important work and health outcomes. The present findings suggest that preferences for cognitive activity plays a significant role in healthcare workers' adaptation to shift work.

Acknowledgements

The authors are grateful to all participants of the Survey of Work and Time for Healthcare Workers (SWAT-Healthcare).

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This paper was supported by Grant Number T01-OH008610 from CDC–NIOSH. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of NIOSH. For further information, please contact the corresponding author.

ORCID

Janet L. Barnes-Farrell http://orcid.org/0000-0001-8714-4813
Rick A. Laguerre http://orcid.org/0000-0002-7467-3860
Lee V. Di Milia http://orcid.org/0000-0001-7681-5589

References

Adan A, Almirall H. 1991. Horne & Östberg morningness-eveningness questionnaire: A reduced scale. Pers Individ Dif. 12:241–253. doi:10.1016/0191-8869(91)90110-W.

Adan A, Archer SN, Hidalgo MP, Di Milia L, Natale V, Randler C. 2012. Circadian typology: A comprehensive review. Chronobiol Int. 29:1153–1175. doi:10.3109/07420528.2012.719971.

Aiken LS, West SG, Reno RR. 1991. Multiple regression: Testing and interpreting interactions. Thousand Oaks, CA: Sage.

Bardoel EA, Drago R, Cooper B, Colbeck C. 2011. Bias avoidance: Cross-cultural differences in the US and Australian academies. Gender Work Organ. 18:e157–179. doi:10.1111/j.1468-0432.2009.00483.x

Barnes-Farrell JL, Davies-Schrils K, McGonagle A, Walsh B, Di Milia L, Fischer FM, Hobbs BB, Kaliterna L, Tepas D.

2008. What aspects of shiftwork influence off-shift well-being of healthcare workers? Appl Ergon. 39:589–596. doi:10.1016/j.apergo.2008.02.019.
Barton J, Spelten E, Totterdell P, Smith L, Folkard S, Costa G. 1995. The standard shiftwork index: A battery of questionnaires for assessing shiftwork-related problems. Work Stress. 9:4–30. doi:10.1080/02678379508251582.
Berger AM, Hobbs BB. 2006. Impact of shift work on the health and safety of nurses and patients. Clin J Oncol Nurs. 10:465. doi:10.1188/06.CJON.465-471.
Bhatti P, Mirick DK, Davis S. 2014. The impact of chronotype on melatonin levels among shift workers. Occup Environ Med. 71:195–200. doi:10.1136/oemed-2013-101730.
Control, C. for D., & Prevention (CDC). (2001). *Measuring healthy days: Population assessment of health-related quality of life*.
Costa G. 1996. The impact of shift and night work on health. Appl Ergon. 27:9–16. doi:10.1016/0003-6870(95)00047-X.
Costa G. 2003. Factors influencing health of workers and tolerance to shift work. Theor Issues Ergon Sci. 4:263–288. doi:10.1080/14639220210158880.
Demerouti E, Bakker AB, Nachreiner F, Schaufeli WB. 2001. The job demands-resources model of burnout. J Appl Psychol. 86:499. doi:10.1037/0021-9010.86.3.499.
Di Milia L. 2005. A psychometric evaluation and validation of the preferences scale. Chronobiol Int. 22:679–693. doi:10.1080/07420520500180454.
Di Milia L, Folkard S, Hill J, Walker C Jr. 2011. A psychometric assessment of the circadian amplitude and phase scale. Chronobiol Int. 28:81–87. doi:10.3109/07420528.2010.502603.
Di Milia L, Wikman R, Smith P. 2008. Additional psychometric evidence and construct validity for a revised preferences scale of morningness. Chronobiol Int. 25:776–787. doi:10.1080/07420520802391098.
Duffy JF, Rimmer DW, Czeisler CA. 2001. Association of intrinsic circadian period with morningness–eveningness, usual wake time, and circadian phase. Behav Neurosci. 115:895. doi:10.1037/0735-7044.115.4.895.
Frone MR, Russell M, Cooper ML. 1992. Antecedents and outcomes of work-family conflict: Testing a model of the work-family interface. J Appl Psychol. 77:65. doi:10.1037/0021-9010.77.1.65.
Ganesan S, Magee M, Stone JE, Mulhall MD, Collins A, Howard ME, Lockley SW, Rajaratnam SMW, Sletten TL. 2019. The impact of shift work on sleep, alertness and performance in healthcare workers. Sci Rep. 9:Article 1. doi:10.1038/s41598-019-40914-x.
Ganzach Y. 2003. Intelligence, education, and facets of job satisfaction. Work Occup. 30:97–122. doi:10.1177/0730888402239328.
Gomes AA, Tavares J, de Azevedo MHP. 2011. Sleep and academic performance in undergraduates: A multi-measure, multi-predictor approach. Chronobiol Int. 28:786–801. doi:10.3109/07420528.2011.606518.
Hanisch KA, Hulin CL. 1990. Job attitudes and organizational withdrawal: An examination of retirement and other voluntary withdrawal behaviors. J Vocat Behav. 37:60–78. doi:10.1016/0001-8791(90)90007-O.
Hayes AF. 2013. Mediation, moderation, and conditional process analysis. In: *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach Edn*. Vol. 1. New York: Guilford Publications. P. 20
Horne JA, Östberg O. 1976. A self-assessment questionnaire to determine morningness-eveningness in human circadian rhythms. Int J Chronobiol. 4:97–110.
Karasek R, Brisson C, Kawakami N, Houtman I, Bongers P, Amick B. 1998. The Job Content Questionnaire (JCQ): An instrument for internationally comparative assessments of psychosocial job characteristics. J Occup Health Psychol. 3:322–355. doi:10.1037/1076-8998.3.4.322.
Khaleque A. 1999. Sleep deficiency and quality of life of shift workers. Soc Indic Res. 46:181–189. doi:10.1023/A:1006971209513.
Kripke DF, Rex KM, Ancoli-Israel S, Nievergelt CM, Klimecki W, Kelsoe JR. 2008. Delayed sleep phase cases and controls. J Circadian Rhythms. 6:1–14. doi:10.1186/1740-3391-6-6.
Lee KA, Lipscomb J. 2003. Sleep among shiftworkers—a priority for clinical practice and research in occupational health nursing. Aaohn J. 51:418–420. doi:10.1177/216507990305101003.
Lewy AJ, Wehr TA, Goodwin FK, Newsome DA, Markey SP. 1980. Light suppresses melatonin secretion in humans. Science. 210:1267–1269. doi:10.1126/science.7434030.
Majumdar P, Sahu S. 2020. Morningness orientation is an important determinant to circadian misalignment and tolerance: An Asian perspective. Chronobiol Int. 37:2–28. doi:10.1080/07420528.2019.1682597.
Marques DR, Gomes AA, Di Milia L, Azevedo MHPD. 2017. Circadian preferences in young adults: Psychometric properties and factor structure of the Portuguese version of the Preferences Scale (PS-6). Chronobiol Int. 34:403–410. doi:10.1080/07420528.2017.1280045.
McMenamin TM. 2007. A time to work: Recent trends in shift work and flexible schedules. Monthly Lab Rev. 130:3.
Moriarty DG, Zack MM, Kobau R. 2003. The centers for disease control and prevention's healthy days measures–Population tracking of perceived physical and mental health over time. Health Qual Life Outcomes. 1:1–8. doi:10.1186/1477-7525-1-37.
Olsson K, Kandolin I, Kauppinen-Toropainen K. 1990. Stress and coping strategies of three-shift workers. Trav Hum. 53:175–188.
Petru R, Wittmann M, Nowak D, Birkholz B, Angerer P. 2005. Effects of working permanent night shifts and two shifts on cognitive and psychomotor performance. Int Arch Occup Environ Health. 78:109–116. doi:10.1007/s00420-004-0585-3.
Pisarski A, Bohle P, Callan VJ. 1998. Effects of coping strategies, social support and work-nonwork conflict on shift worker's health. Scandi J Work Environ Health. 24:141–145.
Portaluppi F, Smolensky MH, Touitou Y. 2010. Ethics and methods for biological rhythm research on animals and human beings. Chronobiol Int. 27:1911–1929. doi:10.3109/07420528.2010.516381.
Preacher KJ, Rucker DD, Hayes AF. 2007. Addressing moderated mediation hypotheses: Theory, methods, and prescriptions. Multivariate Behav Res. 42:185–227. doi:10.1080/00273170701341316.
Saksvik IB, Bjorvatn B, Hetland H, Sandal GM, Pallesen S. 2011. Individual differences in tolerance to shift work–a

systematic review. Sleep Med Rev. 15:221–235. doi:10.1016/j.smrv.2010.07.002.

Shanafelt TD, Boone S, Tan L, Dyrbye LN, Sotile W, Satele D, West CP, Sloan J, Oreskovich MR. 2012. Burnout and satisfaction with work-life balance among US physicians relative to the general US population. Arch Intern Med. 172:1377–1385. doi:10.1001/archinternmed.2012.3199.

Simpkin CT, Jenni OG, Carskadon MA, Wright KP Jr, Akacem LD, Garlo KG, LeBourgeois MK. 2014. Chronotype is associated with the timing of the circadian clock and sleep in toddlers. J Sleep Res. 23:397–405. doi:10.1111/jsr.12142.

Smith CS, Folkard S, Schmieder RA, Parra LF, Spelten E, Almiral H, Sen RN, Sahu S, Perez LM, Tisak J. 2002. Investigation of morning–evening orientation in six countries using the preferences scale. Pers Individ Dif. 32:949–968. doi:10.1016/S0191-8869(01)00098-8.

Smith CS, Reilly C, Midkiff K. 1989. Evaluation of three circadian rhythm questionnaires with suggestions for an improved measure of morningness. J Appl Psychol. 74:728–738. doi:10.1037/0021-9010.74.5.728.

Smith CS, Robie C, Folkard S, Barton J, Macdonald I, Smith L, Spelten E, Totterdell P, Costa G. 1999. A process model of shiftwork and health. J Occup Health Psychol. 4:207. doi:10.1037/1076-8998.4.3.207.

Smith CS, Tisak J, Bauman T, Green E. 1991. Psychometric equivalence of a translated circadian rhythm questionnaire: Implications for between- and within-population assessments. J Appl Psychol. 76:628–636. doi:10.1037/0021-9010.76.5.628.

Takahashi M, Tanigawa T, Tachibana N, Mutou K, Kage Y, Smith L, Iso H. 2005. Modifying effects of perceived adaptation to shift work on health, wellbeing, and alertness on the job among nuclear power plant operators. Ind Health. 43:171–178. doi:10.2486/indhealth.43.171.

Taylor E, Briner RB, Folkard S. 1997. Models of shiftwork and health: An examination of the influence of stress on shiftwork theory. Hum Factors. 39:67–82. doi:10.1518/001872097778940713.

Torsvall L, Åkerstedt T. 1980. A diurnal type scale. Construction, consistency and validation in shift work. Scandi J Work Environ Health. 6:283–290. doi:10.5271/sjweh.2608.

Tucker P, Knowles SR. 2008. Review of studies that have used the standard shiftwork index: Evidence for the underlying model of shiftwork and health. Appl Ergon. 39:550–564. doi:10.1016/j.apergo.2008.02.001.

Wright KP, Bogan RK, Wyatt JK. 2013. Shift work and the assessment and management of shift work disorder (SWD). Sleep Med Rev. 17:41–54. doi:10.1016/j.smrv.2012.02.002.

Zeitzer JM, Dijk D-J, Kronauer RE, Brown EN, Czeisler CA. 2000. Sensitivity of the human circadian pacemaker to nocturnal light: Melatonin phase resetting and suppression. J Physiol. 526:695–702. doi:10.1111/j.1469-7793.2000.00695.x.

Zickar MJ, Russell SS, Smith CS, Bohle P, Tilley AJ. 2002. Evaluating two morningness scales with item response theory. Pers Individ Dif. 33:11–24. doi:10.1016/S0191-8869(01)00131-3.