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The effects of shift work on free-living physical activity and sedentary behavior

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ABSTRACT

Objective. Although occupation may influence physical activity and shift work schedule may influence cardiovascular disease risk factors, our understanding of the effects of shift work schedule on overall physical activity behavior and sedentary behavior is limited.

Methods. Data from the 2005–2006 National Health and Nutrition Examination Survey were used. Shift work schedule was defined as regular daytime shift, evening, night, rotating or another schedule. Physical activity and sedentary behavior were assessed via accelerometry. 1536 adult participants (≥20 years) indicated they currently work and provided data on all study variables.

Results. After adjustments, and compared to adults working a regular daytime shift, those working an evening (RR = 0.41, p = 0.001) and night (RR = 0.30, p = 0.001) shift, respectively, engaged in 59% and 70% less sustained (bouts) moderate-to-vigorous physical activity, but no differences occurred for overall moderate-to-vigorous physical activity. After adjustments, and compared to those working a regular daytime shift, those working a rotating shift engaged in more light-intensity physical activity (overall: $\beta = 26.3$ min/day; p = 0.03; bouts: $\beta = 37.5$, p = 0.01) and less sedentary behavior ($\beta = -28.5$ min/day, p = 0.01).

Conclusions. Shift work schedule differentially influences physical activity and sedentary behavior. Physical activity and sedentary intervention strategies may need to be tailored based on shift work schedule.

Introduction

Among many other factors (e.g., beliefs and policy), research demonstrates that an individual's occupation may play an important role in their occupational and leisure-time physical activity (Church et al., 2011; Kirk and Rhodes, 2011; Vandelanotte et al., 2015). In addition to an individual's specific occupation, their shift work schedule (i.e., daytime, evening, night, rotating, or another shift schedule) may play an important role in their health. For example, previous systematic reviews have demonstrated that individuals working on regular non-daytime shifts (e.g., night shift) may be at an increased risk of obesity, elevated cholesterol and hypertriglyceridemia (Boggild and Knutsson, 1999; Esquirol et al., 2011), possibly due to shift work-induced changes in desynchronized circadian rhythms, sleep disturbances, modulation of food intake, psychosocial stress, and social inequalities (Mosendane and Raal, 2008; Puttonen et al., 2010).

Although occupation may influence physical activity (Kirk and Rhodes, 2011) and shift work schedule may influence cardiovascular disease risk factors (Boggild and Knutsson, 1999; Esquirol et al., 2011), our understanding of the effects of shift work schedule on overall physical activity behavior is limited. It is plausible to suggest that non-daytime shifts (e.g., night shift) may have a negative influence on overall physical activity because of shift-work changes in sleep patterns and daytime energy, for example.

The previous studies (De Bacquer et al., 2009; Esquirol et al., 2009; Karlsson et al., 2003; Nabe-Nielsen et al., 2008; Sakata et al., 2003; Sookoian et al., 2007; Suwazono et al., 2008; van Amelsvoort et al., 2004) that have examined an association between shift work and physical activity explored other relationships as the study's primary focus (e.g., shift work on blood pressure); therefore, these studies were limited in their investigation of the association between shift work and physical activity. The findings of these studies were mixed (addressed in the Discussion section), with these studies employing a subjective crude measure of physical activity, examining non-American samples, considering few potential confounding variables, and did not examine the extent of shift work (i.e., mostly examined day shift vs. non-day shift).

The purpose of this present study was to improve our understanding of the effect of shift work on overall physical activity, including both light-intensity physical activity and moderate-to-vigorous physical activity (MVPA) as these behaviors are considered to be distinct behaviors independently associated with health (Loprinzi et al., 2014). Further, emerging research demonstrates that sedentary behavior (behaviors resulting in energy expenditure ≤1.5 times that of resting energy

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expenditure (Owen et al., 2000)) is distinct from physical activity in that it is associated with various health outcomes independent of physical activity (Thorp et al., 2011). In addition to the paucity of research examining the association between shift work on physical activity, to my knowledge, no study has examined the effects of shift work on overall free-living sedentary behavior. To address gaps in the previous preliminary studies on this topic, the present study utilizes objectively-measured (i.e., accelerometry) physical activity and sedentary data, employs an American sample, and examines additional categories of non-daytime shift work.

Methods

Design and participants

Data from 2005 to 2006 National Health and Nutrition Examination Survey (NHANES) were used, which, at the time of this writing, is the only NHANES cycle with accelerometry and shift work data. NHANES is an ongoing survey conducted by the Centers for Disease Control and Prevention that uses a representative sample of non-institutionalized U.S. civilians, selected by a complex, multistage, stratified, clustered probability design. Participants are interviewed in their home and subsequently examined in a mobile examination center (MEC). The 2005–2006 NHANES study procedures were approved by the National Center for Health Statistics ethics review board. Consent was obtained from all participants prior to any data collection. In the 2005–2006 NHANES, 1536 adult participants (≥20 years) indicated that they currently work and provided data on all study variables, with these 1536 participants constituting the analytic sample.

Assessment of shift work schedule

Among adults indicating that they are currently working at a job or business, they were asked: "Which of the following best describes the hours you usually work at your main job or business: *a regular daytime schedule*, *a regular evening shift*, *a regular night shift*, *a rotating shift*, or *another schedule*."

Physical activity and sedentary behavior

Details regarding accelerometry monitoring of NHANES can be found elsewhere (Troiano et al., 2008). Prior to the participant's examination, accelerometers were initialized to collect data in one minute epoch or time periods. A weighted average (≥2020 counts/min) of 4 accelerometer-derived intensity-related count cut-points was used to classify MVPA (Troiano et al., 2008); light-intensity physical activity was classified as counts/min between 100 and 2019 (Loprinzi, 2013); and sedentary behavior was defined as counts/min between 0 and 99 (Loprinzi and Kohli, 2013; Matthews et al., 2008). Accelerometry data were reduced using the SAS (Statistical Analysis System) macro provided by the National Cancer Institute (CDC).

Bout (i.e., >10 min in duration) and overall MVPA and light-intensity physical activity were further evaluated (Loprinzi and Cardinal, 2013). A 10-minute MVPA/light-intensity activity bout was defined as 10 or more consecutive minutes above the relevant cut-point, with allowance for interruptions of 1 or 2 min below the cut-point. A bout was terminated by 3 min below the threshold (Troiano et al., 2008). Nonwear was defined by a period of a minimum of 60 consecutive minutes of zero activity counts, with the allowance of 1–2 min of activity counts between 0 and 100 (Troiano et al., 2008). For the analyses described here, only those participants with at least 4 days with 10 or more hours per day of monitoring data were included in the analyses (Troiano et al., 2008).

Assessment of covariates

Covariates in the analytic models consisted of *demographic*, *behavioral*, *psychological*, *occupational*, and *biological* parameters that are known to correlate with physical activity and shift work (Boggild and Knutsson, 1999; Esquirol et al., 2011; Warburton et al., 2006).

The *demographic* parameters included: age (years), gender (male/female), race-ethnicity (white/non-white), and education (high school or less/some college or more).

The *behavioral*/*psychological* parameters included: self-reported sleep duration (h/night), energy intake (kcal), saturated fat intake (g), depression, and cotinine (ng/mL; smoking biomarker). Depression (expressed as a continuous variable) was assessed using the Patient Health Questionnaire-9 (PHQ-9) (Kroenke et al., 2001). Energy intake and saturated fat intake were assessed from the mobile examination center dietary interview. Serum cotinine was measured by an isotope dilution-high performance liquid chromatography/atmospheric pressure chemical ionization tandem mass spectrometry.

The *occupational* parameters included: self-reported hours worked per week, # of months at the current job, and occupation. With regard to occupation, an index variable (ranging from 1 to 22) was created that included 22 different occupations based on the 2000 U.S. Census Bureau Indexes of Industry and Occupation (http://www.census.gov/people/io/).

The *biological* parameters included: measured body mass index (kg/m^2), C-reactive protein (mg/dL), measured mean arterial pressure (mm Hg; [(diastolic blood pressure × 2) + systolic blood pressure] / 3), and physician-diagnosed diabetes (yes/no). Details on the data collection protocol and procedures for these biological parameters have been published elsewhere (http://www.cdc.gov/nchs/nhanes.htm).

Data analysis

Statistical analyses (Stata, version 12.0, College Station, TX) accounted for the complex survey design used in NHANES. To account for oversampling, non-response and non-coverage, and to provide nationally representative estimates, all analyses included the use of survey sample weights, stratum and primary sampling units. Recalculated sample weights for the subsamples with 4 or more days of valid accelerometer data were used to make the selected samples nationally representative.

Unadjusted and multivariable regression models were computed, with shift work serving as the independent variable (daytime shift as referent group). Five multivariable regression models were computed to examine the association between shift work schedule and physical activity/sedentary behavior: 1) negative binomial regression model overall MVPA as the outcome variable; 2) negative binomial regression model with bout (8–10-min) MVPA bouts as the outcome variable; 3) linear regression model with overall light-intensity physical activity data as the outcome variable; 4) linear regression model with bout light-intensity physical activity data as the outcome variable; and 5) linear regression model with sedentary behavior as the outcome variable. For MVPA, negative binomial regression was used because MVPA was severely skewed. The following covariates were included in each of the 5 multivariable analytical models: age, gender, race-ethnicity, education, hours slept per night, energy intake, saturated fat intake, cotinine, depression, hours worked per week, length at job, occupation, body mass index, C-reactive protein, mean arterial pressure, and diabetes.

There was no evidence of multicollinearity in the adjusted models; for example, for the sedentary behavior model, the mean variance inflation factor was 1.42, the highest individual variance inflation factor was 3.31, and all tolerance statistics were >.30. For all models, statistical significance was established as $p < 0.05$.

Results

Table 1 displays the weighted characteristics of the analyzed sample. Table 2 displays the weighted regression results. Unadjusted and adjusted results were similar across all models. After adjustments, and compared to adults working a regular daytime shift, those working an evening ($\beta = -0.88$, $p = 0.001$) and night ($\beta = -1.19$, $p = 0.001$) shift engaged in less MVPA when expressed in bouts (i.e., at least 8–10 min bout durations). When converted into a rate ratio (RR), those working evening (RR = 0.41, $p = 0.001$) and night (RR = 0.30, $p = 0.001$) shift, respectively, engaged in 59% and 70% less sustained MVPA. Notably, this occurred despite evening and night shift workers appearing relatively younger (Table 1). For example, compared to daytime workers (41.8 years), evening workers (38.8 years) had a younger mean age, but this was not statistically significant ($p = 0.14$), which is in contrast to the significantly younger age of night workers compared to daytime workers (41.8 years vs. 38.3 years, $p = 0.04$).

After adjustments, and compared to those working a regular daytime shift, those working a rotating shift engaged in more light-intensity physical activity (overall: $\beta = 26.3$ min/day; $p = 0.03$; bouts: $\beta = 37.5$, $p = 0.01$) and less sedentary behavior ($\beta = -28.5$ min/day, $p = 0.01$).