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Dietary Intake among Nurses Working Rotating Hospital Shifts by BMI Category

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Abstract

Background: Shift work has been associated with increased body mass index (BMI), metabolic disruption and increased chronic disease risk. Typically, these reports compare individuals who work the day shift to those who work the night shift. Because shift assignment is not random, differences may reflect other, unmeasured characteristics that account for outcome differences. In this study, we compare individuals who work rotating shifts by BMI category (BMI<25 kg/m^2 *vs.* BMI ≥ 25 kg/m^2).

Objective: To compare dietary intake on days the participant worked the night shift to days she worked the day shift; and to compare these difference by BMI category in a population of female nurses who work rotating shifts at a hospital.

Methods: This cross-sectional study recruited 132 female registered nurses who work rotating shifts in surgical or internal medicine departments. Dietary intake was ascertained using food diaries and analyzed on Tzameret Nutrition Analysis Software (Israel Ministry of Health). Demographic and anthropometric variables were also recorded.

Results: Compared to dietary intake on a day the nurse worked the day shift, intake of the following nutrients increased significantly on the day she worked the night shift: energy: protein; carbohydrates; total fat; saturated fat; and calcium. However, this difference was driven by nurses with BMI<25 kg/m^2; nurses with BMI ≥ 25 kg/m^2 did not alter their dietary intake by shift.

Discussion and conclusion: A significant increase in calorie, macronutrient and calcium intake on days nurses worked the night shift compared to days they worked the day shift was demonstrated; but driven by differences among nurses with BMI<25 kg/m^2. The mechanism for this is not clear but may represent voluntary inhibition among overweight nurses. Prospective follow-up can reveal whether this pattern predicts weight gain over time.

Keywords: Shift work; Dietary intake; Body mass index; Occupational medicine; Nutrition

Background

Shift can be fixed (an individual always works the same shift) or rotating, in which an individual's shift changes periodically; regardless, shift work permits around-the-clock productivity, generally dividing a given 24 hour period into three, eight-hour shifts: morning, evening and night [1]. To facilitate between-study comparability, a definition of night shift work has been proposed: at least three hours of work between 24:00-05:00 hrs [2].

Night shift workers have been shown to have increased prevalence of overweight/obesity, type 2 diabetes and other chronic conditions associated with sleep deprivation and disorder of circadian cycles [3,4]. Hormonal disruption has been associated with night shift work, and may provide a mechanism through which night shift work is associated with cardiovascular disease and obesity [5,6]. Nurses who consistently worked the night shift were shown to have phase desynchrony of core body temperature, peak cortisol, and dim light melatonin onset as well as gene expression patterns different from nurses who worked the day shift [7]. Among female nurses, cumulative night shift work was associated with increase in body mass index (BMI), waist circumference, hip circumference and the waist-to-hip circumference ratio [8]. It is possible that overweight and high risk fat distribution underlie the increased diabetes risk observed in nurses working the night shift [9].

Systematic difference in food intake by shift has been studied in an attempt to understand the association between shift work and overweight/obesity. Most such studies compare dietary intake between night shift and day shift workers; however, this approach ignores the fact that assignment to work shift is not random. It is thus likely that a characteristic associated with night shift work is also associated with body weight and/or food intake. A recent study of nurses who work rotating shifts found that energy, macronutrient and calcium intake was significantly greater on days when they work the night shift than on days when they work the day shift [10].

It was not clear whether present differences in dietary intake differ by BMI category. The present study reconsiders the data in nurses who work rotating shifts [10] and compares between-shift differences in energy and nutrient intake between nurses with BMI<25 kg/m^2 (normal weight) to those with BMI ≥ 25 kg/m^2 (overweight/obese) [11].

Methods

Study design and setting

The present cross-sectional study was designed to compare dietary intake on days on which the participant works the night shift to days on which she works the day shift. In this analysis, by-shift differences in energy and dietary intake were compared by BMI category: BMI<25 kg/m^2 (normal weight) to those with BMI ≥ 25 kg/m^2 (overweight/obese) [11].

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Ethics

The Ethics Committee of Tel Aviv Medical Center, Tel Aviv University and the Israel Ministry of Health granted approval to conduct this study.

Study population

Participants in the present study were recruited from the population of female nurses who work rotating shifts at Tel Aviv Medical Center, a 1500 bed hospital in Tel Aviv, Israel, which employs approximately 2050 nurses. After receiving Ethics Committee approval, investigators met with the nurse managers of each inpatient surgical and internal medicine department to explain study objectives and procedures and to receive consent to recruit participants. Eligible and interested nurses attended a group meeting, each in her own department, whereby, study goals and procedures were explained. Agreement to participate was indicated by providing signed, informed consent. A total of 132 female registered nurses who work rotating shifts in surgical or internal medicine departments were recruited.

Definitions

- **Shift**: The morning shift was defined as the shift from 07:00-15:00 hrs, and the night shift was defined as the shift from 23:00-07:00 hrs. A shift was considered “rotating” if at least once each week the nurse worked a shift different from her other scheduled shifts.
- **Rotating shift**: A shift was considered “rotating” if at least once each week the nurse worked a shift different from her other scheduled shifts.
- **24 hour period**: For the purpose of recording food intake, a 24-hour period was defined as beginning at 00:00-23:59 hrs.

Demographic information

The following information was completed in writing by each nurse using a structured, written questionnaire: age, marital status, land of birth, religion, highest academic degree achieved, advanced training (yes/no), years of professional experience, number of day shifts per week, number of night shifts per week, smoking status (present smoker: yes/no) and participation in physical exercise (yes/no).

Dietary intake

Nurses were instructed to complete a food diary in real time, for a 24 hour period, once on a day they worked a day shift and once on a day they worked a night shift. All foods consumed were to be recorded, including portion size and time of consumption. Nurses were requested to provide as much detail as possible, including brand names where applicable.

The diary, which contained no prompts, was written on lined pages, was provided by the investigator to each participant. The first shift on which the participant worked after providing agreement to participate was the first day on which recording was performed, and the next rotated shift after that served as the comparator shift. The order in which the nurse completed the diary-a day on which she worked the night shift or a day on which she worked the day shift-was determined by her work schedule.

Delta nutrients

The ‘by-shift’ difference in nutrient intake (delta) was calculated by subtracting the nutrient intake on the day a participant worked the day shift from the nutrient intake on the day she worked the night shift.

Anthropometric measures

Measures were acquired when nurses submitted their two completed food diaries to investigators. With participants in light clothing and stocking feet, participants were weighed on a balance scale to the nearest 0.2 kg. Height was measured to the nearest 0.5 cm using the height bar on the balance scale. BMI was calculated as weight (kg)/height $(m)^2$. Waist circumference was measured one cm below the umbilicus, to the nearest 0.5 cm, using a plastic coated cloth tape-measure.

Nutrition analysis

Dietary intake was uploaded to nutrition analysis software (Tzameret Nutrition Analysis Software, Israel Ministry of Health) and analyzed by a registered dietitian. Energy, protein, carbohydrates, total fat, saturated fat, dietary fiber, cholesterol, calcium and iron were assessed.

Statistical methods

Sample size and study power: The study was powered to detect a true, ‘by-shift’ difference in energy intake of 100 ± 400 kcal, assuming a two-sided alpha of 0.05. Using these assumptions, it was calculated that a sample size of 130 individuals would provide 80% power to detect a difference of this size.

Data Analysis: The data set was originally analyzed on SPSS Ver. 21 and re-analyzed on SPSS Ver. 25 (IBM, USA). Continuous data were described as mean ± standard deviation and compared by shift using the t-test for paired observations or the Wilcoxon signed ranks test as appropriate. Comparisons by BMI category were performed using the t-test for independent samples or the Mann-Whitney U as appropriate. Nominal data were described as n(%) and compared by shift using the Chi-Square test, exact as necessary. Multilinear regression analysis was used to predict the ‘by-shift’ difference in energy intake by initially entering variables identified as significant or near significant in univariate analysis. The final model was arrived at using a backward approach; successively removing variables in order develop the most parsimonious model. Variable entry into the model required probability of $F<0.05$, and for removal, probability of $F>0.10$. All tests are two-sided and considered significant at $p<0.05$.

Results

A total of 132 nurses agreed to participate in the study. Of these, 38% had BMI ≥ 25 kg/m^2. Characteristics of the study population are displayed in Table 1. Most participants were married, Jewish and held a University degree. Per definition, BMI was significantly greater in the group with BMI ≥ 25 kg/m^2, and not surprisingly this group weighed significantly more. Subjects in the ≥ 25 kg/m^2 BMI group had significantly greater waist circumference than nurses in the group with BMI<25 kg/m^2, but did not differ significantly by hip circumference, perhaps indicating a pattern of abdominal adiposity. Nurses in the ≥ 25 kg/m^2 BMI group were significantly older than their thinner counterparts, and significantly fewer were born in Israel. Significant differences in smoking or participation in physical activity were not detected between groups.

Table 2 shows dietary intake, ‘by-shift’ and BMI group. With the exception of cholesterol and fiber, nurses in the <25 kg/m^2 group consumed significantly more nutrients on days they worked the night shift than days they worked the day shift. Nurses in the ≥ 25 kg/m^2 BMI

Variables	BMI<25 kg/m² N=82	BMI ≥ 25 kg/m² N=50	*p*-value
Age (years)	34.75 ± 7.92	38.86 ± 9.32	0.01
Born in Israel (%)	55.8	36.7	0.04
Years in nursing profession	7.78 ± 7.97	10.26 ± 9.30	0.11
Number of day shifts per week	2.42 ± 1.51	2.56 ± 1.20	0.51
Number of night shifts per week	1.56 ± 0.74	1.72 ± 0.73	0.22
Jewish (%)	77.9	77.6	0.96
Marital status (%)			
Married	59.7	61.2	0.42
Single	29.9	24.5	
Divorced	7.8	14.3	
Other	2.6	0	
Highest level of education (%)			
Registered nurse	14.3	16.3	0.92
Bachelor's degree	68.8	65.3	
Master's degree	16.9	18.4	
Advanced nursing training (%)	42.1	39.6	0.78
Present smoker (%)	16.9	24.5	0.29
Any physical activity (%)	58.4	46.9	0.21
Body weight (kg)	59.30 ± 7.24	77.78 ± 11.04	<0.0001
BMI (kg/m²)	21.79 ± 2.05	29.52 ± 4.34	<0.0001
Waist circumference (cm)	78.88 ± 9.53	94.85 ± 9.86	<0.0001
Hip circumference (cm)	86.50 ± 20.21	77.33 ± 42.62	0.48
Waist:Hip circumference ratio (cm)	0.93 ± 0.34	1.03 ± 0.49	0.58

Table 1: Characteristics of the study population by BMI category.

Nutrient (unit)	BMI<25 kg/m² N=82	*p*-value	BMI ≥ 25 kg/m² N=50	*p*-value
Day shift energy (kcal)	1385.00 ± 447.56	<0.0001	1526.29 ± 629.12	0.795
Night shift energy (kcal)	1665.34 ± 501.80		1550.80 ± 577.39	
Day shift protein (g)	69.71 ± 31.99	0.003	77.06 ± 37.31	0.49
Night shift protein (g)	80.49 ± 32.69		73.41 ± 34.28	
Day shift carbohydrate (g)	146.19 ± 59.95	0.002	148.49 ± 68.55	0.149
Night shift carbohydrate (g)	174.96 ± 66.35		162.43 ± 59.79	
Day shift total fat (g)	54.96 ± 22.06	<0.0001	66.31 ± 35.46	0.904
Night shift total fat (g)	70.38 ± 28.09		65.61 ± 32.05	
Day shift saturated fat (g)	15.55 ± 7.14	<0.0001	18.20 ± 10.27	0.795
Night shift saturated fat (g)	20.09 ± 8.01		18.61 ± 9.04	
Day shift cholesterol (mg)	294.60 ± 181.74	0.253	398.67 ± 306.32	0.011
Night shift cholesterol (mg)	321.83 ± 211.05		262.31 ± 224.51	
Day shift fiber (g)	12.56 ± 6.99	0.217	14.44 ± 9.88	0.657
Night shift fiber (g)	13.59 ± 7.09		15.06 ± 8.94	
Day shift iron (mg)	8.78 ± 4.36	0.049	8.86 ± 4.69	0.795
Night shift iron (mg)	9.74 ± 4.94		8.84 ± 4.98	
Day shift calcium (mg)	555.75 ± 310.46	0.005	545.27 ± 297.68	0.092
Night shift calcium (mg)	690.61 ± 298.29		629.22 ± 325.22	

Table 2: Nutrient intake by shift and BMI category.

group consumed significantly less cholesterol on days they worked the night shift compared to days they worked the day shift, but 'by-shift' differences were not detected for any other nutrient. Nutrient intake did not differ by BMI category for any nutrient measured. A 'by-BMI' group difference in nutrient intake was not detected for any nutrient measured for the day shift or the night shift. Mean intake for each dietary variable was calculated as the average of intake for that nutrient weighted by the proportion of day and night shifts worked by each study participant.

None of the nutrients differed by BMI category, suggesting that total dietary intake was similar between the two BMI groups.

The 'by-shift' difference (delta) in nutrient intake was compared by BMI group and is presented in Table 3. The delta for energy intake differed significantly by BMI group and was more than 10 times greater in the <25 kg/m^2 BMI group compared to the ≥ 25 kg/m^2 group. The delta for protein also differed significantly; increasing by more than 10 g in the <25 kg/m^2 BMI group but decreasing by almost 4 g in the ≥ 25 kg/m^2 BMI group. Delta for cholesterol showed a similar pattern, increasing by almost 30 mg in the <25 kg/m^2 BMI group while decreasing by almost 140 mg in the ≥ 25 kg/m^2 BMI group.

The 'by-shift' difference in energy was modeled as shown in Table 4. The predicted 'by-shift' difference in energy intake=-248.47-(307.39 × BMI group)+(14.55 × Age)+(32.47 × Born in Israel) where, ≥ 25 kg/m^2 BMI group=1 (*vs.* 0) and 'Born in Israel'=1 (*vs.* 0). This indicates that lower BMI, older age and being born in Israel were positively associated with greater delta energy, or increased energy intake at night. As indicated, the model is significant (p=0.01) but explains only 8.4% of the variability in this outcome.

The model for the 'by-shift' difference in protein intake was not significant; nevertheless, BMI group was identified as a significant predictor of delta protein (beta=-16.69, p=0.01).

The model for the 'by-shift' difference in cholesterol is shown in Table 5. Predicted 'by-shift' difference in cholesterol intake=56.4-(164.55 × BMI group)-(0.45 × Age)-(21.24 × Born in Israel). The model is significant (p=0.02) but explains only 8% of the variability in delta cholesterol. In this model, BMI group emerges as the only predictor of delta cholesterol, such that nurses in the <25 kg/m^2 BMI group.

Discussion

Our previous study found that nurses consume significantly more calories, protein, carbohydrates, calcium, total and saturated fat on days on which they work the night shift than on days they work the day shift [10]. The present study indicates that this difference is driven by the subgroup of nurses with BMI<25 kg/m^2. These nurses consume significantly more of the energy and nutrients listed, as well as more iron, on days they work the night shift. By contrast, none of the nutrients measured differed 'by-shift' among nurses with BMI ≥ 25 kg/m^2. Significantly greater 'by-shift' differences in dietary intake were identified between BMI categories for energy, protein and cholesterol, all of which were greater in the BMI<25 kg/m^2 group. Specifically, protein and cholesterol intake increased in the BMI<25 kg/m^2 group but decreased in the BMI ≥ 25 kg/m^2 on days the nurses worked the night shift compared to days on which they worked the days shift. The 'by-shift' difference in energy intake was positive in both groups, but was greater by a fact of almost 12 in the BMI<25 kg/m^2 group.

Nutrient (unit)	BMI<25 kg/m^2 N=82	BMI ≥ 25 kg/m^2 N=50	*p*-value
Delta energy (kcal)	280.34 ± 546.04	24.51 ± 657.71	0.03
Delta protein (g)	10.78 ± 30.79	-3.65 ± 36.76	0.03
Delta carbohydrate (g)	28.77 ± 76.69	13.93 ± 66.47	0.28
Delta total fat (g)	15.42 ± 31.58	-0.69 ± 40.24	0.06
Delta saturated fat (g)	4.55 ± 8.33	0.41 ± 10.92	0.1
Delta cholesterol (mg)	27.23 ± 207.48	-136.37 ± 362.82	0.002
Delta fiber (g)	1.04 ± 7.29	0.63 ± 9.82	0.97
Delta iron (mg)	0.97 ± 4.26	0.22 ± 5.97	0.45
Delta calcium (mg)	134.86 ± 408.24	83.96 ± 342.02	0.23

Table 3: By-shift differences in nutrients by BMI category.

Variable	Unstandardized Beta	Standardized Beta	*p*-value
BMI group (BMI<25 kg/m^2 *vs.* BMI ≥ 25 kg/m^2)	-307.39	-0.25	0.007
Age	14.55	0.21	0.02
Born in Israel	32.47	0.03	0.76
Constant	-248.47		0.3
R=0.29; R^2=0.084; The model is significant, p=0.01; The "delta" for energy was calculated by subtracting the energy intake for the day shift from the energy intake on the night shift; The index category for BMI group was BMI ≥ 25 kg/m^2.			

Table 4: Multivariate linear regression analysis of the 'by-BMI' group difference in delta energy intake.

Variable	Unstandardized Beta	Standardized Beta	*p*-value
BMI group (BMI<25 kg/m^2 *vs.* BMI ≥ 25 kg/m^2)	-164.55	-0.28	0.003
Age	-0.45	-0.13	0.88
Born in Israel	-21.24	-0.06	0.68
Constant	56.4		0.63
R=0.28, R^2=0.08; the model is significant, p=0.02; The "delta" for energy was calculated by subtracting the energy intake for the day shift from the energy intake on the night shift; the index category for BMI group was BMI ≥ 25 kg/m^2			

Table 5: Multivariate linear regression analysis of the 'by-BMI' group differences in delta cholesterol intake.

This counterintuitive finding may be less perplexing when contextualized in terms of total nutrient intake, which did not significantly differ between the groups. This indicates that the pattern of intake differed without altering mean total intake. Nevertheless, it might be expected that nurses in the BMI ≥ 25 kg/m^2 group would consume more energy.

One possible explanation for this apparent paradox is that the observation is an artifact stemming from nurses in the BMI ≥ 25 kg/m^2 group systematically underreporting their dietary intake. A pattern of underreporting food intake among overweight/obese individuals has been noted in the literature. For example, investigators failed to find an association between self-reported food portion size and BMI in a study using cross-sectional data from the UK National Diet and Nutrition Survey 2008-2014 and the French Étude Individuelle Nationale des Consommations Alimentaires 2005-2007, which together included more than 5000 participants [12]. Underreporting was strongly associated with elevated BMI among adolescents; moreover, underreporting was negatively associated with activation in a region of the left anterior cerebellar lobe implicated in motor control to palatable food receipt [13].

The lack of BMI-group difference in overall intake as well as the increased 'by-shift' dietary intake in the BMI<25 kg/m^2 group may be explained by increased energy consumption in thinner individuals. For example, fat-free mass has been shown to be positively associated with energy intake while fat mass is negatively associated with energy intake. This finding appears to be mediated through physical activity, such that leaner, more active individuals consume more energy [14].

It is possible that the 'by-shift' difference in dietary intake observed for most nutrients in participants in the BMI<25 kg/m^2 group represents energy intake compensation. A study of almost 4000 US adults found that individuals consume less energy in main meals to compensate for calories consumed in snacks without harming overall nutrition quality [15]. Obese individuals may have poorer dietary compensatory skills compared to normal weight individuals, suggested by a weaker inverse association between consumption of energy dense "discretionary" foods and "core" food [16]. If indeed dietary compensation is an explanatory mechanism, it is not clear whether nurses in the BMI<25 kg/m^2 group consume more energy at night to compensate for reduced intake during the day, or whether reduced intake during the day represents willful dietary restriction following increased intake at night.

The obesogenicity of shift work is often attributed to metabolic derangements associated with sleep cycle disruption [17]. Indeed, sleep deprivation has been linked to alterations in hormones associated with appetite and body weight including insulin, leptin, ghrelin, growth hormone and thyroxin [18]. The present study did not utilize sleep diaries, which might have indicated systematic differences in sleep patterns by BMI category on the day nurses worked the day shift *vs.* the day on which they worked the night shift. 'Hours-of-sleep' has been shown to be inversely associated with sugar-sweetened beverage intake [19], and rotating shift work itself has been associated with increased consumption of sweets [20].

Findings of the present study are consistent with these metabolic alterations but suggest that dietary behavior may account for at least some of the association between shift work and increased body weight. While the significant 'by-shift' increase in dietary intake was observed only in the BMI<25 kg/m^2 group, this does not rule out an association with weight gain. Nurses in this group were significantly younger than women in the BMI ≥ 25 kg/m^2 group, and weight has been shown to increase in adulthood especially among individuals who were normal or overweight rather than among obese individuals [21]. If nurses in the BMI<25 kg/m^2 group were followed prospectively, it is possible that weight gain would be observed. Country of birth also differed significantly 'by-BMI' group, such that more nurses in the BMI ≥ 25 kg/m^2 group were born outside of Israel. It has been observed that immigrants to Israel have significantly greater BMI than their native-born counterparts [22]. When age and place of birth were included in the multivariate models of 'by-shift' differences in energy, protein and cholesterol intake, BMI category remained a significant, independent predictor of this outcome.

Interpreting findings of the present study must be viewed through the lens of its limitations. External validity of study findings may be curtailed by the single-centre design. Almost 30% of nurses approached for participation declined, suggesting possible volunteer bias, which may also influence external validity. Food diaries may represent another study limitation. While this method eliminates the recall bias typical of other techniques, food diaries rely on participant skill, motivation and willingness to cooperate [23]. Further, social desirability bias may cause participants to selectively omit foods perceived of as unhealthy [24], leading to an underestimate of true intake. Alternatively, food diaries have been used to facilitate and maintain changes in food intake patterns [25], so it is also possible that nurses actually consumed less food than they would have ordinarily.

Designed to detect a 'by-shift' difference in dietary intake in the same participant, the present study was not powered to detect 'by-BMI' category differences in food consumption. Thus, the lack of 'by-BMI' category differences in may represent lack of study power rather than a true lack of difference.

Conclusion

In conclusion, the present study demonstrated a significant increase in energy and nutrient intake on days the night shift was worked compared to days the day shift was worked among female nurses in the BMI<25 kg/m^2 group. This 'by-shift' difference was not observed among women in the BMI ≥ 25 kg/m^2 group. Differences between BMI groups in 'by-shift' nutrient intake were detected for energy, protein and cholesterol, all of which were significantly greater in the BMI<25 kg/m^2 group.

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