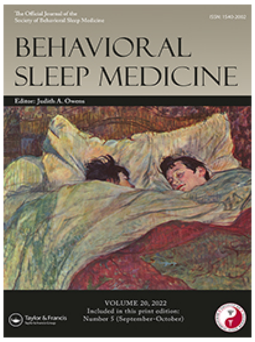

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Sleep Quality and Dietary Patterns in an Occupational Cohort of Police Officers

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ABSTRACT

We examined the association between self-reported sleep quality, sleep duration, and dietary patterns among police officers in the Buffalo Cardio-Metabolic Occupational Stress (BCOPS) study.

422 police officers aged 21–74 (2004–2009).

We used a cross-sectional study design and obtained sleep quality and duration from responses to the 19-item Pittsburgh Sleep Quality Index. Using 46 energy-adjusted food groups derived from a 125-item food frequency questionnaire, we identified dietary patterns using exploratory factor analysis. Multiple linear regression analysis was used to examine the associations of sleep quality and duration with the derived dietary patterns.

We identified major dietary patterns: fruits and vegetables (FV), dairy products, starches and fried foods, and meat and eggs. Individuals with poor sleep quality had a lower average FV score than those with optimal sleep (β [SE] = −0.32 [0.13]; *p* = .01). Significant interactions were observed between sex and the FV and dairy products dietary patterns, where women with poor sleep quality had a lower mean FV score compared to women with optimal sleep quality (β [SE] = −0.81 [0.29]; *p* = .01). Women with < 6 hours sleep duration had a lower mean dairy score compared to women with ≥ 7 hours sleep duration (β [SE] = −0.69 [0.29]; *p* = .02). We did not observe these associations among men.

Among women, good sleep quality and long sleep duration were associated with a dietary pattern high in consumption of both fruits and vegetables and dairy products.

Abbreviations: BCOPS: Buffalo Cardio-Metabolic Occupational Stress study; BMI: body mass index; FFQ: food frequency questionnaire; FV: fruits and vegetables; KMO: Kaiser-Meyer-Olkin test; MET: metabolic equivalent of task score; PSQI: Pittsburgh Sleep Quality Index questionnaire

Introduction

Lack of adequate sleep quality and duration are major public health concerns in the U.S.; nearly 35% of Americans report sleeping ≤ 6 hours per night (Liu et al., 2016). Numerous chronic diseases, such as cancer, heart disease, and stroke, are linked to poor sleep (Ayas et al., 2003; Gangwisch et al., 2006; Kakizaki et al., 2008; Patel et al., 2004). Recent epidemiologic evidence indicates that there may also be a relationship between sleep quality and duration and dietary intake (Grandner et al., 2013, 2014, 2010; Kant & Graubard, 2014; Kim et al., 2011; Kurotani et al., 2015; Shi et al., 2008). The impact of sleep

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quality and duration on chronic disease risk may be in part through an influence of sleep on diet, a known risk factor for many chronic diseases (US Department of Health and Human Services, 2015).

There is evidence for an association between poor sleep quality, short sleep duration, and total energy consumption as well as dietary intake of certain macronutrients and alcohol (Grandner et al., 2013, 2010; Kant & Graubard, 2014). Campanini et al. reported a positive association between adherence to a Mediterranean diet and self-reported sleep quality in the Seniors-ENRICA cohort (Campanini et al., 2017). Researchers have also observed higher total energy, fat, sugar, and alcohol intake in people with shorter compared to longer sleep duration (Galli et al., 2013; Grandner et al., 2013, 2010; Kant & Graubard, 2014; Patterson et al., 2014). In a study of 68,832 Chinese women over 45 years of age, Tu et al. observed that lower fruit and meat intake was associated with shorter self-reported sleep duration (Tu et al., 2012). Stamatakis et al. reported similar findings in a population of older Americans in rural communities (Stamatakis & Brownson, 2008). Despite accumulating evidence to suggest an association between sleep quality, sleep duration and specific facets of diet, the current literature is more limited on the association between sleep quality and duration and patterns of dietary intake, which more comprehensively demonstrates the entirety of all beverages and foods consumed by an individual (US Department of Health and Human Services, 2015). Therefore, dietary patterns may also be more indicative of disease risk than individual diet components (e.g., fat intake) (US Department of Health and Human Services, 2015; Hu, 2002). Poor sleep quality and duration is of particular concern among first responders, who often work long hours and rotating shifts and are at greater risk for sleep disorders. Police officers experience a higher prevalence of sleep apnea (34%) and excessive daytime sleepiness (29%) (Rajaratnam et al., 2011) compared to the general U.S. population (24% in men and 9% in women for sleep apnea and 13% overall for excessive daytime sleepiness) (Ford et al., 2015; Young et al., 2009). In a previous Buffalo Cardio-Metabolic Occupational Police Stress (BCOPS) study, 54% of officers self-reported sub-optimal sleep quality using the Pittsburgh Sleep Quality Index (PSQI), comparable to the prevalence reported by Neylan et al. in over 700 police officers across police departments in the U.S. using the same measure (64%) (Fekedulegn et al., 2016; Neylan et al., 2002). Participants in the BCOPS study were also more likely to self-report short sleep duration compared to the general U.S. working population (33.0% vs. 8.0%, respectively) (Hartley et al., 2011). Police officers are also at greater risk for certain health conditions compared to the general population, including high cholesterol, metabolic syndrome, and obesity (Hartley et al., 2011). The potential intermediate role of dietary intake in relation to sleep quality and duration and chronic disease risk may have important implications for workplace interventions.

Using data from the BCOPS cohort study, we assessed the association of sleep quality and duration with dietary patterns derived from a food frequency questionnaire (FFQ). We hypothesized that police officers reporting poor sleep quality or short sleep duration would have a different dietary pattern than officers with a good sleep quality and long sleep duration.

Materials and methods

Subjects

Participants were urban police officers who participated in the Buffalo Cardio-Metabolic Occupational Police Stress (BCOPS) study between June 4, 2004, and October 2, 2009. This population-based study includes 464 active-duty and retired police officers from the Buffalo Police Department in New York (65% of the total population of officers in 2004). We excluded police officers who were missing sleep quality (N = 38) or FFQ (N = 4) information. The final sample size for this analysis was 422 officers (313 men, 109 women). Further details on the cohort have been published by Violanti et al. (2006). The study was approved by the Institutional Review Board (IRB) of the University at Buffalo and the IRB at the National Institute for Occupational Safety and Health (NIOSH). All participants provided informed consent.

Sleep quality and duration

We obtained sleep quality and duration data from self-reported responses to the Pittsburgh Sleep Quality Index (PSQI) questionnaire (Buysse et al., 1989). The PSQI includes 19 items which assess components of sleep quality over one month. The items are grouped for scoring into seven subscales which include; (1) subjective sleep quality, (2) sleep latency (how long it takes to fall asleep), (3) sleep duration, (4) habitual sleep efficiency (number of hours slept/number of hours in bed), (5) sleep disturbances, (6) use of sleep medications, and (7) daytime dysfunction (difficulty staying awake). Each subscale is weighted equally and receives a score ranging from 0 to 3. The scores for the seven subscales are added to produce a "global" score that ranges from 0–21, with a higher score indicating worse sleep quality. A global score cutoff ≤ 5 is indicative of optimal sleep quality (Buysse et al., 1989). Since over 50% of the study population reported poor sleep quality, we further categorized those with a global PSQI score > 5 as borderline (6–8) or poor (≥ 9) sleep quality, which are similar to previous cut-points used in studies of both healthy and clinical populations (Backhaus et al., 2002; Carpenter & Andrykowski, 1998; Lund et al., 2010; Ohl et al., 2019; Zhang et al., 2019). We categorized sleep duration as <6 hours, 6– < 7 hours, and ≥ 7 hours (Hirshkowitz et al., 2015; Luckhaupt et al., 2010).

Dietary assessment

Dietary intake was collected using the 125 item self-administered Food Frequency Questionnaire (FFQ) developed by the Nutrition Assessment Shared Resource of Fred Hutchinson Cancer Research Center (20160000). Dietary data derived from FFQs is well correlated with nutrient data collected from 24-hour recall, 4-day food records, and biological measurements (Goldbohm et al., 1994; Kroke et al., 1999; Lemaitre et al., 1998; Patterson et al., 1999). Participants provided information on how often they consumed food and beverages over the previous year (never or less than 1 per month, 1 per month, 2–3 per month, 1 per week, 2 per week, 3–4 per week, 5–6 per week, 1 per day, and ≥ 2 per day), including fruits, vegetables, grains, meats, dairy, snacks, and beverages. We weighted the food and beverage items for daily caloric intake from macronutrients (servings per day of item/total daily kilocalories (kcal) derived from macronutrients) and condensed the items into 46 non-overlapping food groups, which are presented in Supplemental Table 1.

Considered covariates

We obtained information on demographic, medical, work history, and psychosocial characteristics from questionnaires administered from 2004–2009. This included age (continuous), the season of survey completion (spring, summer, fall, winter), sex (male, female), race (white, other), education (≤ 12 years, some college, college), marital status (never married, married, divorced, widowed), smoking status (never, former, current), officer rank (officer, other, retired), predominant work shift in past year (day, afternoon, midnight), second job (yes, no), years of service (0–9 years, 10–14 years, 15–19 years, ≥ 20 years), hypertension (yes, no), diabetes (yes, no), hypercholesterolemia (yes, no), body mass index (BMI) (≤ 24.9, 25.0–29.9, ≥ 30), 7-day metabolic equivalent of task (MET) score (continuous), and total hours worked per week (continuous). Duration of physical activity (hours per week, hours per weekend) and intensity (moderate, hard, very hard) of three types of physical activity (occupational, household and sports) were collected using the Seven-Day Physical Activity Recall questionnaire from the Stanford Five-City Project and used to calculate a total MET score (Richardson et al., 2001).

Statistical analysis

We used the Pearson's chi-square test and the ANOVA test (using the Tukey–Kramer post hoc test for multiple comparisons) to assess the differences in population characteristics across sleep quality and sleep duration groups. ANOVA was also used to examine differences in dietary factor scores by population characteristics and macronutrient intake. We used the Kaiser-Meyer-Olkin (KMO) test of sampling adequacy and Bartlett's test of sphericity to determine if the dietary data were sufficient for identifying underlying patterns before conducting factor analysis (Yong & Pearce, 2013). The overall KMO value should exceed 0.50 and for these data was 0.70, indicating an adequate sample size and the presence of distinct factors (Yong & Pearce, 2013). The Bartlett's test was statistically significant ($p < .001$), which showed there were correlations across the 46 food groups which could summarize the dietary data as patterns using factor analysis (Yong & Pearce, 2013).

We used exploratory factor analysis to derive factor patterns to which each participant is assigned an individual factor score. Positive factor scores correspond to higher consumption of foods within the dietary pattern while negative scores refer to lower consumption of those foods. Similar to previous nutritional epidemiologic studies applying factor analysis modeling methods, we used an eigenvalue greater than one and the interpretability of the factor patterns after orthogonal rotation as criteria for determining the number of dietary patterns to retain (Edefonti et al., 2010; Fung et al., 2005; Hamer & Mishra, 2010; Zou et al., 2017). The Velicer's minimum average partial (MAP) test was also performed for comparison and yielded the same number of factors to retain (Velicer et al., 2000). We removed food groups with a loading of 0.20 or less across all dietary patterns from the analysis. We applied the Anderson-Rubin method to calculate a factor score for each participant for every factor pattern (Anderson & Rubin, 1956; DiStefano et al., 2009). This method produces uncorrelated factor scores with a mean of 0 and a standard deviation of 1. We observed four major dietary patterns which are named after the top weighted foods from the factor analysis. Each participant's score on each diet pattern, although named after the top weighted foods, are estimated using linear combinations of all items entered into the factor analysis. In order to discuss results related to each unique linear combination of factor scores we have named each dietary pattern as the following: pattern 1: high consumption of fruits and vegetables (FV), pattern 2: high consumption of dairy products, pattern 3: high consumption of starches and fried foods, and pattern 4: high consumption of meat and eggs (Table 1 and Supplemental Table 2).

We then used multiple linear regression to estimate the associations of sleep quality, sleep duration, subjective sleep quality, sleep latency, habitual sleep efficiency, sleep disturbances, use of sleep medications, and daytime dysfunction with the dietary factor patterns. Sleep quality and individual components of the PSQI were modeled as dummy categorical variables with 0/1 coding, with the referent group excluded from the model (e.g., sleep quality – optimal: 0 = no, 1 = yes; borderline: 0 = no, 1 = yes; poor: 0 = no, 1 = yes). Covariates which were significantly associated with sleep quality, at least one dietary pattern, and which changed the age-adjusted beta coefficient for the dietary pattern score by more than 10% remained in the final models. The multivariable models for sleep quality included adjustment for age, sex, the season of survey completion, BMI, predominant work shift, and physical activity. Models for the individual components of the PSQI, such as sleep duration, included adjustment for the covariates used in the previous model and use of sleeping medications (none, < 1/week, ≥ 1/week). For all analyses, a p-value of < 0.05 was considered statistically significant. Due to sample size limitations we used a less stringent cutoff of $p < .10$ for the assessment of effect modification. We considered age, sex, race, and physical activity as potential effect modifiers. The results were stratified by sex due to evidence of significant interaction via a cross-product term in the FV and dairy products models (p-interaction: borderline = 0.08, poor = 0.05 for FV and borderline = 0.04 and poor = 0.72 for dairy products, respectively). We performed all statistical procedures using SPSS (IBM Corp, Armonk, NY) and SAS 9.3 (SAS Institute, Cary, NC).

Results

Of the 422 participants included in the analysis, 199 reported optimal sleep quality, 102 reported borderline sleep quality, and 121 reported poor sleep quality (Table 2). Those with poor sleep quality reported greater mean physical activity than those with optimal sleep quality, with a higher proportion

Table 1. Rotated factor loading matrix for dietary patterns identified by factor analysis, the Buffalo Cardio-Metabolic Occupation Police Stress study, (n = 422).[a]

Food Group	Pattern 1: High in Fruits & Vegetables	Pattern 2: High in Dairy Products	Pattern 3: High in Starches & Fried Foods	Pattern 4: High in Meat & Eggs
Dark green vegetables	0.75	0.30		
Other vegetables	0.75	0.24		
Red orange vegetables	0.64	0.42		
Beans	0.50		0.22	
Citrus fruits	0.42	0.41		
Other fruits	0.42	0.31		
Seafood (not fried)	0.36			
Cheese	0.30			0.28
Soy	0.26			
Soup	0.23			
Wine				
Candy				
Cereal		0.62		
Water	0.29	0.52		
Milk		0.45		
Poultry (not fried)		0.41		0.22
Frozen yogurt		0.37		
Tuna		0.29		
Low-fat chips		0.28		
Coffee		0.28		
Tea		0.25		
Nuts		0.20		
Starches	0.31		0.48	
Sides	0.35		0.38	
Starches (fried)			0.38	0.23
Seafood (fried)			0.36	
Pastries			0.34	
Poultry (fried)			0.32	
Pasta			0.30	
Chips			0.28	
Stew and chili	0.20		0.27	
Fruit juice			0.25	
Ice cream			0.22	
Pizza			0.21	
Liquor				
Beer				
Meal replacement products				
Cured meats				0.44
Meats				0.42
Condiments	0.41	0.32		0.41
Eggs				0.30
Butter			0.26	0.30
Soda				0.22
Burritos				
Bread				
Vegetable juice				

[a]Displays factor scores ≥0.20.

of physical activity derived from occupational tasks (data not shown in tables). Those with poor sleep quality were more likely to work a non-day shift and to have worked as a police officer for > 15 years compared to those with optimal sleep quality. Those with short sleep duration (< 6 hours/night) also had a higher mean physical activity than those with long sleep duration (≥ 7 hours/night), while those with moderate sleep duration (6–< 7 hours) had a higher mean percent of their daily caloric intake from fat (data not shown). We did not observe statistically significant differences for other covariates examined according to sleep quality or sleep duration.

Table 2. Population characteristics by sleep quality category, overall and by sex, the Buffalo Cardio-Metabolic Occupation Police Stress study, (n = 422).

	Overall			Women			Men		
Characteristic	Optimal	Borderline	Poor	Optimal	Borderline	Poor	Optimal	Borderline	Poor
Total (n)	199	102	121	48	21	40	151	81	81
BMI, kg/m^2, n (%)									
≤24.9	31 (16)	22 (22)	26 (21)	22 (46)	14 (67)	18 (45)	9 (6)	8 (10)	8 (10)
25.0–29.9	91 (46)	39 (38)	44 (36)	19 (40)	6 (29)	11 (28)	72 (48)	33 (41)	33 (41)
≥30	73 (37)	41 (40)	50 (41)	7 (15)	1 (5)	10 (25)	66 (44)	40 (49)	40 (50)
Predominant work shift (last year), n (%)[a,c]									
Day	95 (48)	28 (27)	51 (42)	35 (73)	14 (67)	27 (68)	60 (40)	14 (17)	24 (30)
Afternoon	39 (20)	35 (34)	28 (23)	3 (6)	3 (14)	3 (8)	36 (24)	32 (40)	25 (31)
Midnight	31 (16)	30 (29)	29 (24)	6 (13)	2 (10)	8 (20)	25 (17)	28 (35)	21 (26)
Years of service, n (%)[a,c]									
0–9	55 (28)	33 (32)	29 (24)	15 (31)	11 (52)	13 (33)	40 (26)	22 (27)	16 (20)
10–14	39 (20)	30 (29)	19 (16)	13 (27)	3 (14)	5 (13)	26 (17)	27 (33)	14 (17)
15–19	39 (20)	15 (15)	31 (26)	8 (17)	3 (14)	12 (30)	31 (21)	12 (15)	19 (23)
≥20	66 (33)	23 (23)	42(35)	12 (25)	4 (19)	10 (25)	54 (36)	19 (23)	32 (40)
Season of survey completion									
Spring	50 (25)	29 (28)	35 (29)	13 (27)	5 (24)	11 (28)	37 (25)	24 (30)	24 (30)
Summer	41 (21)	23 (23)	25 (21)	13 (27)	5 (24)	7 (18)	28 (19)	18 (22)	18 (22)
Fall	55 (28)	26 (25)	31 (26)	12 (25)	6 (29)	9 (23)	43 (28)	20 (25)	22 (27)
Winter	49 (25)	24 (24)	29 (24)	10 (21)	5 (24)	12 (30)	39 (26)	19 (23)	17 (21)
Mean ± SD									
Age, years	42 ± 9	41 ± 7	43 ± 9	40 ± 6	40 ± 8	42 ± 6	43 ± 10	41 ± 7	44 ± 10
7-day PA, MET[a]	277 ± 39	288 ± 45	288 ± 49	274 ± 36	292 ± 47	287 ± 45	278 ± 40	287 ± 45	288 ± 52
Energy from macronutrients (kcal)	1,774 ± 771	1,895 ± 820	1,949 ± 814	1,470 ± 707	1,758 ± 577	1,650 ± 680	1,871 ± 768	1,931 ± 872	2,097 ± 838
Carbohydrate (% kcals)	45 ± 9	45 ± 8	43 ± 9	47 ± 10	44 ± 8	44 ± 11	44 ± 9	45 ± 9	43 ± 8
Fat (% kcals)	33 ± 7	33 ± 7	34 ± 8	32 ± 8	33 ± 6	33 ± 9	34 ± 7	33 ± 7	35 ± 7
Protein (% kcals)	18 ± 4	18 ± 4	17 ± 4	17 ± 4	18 ± 4	17 ± 4	18 ± 4	17 ± 4	17 ± 4
Alcohol (% kcals)	4 ± 6	4 ± 6	5 ± 8	3 ± 6	5 ± 6	6 ± 11	4 ± 6	4 ± 6	5 ± 6

Abbreviations: BMI – body mass index; PA – physical activity; MET – metabolic equivalent of task; kcal – kilocalories.
[a] $p < .05$ for the overall model (chi-square test for categorical, ANOVA test for continuous).
[b] $p < .05$ for the model restricted to women.
[c] $p < .05$ for the model restricted to men.

Table 3. Beta coefficients (β) and standard errors (SE) for mean differences in diet pattern score by sleep quality, the Buffalo Cardio-Metabolic Occupation Police Stress Study, (n = 422).

	Overall[a,d]			Women[b,e]			Men[c,e]		
Sleep Quality	β	SE	p-value	β	SE	p-value	β	SE	p-value
Pattern 1: High Consumption of Fruits and Vegetables									
Optimal	ref	ref	ref	ref	ref	ref	ref	ref	ref
Borderline	−0.18	0.13	.18	−0.62	0.35	.08	−0.06	0.14	.68
Poor	−0.32	0.13	.01	−0.81	0.29	.01	−0.16	0.13	.23
PSQI Global Score	−0.03	0.02	.05	−0.07	0.04	.07	−0.02	0.02	.19
Pattern 2: High Consumption of Dairy Products									
Optimal	ref	ref	ref	ref	ref	ref	ref	ref	ref
Borderline	−0.04	0.13	.75	−0.64	0.32	.05	0.14	0.14	.31
Poor	−0.24	0.12	.05	−0.47	0.27	.09	−0.16	0.14	.25
PSQI Global Score	−0.03	0.02	.05	−0.06	0.03	.09	−0.02	0.02	.24
Pattern 3: High Consumption of Starches and Fried Foods									
Optimal	ref	ref	ref	ref	ref	ref	ref	ref	ref
Borderline	0.06	0.14	.67	0.25	0.27	.37	−0.06	0.16	.70
Poor	0.03	0.13	.83	0.13	0.23	.56	−0.03	0.16	.84
PSQI Global Score	0.01	0.02	.73	0.001	0.03	.97	0.01	0.02	.78
Pattern 4: High Consumption of Meats and Eggs									
Optimal	ref	ref	ref	ref	ref	ref	ref	ref	ref
Borderline	−0.12	0.14	.39	0.09	0.33	.79	−0.17	0.15	.24
Poor	−0.08	0.13	.54	0.06	0.28	.84	−0.12	0.14	.41
PSQI Global Score	0.003	0.02	.86	0.02	0.03	.58	−0.01	0.02	0.77

Abbreviations: PSQI – Pittsburgh Sleep Quality Index,ref – referent.
[a]Overall: Optimal (n = 199), Borderline (n = 102), Poor (n = 121).
[b]Women: Optimal (n = 48), Borderline (n = 21), Poor (n = 40).
[c]Men: Optimal (n = 151), Borderline (n = 81), Poor (n = 81).
[d]Models adjusted for age, sex, the season of survey completion, BMI, predominant work shift, and physical activity.
[e]Models adjusted for age, the season of survey completion, BMI, predominant work shift, and physical activity.

In the overall model, we observed a linear association between the PSQI global score for sleep quality and the FV dietary pattern (β [SE] = −0.03 [0.02]; *p* = .05) (Table 3). Individuals with poor sleep quality had a lower average FV score than those with optimal sleep quality (β [SE] = −0.32 [0.13]; *p* = .01). After sex stratification, women with poor sleep quality had significantly lower mean scores on the FV pattern compared to women with optimal sleep scores (β [SE] = −0.81 [0.29]; *p* = .01). Sleep duration was significantly linearly associated with the dairy products dietary pattern among women (β [SE] = 0.24 [0.10]; *p* = .02) (Table 4). Women with short sleep duration (< 6 hours) had significantly lower mean scores on the dairy products pattern as compared to women with long sleep duration (≥7 hours) (β [SE] = −0.69 [0.29]; *p* = .02). Sleep quality and sleep duration were not associated with dietary patterns in men.

Women reporting ≥ 10 sleep disturbances per week had lower mean FV pattern scores compared to those who reported none (β [SE] = −1.30 [0.61]; *p* = .04). Compared to women with optimal subjective sleep quality, those reporting borderline subjective sleep quality had higher mean scores on the meat and eggs pattern (β [SE] = 0.72 [0.34]; *p* = .04). In men, borderline daytime dysfunction compared to none was associated with a lower mean FV pattern score (β [SE] = −0.38 [0.12]; *p* = .002). Use of sleep medications ≥ 1/week compared to no use was associated with a lower mean starch and fried foods score (β [SE] = −0.62 [0.17]; *p* = .0004). We did not observe statistically significant associations for sleep latency or habitual sleep efficiency in men or women.

Table 4. Beta coefficients (β) and standard errors (SE) for mean differences in diet pattern score by sleep duration, the Buffalo Cardio-Metabolic Occupation Police Stress study, (n = 422).

	Overall[a,d]			Women[b,e]			Men[c,e]		
Sleep Duration	β	SE	p-value	β	SE	p-value	β	SE	p-value
Pattern 1: High Consumption of Fruits and Vegetables									
≥7 Hours	ref	ref	ref	ref	ref	ref	ref	ref	ref
6–<7 Hours	0.04	0.13	.78	0.14	0.36	.69	0.05	0.14	.74
<6 Hours	−0.05	0.13	.70	−0.28	0.32	.39	0.02	0.14	.89
Per Hour of Sleep	0.04	0.05	.34	0.15	0.12	.21	0.01	0.05	.81
Pattern 2: High Consumption of Dairy Products									
≥7 Hours	ref	ref	ref	ref	ref	ref	ref	ref	ref
6–<7 Hours	−0.19	0.13	.13	−0.30	0.32	.34	−0.14	0.14	.32
<6 Hours	−0.24	0.13	.05	−0.69	0.29	.02	−0.05	0.14	.70
Per Hour of Sleep	0.08	0.04	.06	0.24	0.10	.02	0.03	0.05	.58
Pattern 3: High Consumption of Starches and Fried Foods									
≥7 Hours	ref	ref	ref	ref	ref	ref	ref	ref	ref
6–<7 Hours	0.06	0.13	.62	0.26	0.27	.33	−0.04	0.15	.81
<6 Hours	0.25	0.13	.05	0.12	0.24	.62	0.25	0.16	.10
Per Hour of Sleep	−0.06	0.05	.17	−0.03	0.09	.72	−0.05	0.05	.31
Pattern 4: High Consumption of Meats and Eggs									
≥7 Hours	ref	ref	ref	ref	ref	ref	ref	ref	ref
6–<7 Hours	0.14	0.13	.28	0.48	0.32	.14	0.02	0.15	.87
<6 Hours	−0.13	0.13	.33	0.28	0.29	.33	−0.26	0.15	.08
Per Hour of Sleep	0.01	0.05	.74	−0.13	0.11	.24	0.06	0.05	.24

Abbreviations: ref – referent.
[a]Overall: ≥7 hours (n = 156), 6–<7 hours (n = 132), <6 hours (n = 134).
[b]Women: ≥7 hours (n = 43), 6–<7 hours (n = 28), <6 hours (n = 38).
[c]Men: ≥7 hours (n = 113), 6–<7 hours (n = 104), <6 hours (n = 96).
[d]Models adjusted for age, sex, the season of survey completion, BMI, predominant work shift, physical activity, and use of sleeping medications.
[e]Models adjusted for age, the season of survey completion, BMI, predominant work shift, physical activity, and use of sleeping medications.

Discussion

In this cross-sectional study of urban police officers in the United States, we classified individuals according to four dietary patterns: pattern 1: high consumption of fruits and vegetables, pattern 2: high consumption of dairy products, pattern 3: high consumption of starches and fried foods, and pattern 4: high consumption of meat and eggs. Police officers reporting borderline or poor sleep quality had lower mean FV dietary pattern scores than those reporting optimal sleep quality, suggesting that better sleep quality is positively associated with greater intake of healthy foods, such as dark green and red-orange vegetables, citrus and other fruits, and beans. We observed this association in women, but not in men. Sleep quality was not significantly associated with other dietary patterns.

Our findings are consistent with previous studies conducted in different populations. A study of 2,025 Japanese manufacturing workers, aged 18–70 years, who completed a dietary questionnaire on eating habits in the last month, reported that a dietary pattern high in vegetable consumption was associated with shorter self-reported sleep latency (Kurotani et al., 2015). Katagiri and colleagues reported an association between poor sleep quality using the PSQI and low consumption of vegetables and fish among 3,129 employed Japanese women aged 34 to 65 years (Katagiri et al., 2014). Cao et al. also found that sleep initiation, measured via polysomnography, was positively associated with a dietary pattern high in fruits and vegetables in 784 Australian men participating in the Male Androgen Lifestyle, Environment, and Stress study (Cao et al., 2017). In a cross-sectional study of 23,829 adults from the Swedish EpiHealth cohort, Theorell-Haglöw et al. observed that good sleep quality and long sleep duration were associated with consuming a Mediterranean diet (i.e., high intake of fruits, vegetables, and whole grains and low intake of red meats) (Theorell-Haglöw et al., 2020).

Though our analysis utilized a cross-sectional study design, we propose that additional studies explore the biologically plausibility that sleep quality and duration influence dietary intake. Individuals with poor sleep quality and short sleep duration may be more likely to make poor dietary choices, as sleep influences appetite-related functions in the brain (Greer et al., 2013; Hanlon & Van Cauter, 2011). Poor sleep quality and short sleep duration are associated with decreased levels of the hormone leptin, which regulates appetite suppression, and elevated levels of the hormone ghrelin, which stimulates hunger (Klok et al., 2007). In a small 3-condition crossover trial of nine men aged 20–40 years, Schmid et al. reported that one night of total sleep deprivation led to higher levels of ghrelin compared to one night of sleeping seven hours (Schmid et al., 2008).

As noted, we observed a direct association between sleep quality and the FV dietary pattern only in women and not men. Haghighathoost et al. found that among 410 Iranian women under 30 years of age, those who slept < 6 hours/day had higher intake of total carbohydrates, but lower intake of fruits, compared to those who slept ≥ 6 hours/day (Haghighatdoost et al., 2012). A late midpoint of sleep (midpoint between falling asleep and waking up) was also inversely associated with vegetable, milk, and egg consumption in a cross-sectional study of 3,304 young Japanese women (Sato-Mito et al., 2011).

Results from studies on sleep behaviors by sex are inconsistent. Some of this inconsistency between studies may be due to differences in participants' ages and in the measurement of sleep (self-report vs. actigraphy) from study to study (Lauderdale et al., 2006; Mezick et al., 2009; Roane et al., 2015). Mezick et al. found that among middle-aged adults, women had greater variability in sleep duration and disturbances than men (Mezick et al., 2009). In a previous study of the BCOPS cohort, women were slightly more likely to report daytime dysfunction compared to men (Bond et al., 2013). Menopausal symptoms are associated with sleep disturbances and difficulty falling asleep (Brown et al., 2009). Women may also be more likely to change their eating behaviors as a result of stress or depression (Allgöwer et al., 2001; Weinstein et al., 1997). While we observed a significant association between better sleep quality and higher fruit and vegetable consumption in women, we also observed an association of fewer sleep disturbances with higher consumption of these same foods in men, indicating a need for additional research on how various dimensions of sleep may differentially influence dietary patterns in women and men.

Our study included several limitations. Due to the cross-sectional design of the study, we cannot determine if the observed association between sleep quality and dietary intake is causal. Recall bias is possible if those with poor sleep quality or short duration reported their dietary intake over the past year differently than those with optimal sleep characteristics. The use of self-reported sleep duration may also be particularly prone to misclassification bias. Residual confounding may exist if we did not adjust for factors related to both sleep characteristics and diet. For example, no data were available for adjustment of our associations in women by menopausal status and a history of mental health disorders was not evaluated. Further, while the PSQI may broadly indicate whether an exposure under study may be associated with sleep quality and duration, it does not capture specific information on factors that may contribute to greater versus lower scores on the PSQI. In a previous BCOPS study, poor sleep quality and duration were significantly associated with frequent exposure to traumatic workplace events in police officers and these findings varied by sex (Bond et al., 2013). We were also unable to example potential latency effects that may influence the association between sleep quality and dietary patterns, such as retirement duration, though exclusion of retired participants did not change the reported effect estimates.

Our study had numerous strengths. A validated sleep quality questionnaire was used addressing multiple aspects of sleep behavior and was administered using a standardized protocol (compared to clinical and polysomnographic data, the PSQI has a sensitivity of 89.6% and a specificity of 86.5%) (Buysse et al., 1989). Data were available on the intake of over 100 food items and for a wide range of potential confounders with minimal missing data. The BCOPS study also provided a unique opportunity to explore the relationship between sleep quality and duration and diet in a U.S. worker population that is also at high risk for sleep disorders and other chronic health conditions.

Overall, findings from this study are suggestive of an association between poor sleep quality and low fruit and vegetable intake in police officers; and this association differed by sex. This study adds to the limited literature on the role of sleep quality on food-based dietary patterns and may provide direction for future studies exploring methods to reduce obesity and cardiovascular disease among police officers. Consideration of work schedule policies, fatigue management training, and nutrition and wellness counseling for police officers in interventional studies may help mitigate the impact of poor sleep quality and short sleep duration on unhealthy eating habits. Currently, studies examining the association between sleep quality and food-based dietary consumption are largely limited to cross-sectional studies which primarily examine intake of specific nutrients or food groups over comprehensive dietary patterns. Prospective studies are warranted, with a larger sample size and further consideration of factors, such as sex, which may modify the association between sleep quality and dietary patterns.

Data availability statement

The datasets analyzed during the current study are not publicly available due to potential for re-identification of de-identified study participants, which could compromise research participant privacy/consent.

Ethical standards disclosure statement

The study was approved by the Institutional Review Board (IRB) of the University at Buffalo and the IRB at the National Institute for Occupational Safety and Health (NIOSH). All participants provided informed consent.

Statement of authors' contributions to manuscript

RV-K and AEM designed the study and developed the overall research plan. AM, JG, and JV provided the data necessary for the research. RV-K was responsible for data analysis and drafted the manuscript. AM, JG, and MA verified the analytic methods. RV-K, AEM, HMO-B, AM, JG, MA, and JV interpreted the results and revised the manuscript. All authors have read and approved the final manuscript.

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