Journal of Safety Research xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Journal of Safety Research

journal homepage: www.elsevier.com/locate/jsr

Fatigue and on-duty injury among police officers: The BCOPS study

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ARTICLE INFO

Article history:
Received 21 March 2016
Received in revised form 14 June 2016
Accepted 30 November 2016
Available online xxxx

Keywords:
Non-fatal injuries
Chronic tiredness
Law enforcement
Work history

ABSTRACT

Introduction: Policing involves inherent physical and psychological dangers as well as occupational stressors that could lead to chronic fatigue. Although accounts of adverse events associated with police fatigue are not scarce, literature on the association between chronic fatigue and on-duty injury are limited. *Methods*: Participants were officers from the Buffalo Cardio-Metabolic Occupational Police Stress (BCOPS) Study. A 10-item questionnaire was administered to assess how tired or energetic the officers generally felt irrespective of sleep hours or workload. The questionnaire consisted of five positively worded and five negatively phrased items that measured feelings of vigor/energy and tiredness, respectively. Total as well as separate scores for positive and negative items were computed by summing scores of individual items. Payroll records documenting each officer's work history were used to assess occurrence of injury. Poisson regression was used to estimate prevalence ratios (PR) of injury. *Results*: Nearly 40% of officers reported feeling drained. *Overall prevalence of on-duty injury during the past year was 23.9%.* Injury prevalence showed a significant increasing trend across tertiles of total fatigue score: 19.6, 21.7, and 30.8% for lowest, middle and highest tertiles, respectively (trend p-value = 0.037). After controlling for potential confounders, a 5-unit increase in total fatigue score was associated with a 12% increase in prevalence of injury which was marginally significant (p = 0.075). A 5-unit increase in fatigue score of the positively worded items was associated with a 33% increase in prevalence of injury (PR = 1.33, 95% CI: 1.04–1.70, p = 0.022). *Conclusion*: Officers who do not feel active, full of vigor, alert, or lively had a significantly higher prevalence of non-fatal work place injury compared to their counter parts. *Practical applications:* With additional prospective evidence, workplace interventions designed to enhance level of energy may reduce feelings of tiredness and hence may prevent workplace injury.

1. Introduction

Fatigue, broadly defined as "a feeling of weariness, tiredness, or lack of energy," is a frequently cited complaint among the U.S. workforce with reported prevalence of 38% (Ricci, Chee, Lorandeau, & Berger, 2007). It is an especially serious concern among police officers who are overly fatigued because of long and irregular work hours, shift work, sleep deprivation, and the inherent physical and psychosocial danger associated with the job (Vila, 2006; Vila & Kenney, 2002). Law enforcement is also one of six occupations with the highest incidence rates of nonfatal occupational injuries. The most recent data provided by U.S. Bureau of Labor Statistics (BLS) indicated that, in 2014, police and Sheriffs patrol officers had one of the highest days away from work (DAFW) nonfatal injury rates (485.8 per 10,000 full-time workers) among all occupations (107.1 per 10,000 full-time workers) and incurred the highest number of injuries among local government and second highest among state government employees (BLS, 2014). Fatigue in police officers impairs vigilance, reaction time, and performance thereby elevating the risk for fatal and non-fatal injuries to both the officers and the general public (Garbarino et al., 2007; Rajaratnam et al., 2011; Vila, 2006; Vila & Kenney, 2002; Waggoner, Grant, Van Dongen, Belenky, & Vila, 2012).

While considerable attention has been placed on the psychosocial and cardio-metabolic health of police officers (Violanti et al., 2006), scientific research on occupational injury of officers is limited, and statistics for injuries are less readily available (LaTourrette, 2011). In 2009, the National Public Safety Agenda, which is part of the National Occupational Research Agenda (NORA) for occupational safety and health research and practice in the United States, recognized that data on occupational injuries and illness among law enforcement personnel are not sufficient (NORA, 2009). Fatigue is a well-known risk factor for injury, yet the scientific literature documenting the prevalence of fatigue among police officers, particularly its association with non-fatal on-duty injury, is limited (James & Vila, 2015).

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http://dx.doi.org/10.1016/j.jsr.2016.11.006
0022-4375/

Fatigue is a latent construct that cannot be directly measured. It is argued that fatigue is best viewed as a continuum (Lewis & Wessely, 1992; Ricci et al., 2007), where at the lower end it occurs frequently and consists of acute episodes that resolve quickly following an intervention (e.g., rest, improvement of the stressor), while at the severe end it occurs less frequently but is symptomatic of a more chronic and potentially disabling conditions that cannot be quickly resolved with rest (often referred to as chronic fatigue). Chronic fatigue was defined by Barton et al. (1995) as "a general tiredness and lack of energy irrespective of whether an individual has not had enough sleep or has been working hard, which persists even on rest days and holidays." Although there is no standard way to assess fatigue, there are a variety of questionnaires, with high reliability and validity, which have been designed to assess fatigue in working populations (De Vries, Michielsen, & Van Heck, 2003). However, the applicability of these instruments in assessing fatigue prevalence in police officers has not been explored.

Prior studies that highlighted the significant impact of fatigue on injury and performance in police officers (James & Vila, 2015; Senjo, 2011; Vila, 2006; Violanti et al., 2012, 2013) utilized proxy indicators of fatigue (e.g., shift work, long work hours, insufficient sleep); rather than chronic fatigue assessed using one of several validated instruments. Therefore, the purpose of this research was to estimate the prevalence of chronic fatigue (assessed based on a validated instrument) and then examine its association with non-fatal workplace injury (objectively assessed using organizational work history records), among officers working in mid-sized urban police department. In our analysis, the association of interest was adjusted for demographic and lifestyle factors that were reported to affect non-fatal occupational injury in various occupational groups. These factors included age (Landen & Hendricks, 1992), gender (Berecki-Gisolf, Smith, Collie, & Mcclure, 2015), race/ethnicity (Hurley & Lebbon, 2012), education (Kim et al., 2014), workload (Nakata et al., 2006), physical activity (Caban-Martinez et al., 2015), and alcohol consumption (Stallones & Xiang, 2003).

2. Methods

2.1. Study population

Participants from the Buffalo Cardio-Metabolic Occupational Police Stress (BCOPS) study were used for the current analyses. The BCOPS study was a cross-sectional study aimed at investigating the associations of occupational stressors with the psychological and physiological health of police officers. The study was initiated in 2004 and a total of 710 police officers who worked with the Buffalo Police Department in New York were invited to participate in the BCOPS study; 464 (65.4%) officers agreed to participate and were examined once during the period of June 4, 2004 to October 2, 2009. No specific inclusion criteria were indicated for the study, only that participants be a sworn police officer and willing to participate. Comparisons of available demographic variables (sex, age, and police rank) showed no significant differences between participants and non-participants. A written informed consent was collected from each participant. Data collection was performed at The Center for Preventive Medicine, State University of New York at Buffalo. The study was approved by the Internal Review Board of the State University of New York at Buffalo, and the National Institute for Occupational Safety and Health (NIOSH) Institutional Review Board (IRB).

2.2. Measures and study design

Data originated from two sources. The first source was the BCOPS study where data on demographic, physical, biological, and psychosocial characteristics were collected from each participant. As part of the study, the participants filled out a questionnaire designed to assess chronic fatigue which served as the exposure variable of interest. The second source was work history records of the BCOPS study participants obtained from the Buffalo, NY police payroll department. The work history records were used to derive occurrence of nonfatal on-duty injury which served as the outcome variable of interest.

2.3. Assessment of chronic fatigue

Chronic fatigue was assessed using a 10-item questionnaire developed by Barton et al. (1995). In the current study the questions about chronic fatigue were introduced with this statement: "The following items relate to how tired or energetic you generally feel, irrespective of whether you have had enough sleep or have been working very hard. Some people appear to suffer from permanent tiredness, even on rest days and holidays, while others seem to have limitless energy. Please indicate the degree to which the following statements apply to your own normal feelings." The study participants were then asked to rate (score) each of the 10 items on a five-point Likert scale (5 = very much, 4 = much, 3 = somewhat, 2 = little, 1 = not at all). The questionnaire consisted of five items (I usually feel drained, I feel tired most of the time, I usually feel rather lethargic, I often feel exhausted, and I feel weary much of the time) designed to measure general feelings of tiredness and lack of energy while the remaining five items (I generally feel I have plenty of energy, I generally feel quite active, I generally feel full of vigor, I generally feel alert, and I usually feel lively) were positively worded to measure general feelings of vigor and energy (the opposite of fatigue). A single total score was computed by summing the ratings from the 10 items after reverse-coding the five positively oriented items. A higher score indicates greater feelings of chronic fatigue. In addition, separate scores for the positively and negatively worded questions were computed. The chronic fatigue questionnaire was introduced to the BCOPS study 9 months after the start of the first clinic examination and hence only 316 of the 464 participants had the opportunity to complete the questionnaire (the remaining 148 officers who did not complete the fatigue questionnaire were excluded from analyses). The instrument has high reliability with Cronbach's alpha coefficient of 0.84 (Cohen, Manion, & Morrison, 2000). For our sample of officers the estimated alpha coefficient was 0.94 and it was obtained using the SAS procedure PROC CORR with the ALPHA option.

2.4. Assessment of on-duty injury

The second source of data (the work history records) was a longitudinal dataset that was made available in an electronic format and contained a day-by-day account of activities, for each officer, including the start time of work, the type of activity (e.g., regular work, overtime work), the type of leave (e.g., injury, sick, or vacation), and the number of hours worked for a period spanning 15 years (from May 23, 1994 to date of the BCOPS study exam). The work history records during the 1-year period prior to date of clinic examination were used to derive occurrence of injury (yes/no) for each officer and this binary variable served as the outcome variable of interest in the current analyses. For example, during the BCOPS study if an officer was examined on 8/15/2005 then we examined daily work history records of this officer from 8/15/2004 to 8/15/2005 (1-year period) to assess occurrence of on-duty injury. The work history data contained work absences due to injury that occurred while on duty. The occurrence of on-duty injury was identified when the payroll record indicates that an officer is paid for regular work but is off-duty due to injury that occurred while at work. No additional information was available concerning the type of injury or its severity. The work history data were also used to derive dominant shift (a covariate of interest) during the same 1-year period for each officer. The methodology for derivation of dominant shift as day, afternoon or night is described in Fekedulegn et al. (2013).

2.5. Assessment of covariates

Study participants self-reported demographic and lifestyle characteristics including age, gender, race/ethnicity, marital status, education, rank, years of service, smoking and alcohol consumption, workload, physical activity, and sleep quality. Height and weight were measured with shoes removed and recorded to the nearest half centimeter and rounded up to the nearest quarter of a pound, respectively, then body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Alcohol consumption was measured from data collected using Food Frequency Questionnaire (FFQ) where, among other things, the officers also reported how often they drank the following amounts of alcoholic beverages: beer (12 oz), red wine (6 oz), white or rose wine (6 oz), and liquor and mixed drinks (1.5 oz). The number of drinks per week was derived as the sum of consumption of these amounts from the four types of alcoholic beverages. Physical activity was assessed using the Seven-Day Physical Activity Recall questionnaire developed in the Stanford Five-City Project (Sallis et al., 1985). This was an interviewer administered questionnaire where the officers were asked to provide the number of hours they spent on three types of physical activity (occupational, sports, and household) during the previous 7 days at each of the following intensities: moderate, hard, and very hard. Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI) questionnaire. This was a 19-item questionnaire designed to assess the quality and pattern of sleep in adults during the previous month. A total global score for sleep quality was calculated by summing scores on the following seven components: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, use of sleep medications, and daytime dysfunction. A standard cut point of >5.0 and ≤ 5.0 was used to define "poor" and "good" sleep quality respectively (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). Workload was assessed by asking the officers the question "What is the work activity level at your district?" to which they responded by selecting one of the following: high work load (very busy with frequent complaints, high crime area); moderate work load (moderate complaint rate, average crime); or low work load (precinct not busy, low crime area).

2.6. Statistical analyses

Of the 464 BCOPS study participants, officers who did not complete the chronic fatigue questionnaire ($n = 148$) were excluded. Of the 316 remaining officers, we further excluded 36 officers who retired at least a year prior to date of exam and hence did not have work history records to determine occurrence of injury during the 1-year prior to examination. The current analyses were therefore performed using the 280 officers with complete data on both the exposure variable (chronic fatigue score) and the outcome (occurrence of on-duty injury). Initial analyses included descriptive results to characterize the composition of the study sample and examined the association of demographic and lifestyle characteristics with fatigue score and occurrence of injury using chi-square tests and analysis of variance (ANOVA).

The primary research question of interest (is there an association between chronic fatigue and occurrence of on-duty injury?) was examined using Poisson regression analysis with a robust error variance (Zou, 2004). First, we examined the association between chronic fatigue scores (overall score, score from the positive items, and score from the negative items) and occurrence of on-duty injury. In these analyses, the fatigue score was treated both as a continuous variable as well as a categorical variable (by creating tertiles). Second, we examined the association between each of the 10 items of the chronic fatigue questionnaire (individually) and injury prevalence. For this analysis we classified the ratings for each item into two categories because of small sample sizes in some of the original 5 categories. Those that rated the item as 1 (not at all) or 2 (little) were classified in one group, while those that rated the item as 3 (somewhat) or 4 (much) or 5 (very much) were combined into a second group. In both analyses prevalence ratios (PR) and their 95% confidence intervals (CI) were computed as measures of association. The unadjusted, age- and multivariate-adjusted PRs were estimated. The multivariate model adjusted for the following covariates: age, gender, race/ethnicity, education, workload, physical activity, and alcohol consumption. The variables chosen as covariates in the multivariable model are based on previous findings in the literature and those that are marginally ($p\text{-value} < 0.08$) or significantly ($p < 0.05$) associated with either the exposure (fatigue) or the outcome (injury). Sleep quality and shift work are proxy measures of fatigue and hence including them in the multivariable model is considered over-adjustment. The demographic and lifestyle factors were first tested for potential effect modification by including their interaction terms in a multivariable model. For all tests, statistical significance was assessed at the 5% level. All analyses were conducted using the SAS system, version 9.3.

3. Results

3.1. Demographic and lifestyle characteristics

The demographic and lifestyle characteristics of the participants are presented in Table 1. The study population consists of 73% males and the majority was white (75%), married (70%), had a rank of patrol officer (79%), and reported high workload (64%) and poor sleep quality (57%). The mean age was 40.7 years ($SD = 6.4$) and the officers were on average overweight (mean $BMI = 29.4$, $SD = 4.8$). The data in Table 1 also shows mean fatigue scores and prevalence of on-duty injury (in the past year) by levels of demographic and lifestyle characteristics. Mean fatigue score did not vary significantly by levels of demographic and lifestyle characteristics except for race/ethnicity, sleep quality, and physical activity levels. White officers, and those who reported poor sleep quality had a significantly higher mean fatigue score compared to their counterparts. Physical activity hours were negatively correlated with fatigue score where officers with lower physical activity reported higher fatigue score ($r = -0.19$, $p\text{-value} = 0.0017$, Table 1). Prevalence of injury varied significantly by levels of workload, sleep quality, shift work, and physical activity levels (Table 1). Officers who reported high workload, poor sleep quality, and worked on the night shift had higher prevalence of on-duty injury compared to their counterparts. Physical activity hours were positively associated with prevalence of injury; for one standard deviation increase in hours of physical activity the prevalence of injury increased by 19%.

3.2. Distribution of chronic fatigue items

A majority of the officers responded favorably ("somewhat" to "very much") to the five fatigue questionnaire items designed to measure general feelings of vigor and energy (Fig. 1A). The percentage of officers who responded "somewhat" to "very much" to these items ranged from 67.1% (I generally feel full of vigor) to 90.4% (I generally feel alert). On the other hand, the response of "somewhat" to "very much" to the five items designed to measure general feelings of tiredness and lack of energy ranged from 31.1% (I feel weary much of the time) to 39.3% (I usually feel drained). The total fatigue score (sum of score from all 10 items) ranged from 10 to 50 with a mean of 24.8 ($SD = 8.1$) and 46% reported above this average chronic fatigue score.

We also explored the factor structure of the chronic fatigue questionnaire for our sample of police officers. Using structural equation modeling (SEM), we fit a confirmatory factor analysis (CFA) model to estimate the latent construct (chronic fatigue) using the 10 questionnaire items. We compared a one-factor model that hypothesizes all 10 items load to a single latent variable versus a two-factor model that assumes the positively worded items load to one latent variable while the negatively worded items load to a second latent construct.

Table 1
Demographic and life style characteristics and their association with fatigue score and on-duty injury, BCOPS study, 2004–2009.

Characteristics	Study sample		Chronic fatigue score		On-duty injury (past year)	
	N	% (±SD)	Mean ± SD	p-Value[c]	Prevalence (%)	p-Value[d]
Gender						
Male	205	73.2	24.2 ± 7.3	0.0598	24.4	0.7647
Female	75	26.8	26.3 ± 9.9		22.7	
Race						
White	205	74.6	25.6 ± 8.5	0.0029	23.4	0.6973
Black/Hispanic	70	25.5	22.2 ± 6.6		25.7	
Education						
≤High school/GED	27	9.7	21.7 ± 7.6	0.0753	11.1	0.2664
College <4 yrs	158	56.8	25.4 ± 8.6		25.3	
College 4+ yrs	93	33.5	24.4 ± 7.3		24.7	
Marital status						
Single	36	13.0	25.1 ± 8.3	0.7917	33.3	0.1608
Married	194	69.8	24.9 ± 8.2		20.6	
Divorced	48	17.3	24.0 ± 8.0		29.2	
Smoking status						
Current	53	19.2	26.6 ± 9.6	0.1172	26.4	0.3460
Former	50	18.1	23.3 ± 8.0		16.0	
Never	173	62.7	24.7 ± 7.7		25.4	
Rank						
Patrol officer	220	78.9	26.0 ± 8.0	0.1938	24.6	0.4996
Other[a]	59	21.2	24.4 ± 8.2		20.3	
Workload (high)						
Low/medium	98	35.8	25.3 ± 8.5	0.4273	16.3	0.0317
High	176	64.2	24.5 ± 8.0		27.8	
Sleep quality						
Poor	152	57.4	27.1 ± 8.1	<0.0001	28.3	0.0452
Good	113	42.6	21.6 ± 7.3		17.7	
Shift work (past year)						
Day	117	42.2	24.8 ± 9.1	0.9451	18.8	0.0019
Afternoon	86	31.1	25.0 ± 7.5		16.3	
Night	74	26.7	24.5 ± 7.4		37.8	
Age (in years)	280	40.7 ± 6.4	r[e] = −0.09	0.1340	PR[f] = 0.87	0.2071
Years of service	279	13.7 ± 6.5	r = −0.11	0.0696	PR = 0.78	0.0531
Body mass index (kg/m^2)	279	29.4 ± 4.8	r = 0.08	0.1574	PR = 0.89	0.2782
Physical activity[b] (h/week)	279	16.2 ± 14.3	r = −0.19	0.0017	PR = 1.19	0.0489
No. of alcohol drinks/week	275	5.2 ± 8.4	r = 0.10	0.0909	PR = 1.02	0.8934

Results for continuous variables are means ± SD.
[a] Other includes Sergeant, Lieutenant, Captain, and Detective.
[b] Physical activity hours per week including occupational, household, and leisure time activities.
[c] p-Values are from analysis of variance (ANOVA) for categorical variables or correlation analysis for continuous variables.
[d] p-Values are from χ^2 tests of independence or Fisher's exact test for categorical variables. For continuous variables, P-values are from Poisson regression testing linear trend in prevalence of injury.
[e] Denotes the correlation between fatigue score and each of the continuous variables.
[f] PR denotes the prevalence ratio associated with one standard deviation increase in each continuous variable.

Comparison of several fit indices indicated that the two-factor model appears to fit the data better compared to the one-factor model. The Comparative Fit Index (CFI) values, where a good fit is indicated by a value of 0.95 and above, were 0.98 for the two-factor model versus 0.83 for the one-factor model. The standardized root mean square residual (SRMSR) values, where a good fit is indicated by a value lower than 0.08, were 0.024 for two-factor model and 0.082 for one-factor model.

3.3. On-duty injury

In the current sample, prevalence of on-duty injury during the past year was 24% (95% CI: 19.4–29.5); 67 of the 280 officers had on-duty injury during the past year. Among those injured, 46% (95% CI: 35.8–59.9) experienced an extended injury, which was defined as work absences that lasted at least 90 days during the past year and the average duration (in days) of injury leave was 100.6 days (SD = 100.2) (data not shown).

3.4. Association of chronic fatigue score with on-duty injury

The associations between fatigue score and occurrence of on-duty injury are presented in Table 2. Results indicate an increasing trend in prevalence of on-duty injury across tertiles of total fatigue score (19.6%, 21.7%, 30.8% for the lowest, middle, and highest tertiles, respectively, trend p-value = 0.0372). After adjusting for age, gender, race/ethnicity, education, workload, physical activity, and alcohol consumption, the prevalence of injury among officers in the highest tertile of total fatigue score was 67% larger compared to those in the lowest tertile (PR = 1.67, 95% CI: 0.99–2.83, p = 0.0554) but with borderline statistical significance. Analyses of total fatigue score in continuous form indicated that a 5-unit increase in total fatigue score was associated with a 12% increase in prevalence of on-duty injury (PR = 1.12, 95% CI: 0.99–1.27, p = 0.0746) yet the estimate had borderline statistical significance.

The association between fatigue score from the positively worded items and on-duty injury achieved statistical significance. A 5-unit

Please cite this article as: Fekedulegn, D., et al., Fatigue and on-duty injury among police officers: The BCOPS study, *Journal of Safety Research* (2016), http://dx.doi.org/10.1016/j.jsr.2016.11.006

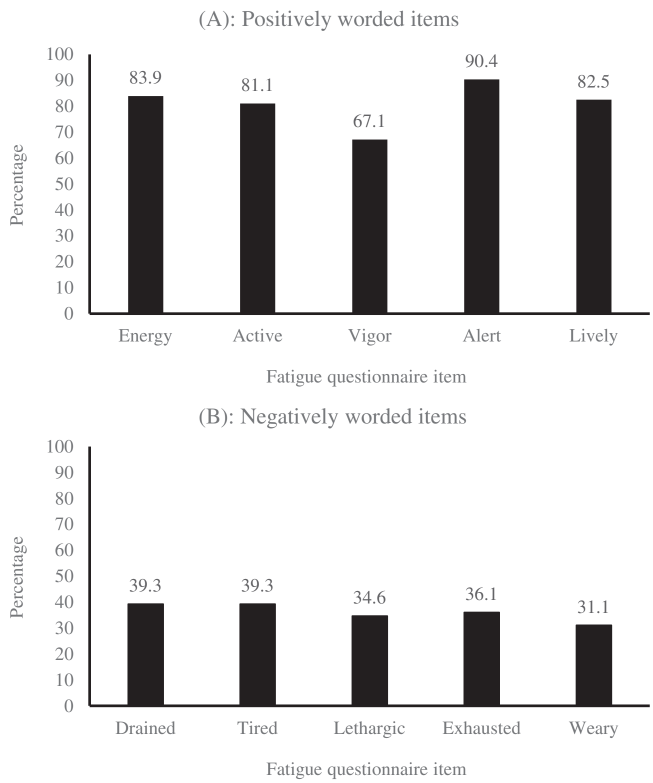

Fig. 1. Percentage of participants responding to chronic fatigue questionnaire items among police officers. Responses of "somewhat" to "very much" were combined. Part A shows percentages for the positively worded items (I generally feel I have plenty of energy, I generally feel quite active, I generally feel full of vigor, I generally feel alert, and I usually feel lively). Part B shows percentages for the negatively worded items (I usually feel drained, I feel tired most of the time, I usually feel rather lethargic, I often feel exhausted, and I feel weary much of the time).

increase in fatigue score of the positively worded items was associated with a 33% increase in prevalence of injury (PR = 1.33, 95% CI: 1.04–1.70, p = 0.0215). Injury prevalence was 62% higher among officers in the highest tertile of the score for the positive items compared to those in the lowest tertile (PR = 1.62, 95% CI: 0.94–2.81, p = 0.0827). On the other hand, there was no significant association between fatigue score from the negatively worded items and occurrence of injury; a 5-unit increase in score from these items was associated with 13% increase in prevalence of injury (PR = 1.13, 95% CI: 0.90–1.41, p = 0.2842), and those in the highest tertile of fatigue score from the negative items had injury prevalence that was 45% larger compared to those in the lowest tertile (PR = 1.45, 95% CI: 0.83–2.53, p = 0.1941).

3.5. Association of individual items of chronic fatigue questionnaire with on-duty injury

The association of ratings to the individual items of the chronic fatigue questionnaire with occurrence of injury is presented in Table 3 (for the positively worded items) and Table 4 (for the negatively worded items). As expected, the results in Table 3 show a significantly higher prevalence of on-duty injury among officers who responded "not at all" or "little" to 4 of the 5 positively worded items. After multivariate adjustment, officers who do not feel active (PR = 1.74, 95% CI: 1.09–2.80, p = 0.0210) had significantly higher prevalence of on-duty injury compared to their counterparts. Prevalence of on-duty injury was 75% larger among officers who generally do not feel full of vigor compared to those who do feel full of vigor (PR = 1.75, 95% CI: 1.13–2.71, p = 0.0118). Officers who generally do not feel alert had more than double the prevalence of injury compared to those who do feel alert (PR = 2.31, 95% CI: 1.36–3.94, p = 0.0020). Officers who do not feel lively had injury prevalence that is 67% larger (PR = 1.67, 95% CI: 1.00–2.79, p = 0.0495) compared to their counterparts. On the other hand, there was no significant association between the ratings for the negatively worded items and prevalence of injury (Table 4); the only exception is a borderline statistical significance between the rating for "I often feel exhausted" and injury occurrence where those who often felt exhausted had a 52% higher prevalence of injury compared to their counterparts (PR = 1.52, 95% CI: 0.99–2.33, p = 0.0541).

4. Discussion

There are approximately 900,000 sworn law enforcement officers serving in the United States (NLEOMF, 2016). This workforce is known to disproportionately suffer from cardiovascular, metabolic, and psychosocial disorders (Barron, 2008; Hartley, Burchfiel, Fekedulegn, Andrew, & Violanti, 2011; Liberman et al., 2002; Violanti et al., 2009; Zimmerman, 2012). In addition, policing is one of the occupations with the highest rate of non-fatal on-duty injury. According to the Bureau of Labor Statistics (BLS), police and sheriff's patrol officers was one of six occupations (correctional officers and jailers, firefighters, nursing assistants, construction laborers, and heavy and tractor-trailer truck drivers) where the incidence rate of non-fatal workplace injury,

Table 2
Prevalence and prevalence ratio (95% CI) of on-duty injury by levels of chronic fatigue score (overall score, score for the positive items, and score for the negative items).

	N	Number of injury cases	Prevalence of injury (%)	Prevalence ratio (95% CI)		
				Unadjusted	Age-adjusted	MV-adjusted[1]
Total fatigue score (all 10 items)[b]	280	67	23.9 (19.4–29.5)	1.08 (0.96–1.22)	1.07 (0.96–1.21)	1.12 (0.99–1.27)
Tertiles						
Low (10–20)	97	19	19.6 (13.1–29.3)	Referent		
Medium (21–27)	92	20	21.7 (14.8–32.0)	1.11 (0.63–1.94)	1.13 (0.64–1.98)	1.08 (0.61–1.91)
High (28–50)	91	28	30.8 (22.6–41.9) (p = 0.0372)[c]	1.57 (0.95–2.61)	1.54 (0.93–2.55)	1.67 (0.99–2.83)
Score for positive items[b]				1.21 (0.96–1.52)	1.20 (0.95–1.50)	1.33 (1.04–1.70)
Tertiles						
Low (5–10)	85	17	20.0 (13.1–30.6)	Referent		
Medium (11–15)	115	27	23.5 (16.9–32.7)	1.17 (0.69–2.01)	1.13 (0.66–1.94)	1.06 (0.61–1.83)
High (16–25)	80	23	28.8 (20.4–40.6) (p = 0.0945)[c]	1.44 (0.83–2.49)	1.40 (0.81–2.41)	1.62 (0.94–2.81)
Score for negative items[b]				1.09 (0.88–1.35)	1.08 (0.87–1.33)	1.13 (0.90–1.41)
Tertiles						
Low (5–8)	86	17	19.8 (12.9–30.3)	Referent		
Medium (9–13)	108	27	25.0 (18.0–34.7)	1.26 (0.74–2.16)	1.27 (0.74–2.18)	1.35 (0.78–2.31)
High (14–25)	86	23	26.7 (18.9–37.9) (p = 0.1418)[c]	1.35 (0.78–2.35)	1.33 (0.77–2.30)	1.45 (0.83–2.53)

[a] Adjusted for age, gender, race/ethnicity, education, workload, physical activity, and alcohol consumption.
[b] Prevalence ratios are for 5-unit increase in fatigue score.
[c] P-value testing a linear trend in prevalence of injury across increasing tertiles of chronic fatigue score (Cochran–Armitage trend test).

Table 3
Prevalence and prevalence ratio (95% CI) of on-duty injury by levels of the five positively worded items of the chronic fatigue questionnaire.

Characteristics	Number participants	Number of injury cases	Prevalence of injury (%)	Prevalence ratio (95% CI)		
				Unadjusted	Age-adjusted	MV-adjusted[a]
I generally feel I have plenty of energy						
Somewhat – very much	235	54	23.0	Referent		
Not at all – little	45	13	28.9	1.26 (0.75–2.10)	1.26 (0.75–2.10)	1.43 (0.85–2.40) [b](p = 0.1732)
I generally feel quite active						
Somewhat – very much	227	50	22.0	Referent		
Not at all – little	53	17	32.1	1.46 (0.92–2.31)	1.42 (0.89–2.25)	1.74 (1.09–2.80) (p = 0.0210)
I generally feel full of vigor						
Somewhat – very much	188	38	20.2	Referent		
Not at all – little	92	29	31.5	1.56 (1.03–2.36)	1.55 (1.02–2.34)	1.75 (1.13–2.71) (p = 0.0118)
I generally feel alert						
Somewhat – very much	253	56	22.1	Referent		
Not at all – little	27	11	40.7	1.84 (1.11–3.07)	1.81 (1.08–3.01)	2.31 (1.36–3.94) (p = 0.0020)
I usually feel lively						
Somewhat – very much	231	52	22.5	Referent		
Not at all – little	49	15	30.6	1.36 (0.84–2.21)	1.33 (0.82–2.15)	1.67 (1.00–2.79) (p = 0.0495)

[a] Adjusted for age, gender, race/ethnicity, education, workload, physical activity, and alcohol consumption.
[b] p-Value for the multivariable adjusted prevalence ratio.

per 10,000 full-time workers, was greater than 300 (BLS, 2014). The rate of non-fatal occupational injuries is two to three times the national average, while fatal injury rates are nearly four times greater among officers compared to the average American worker (LaTourrette, 2011). Although fatigue is commonly understood to be a risk factor for on-duty injury among police, scientific literature is limited. Assessment of the prevalence of fatigue among law enforcement officers, who work under high-risk and dynamic environments, engage in extended driving, and often need to make on-the-spot decisions in complex and ambiguous situations, is particularly important because fatigue in police officers can have devastating consequences to the officers and the general public (Vila & Kenney, 2002). Police officers, therefore, represent a unique occupation group for research focusing on fatigue, sleep, and human performance (Vila, 2006). In this study, we assessed chronic fatigue in police officers working in a mid-sized urban department and examined its association with occurrence of non-fatal workplace injury. The results indicated that 46% of the officers had above average chronic fatigue score (>24.8) and nearly 40% reported feeling drained. Overall, the prevalence of workplace injury increased significantly across tertiles of total fatigue score. In particular, injury was more than twice as prevalent among officers who generally did not feel alert compared to their counterparts. Prevalence of non-fatal workplace injury was at least 65% larger among officers who did not feel active, full of vigor, or lively compared to those who did.

There are a number of studies that attempted to examine the relationship between fatigue and safety outcomes in working populations.

Table 4
Prevalence and prevalence ratio (95% CI) of on-duty injury by levels of the five negatively worded items of the chronic fatigue questionnaire.

Characteristics	Number participants	Number of injury cases	Prevalence of injury (%)	Prevalence ratio (95% CI)		
				Unadjusted	Age adjusted	MV-adjusted[a]
I usually feel drained						
Not at all – little	170	39	22.9	Referent		
Somewhat – very much	110	28	25.5	1.11 (0.73–1.69)	1.08 (0.71–1.65)	1.13 (0.74–1.73) [b](p = 0.5667)
I feel tired most of the time						
Not at all – little	170	37	21.8	Referent		
Somewhat – very much	110	30	27.3	1.25 (0.83–1.90)	1.24 (0.82–1.89)	1.33 (0.87–2.04) (p = 0.1905)
I usually feel rather lethargic						
Not at all – little	183	40	21.9	Referent		
Somewhat – very much	97	27	27.8	1.27 (0.84–1.94)	1.25 (0.82–1.90)	1.34 (0.86–2.08) (p = 0.1939)
I often feel exhausted						
Not at all – little	179	38	21.2	Referent		
Somewhat – very much	101	29	28.7	1.35 (0.89–2.05)	1.34 (0.88–2.03)	1.52 (0.99–2.33) (p = 0.0541)
I feel weary very much of the time						
Not at all – little	193	46	23.8	Referent		
Somewhat - very much	87	21	24.1	1.01 (0.65–1.59)	0.99 (0.63–1.55)	1.13 (0.72–1.79) (p = 0.5935)

[a] Adjusted for age, gender, race/ethnicity, education, workload, physical activity, and alcohol consumption.
[b] p-Value for the multivariable adjusted prevalence ratio.

Some were based on assessment of fatigue using validated questionnaires (Fang, Jiang, Zhang, & Wang, 2015; Swaen, Van Amelsvoort, Bültmann, & Kant, 2003) while most use proxy indicators of fatigue (Kao, Spitzmueller, Cigularov, & Wu, 2016; Salminen et al., 2010) namely sleep deprivation/disorder, shift work, and irregular work hours. In a prospective study (Swaen et al., 2003) that examined the effect of fatigue [assessed using the Checklist Individual Strength (CIS) questionnaire] on injury, the risk of workplace injury was 69% higher among those in the highest tertile of fatigue score compared to those in the lowest tertile following adjustment for multiple potential confounders (RR = 1.69, 95% CI: 1.03–2.78). The magnitude of the effect size is consistent with our findings despite differences in study design and study population. The study by Swaen et al. (2003) also reported the negative consequence of irregular work hours; those working irregular shifts (but not night shift) had a five-fold higher risk (crude RR = 4.76, 95% CI:2.42–9.35) of occupational injuries compared to those working on day shifts. There are numerous studies that showed sleep problems (another proxy measure of fatigue) are associated with increased risks of workplace injuries and accidents (Chau, Mur, Touron, Benamghar, & Dehaene, 2004; Salminen et al., 2010; Uehli et al., 2014a, 2014b). A recent meta-analysis of observational studies dealing with sleep problems and injury revealed that workers with sleep problems were 62% more likely to being injured at the workplace compared to those without sleep problem (RR = 1.62, 95% CI: 1.43–1.84) and that 13% of the workplace injuries could be attributed to sleep problems (Uehli et al., 2014a). A case–control study (Chau et al., 2004) that examined correlates of occupational injury indicated that injured workers had 30% higher odds of having a sleep disorder compared to non-injured workers (OR = 1.30, 95% CI: 1.08–1.57). A prospective study of Finish public sector workers (Salminen et al., 2010) also reported a similar estimate where the risk of workplace injury was 38% higher among those who experienced disturbed sleep compared to those who did not (OR = 1.38, 95% CI: 1.02–1.87). Among truck drivers long workhours (driving and non-driving) have been significantly associated with an increase in safety critical events (Soccolich et al., 2013), and driver fatigue was a significant risk factor for occupational light vehicle crashes (OR = 2.1, 95% CI: 1.5–2.7; Stuckey, Glass, LaMontagne, Wolfe, & Sim, 2010).

In policing, formal studies of fatigue and on-duty injury, although limited and based on proxy indicators of fatigue, highlight findings consistent with those in other occupational groups or the general population. An experimental study by James and Vila (2015) examined the extent fatigue (defined as shift work) degrades post-shift non-operational driving (i.e., lab-based simulated driving) performance of officers. Their results showed that officers working on night shift (fatigued condition) had significantly greater lane deviation compared to those on day shift. Analysis of shift work in relation to injury based on the same study population used for the current study (Violanti et al., 2012) showed that the incidence rate of non-fatal on-duty injury was 72% larger for officers working on the night shift compared to those on the day shift (IRR = 1.72; 95% CI = 1.26–2.36) while the risk of long-term injury (≥90 days of work absence) was three-fold higher among officers working the night shift (Violanti et al., 2013). These studies also indicated that high workload in combination with night shift work significantly exacerbated the risk of workplace injury. Officers in the United States are reported to work extraordinarily high numbers of hours per week (graveyard shifts, overtime, second jobs, etc.) resulting in insufficient sleep and poor rest that heightens the risk of injury (Senjo, 2011). The prevalence of poor sleep quality in U.S. police officers was 64% compared to 45% among those not involved in emergency services (Neylan et al., 2002). In a study of police officers from the United States and Canada, Rajaratnam et al. (2011) reported that 40% had at least one sleep disorder, 34% had obstructive sleep apnea, 7% had insomnia, 29% reported excessive sleepiness, and 26% reported falling asleep while driving at least once in a month. In policing, where officers are engaged in extended driving, nodding off while driving and difficulty to maintain constant vigilance because of sleepiness leads to disastrous outcomes to both the officers and the public at large. A study by Vila (2000) reported that 4 of out of 8 officers involved in on-duty injuries and accidents were impaired because of fatigue. The most common types of nonfatal injuries among officers are strains and sprains, particularly those to the back, often caused by trips and falls (particularly during foot pursuits) and extended driving. Vehicle crashes represent the greatest fraction of both fatal and non-fatal injuries, making driving the most dangerous activity police engage in (LaTourrette, 2011).

Fatigue has also been reported to be associated with (or co-occurs with) a number of adverse psychological health outcomes including depression and anxiety, and chronic diseases (Chen, 1986; Franssen, Bültmann, Kant, & Van Amelsvoort, 2003). U.S. workers reporting fatigue are four times more likely to experience depressive symptoms than workers who did not report fatigue (Ricci et al., 2007). In our police study sample, a 5-unit increase in total fatigue score was associated with a 72% elevation in prevalence of depression (PR = 1.72, 1.49–1.98, $p < 0.0001$, data not shown). Overall, the proportion of officers who self-reported their general health as “fair or poor” increased by 51% for a 5-unit increase in total fatigue score (PR = 1.51, 1.24–1.84, $p < 0.0001$, data not shown). It is worth mentioning that worker fatigue also has significant economic consequences. The health related lost productive time (LPT) among workers with fatigue cost U.S. employers an estimated $136 billion annually (Ricci et al., 2007); where 66% of U.S. workers with fatigue reported health-related lost productive time (LPT) compared to only 26% of those without fatigue.

The current study has several strengths including the use of objective daily work history records from which on-duty injury was ascertained, a relatively large sample, high reliability of the chronic fatigue questionnaire which was specifically designed to assess fatigue in occupations involving shift work (Khaleghipour, Masjedi, & Kelishadi, 2015), and adjustment of the association of interest for multiple potential confounders. Despite these strengths, the findings from this study ought to be interpreted in the context of potential limitations. The study is based on urban police officers from the eastern United States (convenience sample) and therefore may have limited generalizability to all officers. Chronic fatigue was assessed through self-report and hence there is a possibility of response bias (especially socially desirable responding) that could underestimate the prevalence of fatigue. Despite our effort, we were not able to access the data on the type and severity of injury for reasons related to privacy. From a methodological viewpoint, occurrence of on-duty injury was assessed during the 1-year prior to assessment of fatigue, and therefore based on the cross-sectional study design it is assumed that chronic fatigue assessed at the clinic examination has been present or consistent throughout the previous 1 year period. The cross-sectional study design limits casual inference.

In summary, this study of urban police officers showed that those who do not feel active, full of vigor, alert, or lively had a significantly higher prevalence of non-fatal work place injury compared to their counter parts. To the authors' best knowledge, there are no epidemiologic studies that assessed chronic fatigue using one of available validated instruments and examined its association with objectively assessed on-duty injury among police officers in the United States. This study adds to the body of knowledge regarding the association of fatigue with workplace injury among high stress occupations and may have future implications that ultimately will lead to interventions that could reduce officer's fatigue and injury occurrence. Policing, by its nature, involves exposure to inherent physical and psychological dangers as well as additional occupational stressors (e.g., long work hours, shift work, and irregular schedules) that significantly increase the risk for chronic fatigue and numerous adverse health outcomes including fatal and non-fatal workplace injuries. In their report titled “Tired cops” Vila and Kenney (2002) provide accounts of devastating tragedies (injuries) associated with police fatigue. Altogether, the human and economic cost associated with fatigue and workplace injury could represent a substantial burden to officers and their families and warrants

Please cite this article as: Fekedulegn, D., et al., Fatigue and on-duty injury among police officers: The BCOPS study, *Journal of Safety Research* (2016), http://dx.doi.org/10.1016/j.jsr.2016.11.006

greater attention. Hence, there is a need to identify strategies to reduce the risk factors that lead to chronic fatigue and workplace injury. Comprehensive fatigue management programs that include education on the health and safety consequences of fatigue, regulations on the length of work hours per day and per week, workplace interventions that improve alertness/fitness, and screening for sleep disorders are essential to minimize fatigue and its negative consequences. Fatigue intervention also ought to consider psychosocial work characteristics. For example, a prospective study has shown that decision latitude in men and co-worker social support in women were protective against fatigue (Bültmann, Kant, Van Den Brandt, & Kasl, 2002). Physical inactivity and obesity have long been recognized as risk factors for fatigue (Chen, 1986). A study by Zimmerman (2012) indicated that workplace programs to promote the health and fitness of police officers are commonly lacking despite the fact that obesity may be more common in police officers compared with other groups. Weight loss and fitness could be important factors in reducing acute musculoskeletal injuries (LaTourrette, 2011). Future studies with larger sample size and a prospective design are worthwhile and could provide better insight in designing effective interventions.

Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

Acknowledgments

This work was supported by the National Institute for Occupational Safety and Health (NIOSH), contract no. 200-2003-01580. The findings and conclusions in this article are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health. In addition, citations to websites external to NIOSH do not constitute NIOSH endorsement of the sponsoring organizations or their programs or products. Furthermore, NIOSH is not responsible for the content of these websites. All web addresses referenced in this document were accessible as of the publication date. This project was made possible through a partnership with the CDC Foundation.

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Please cite this article as: Fekedulegn, D., et al., Fatigue and on-duty injury among police officers: The BCOPS study, *Journal of Safety Research* (2016), http://dx.doi.org/10.1016/j.jsr.2016.11.006