SH@W Safety and Health at Work www.e-shaw.org

Saf Health Work 2011;2:169-75 | DOI:10.5491/SHAW.2011.2.2.169

pISSN : 2093-7911
eISSN : 2093-7997

Original Article

Correlation of Occupational Stress Index with 24-hour Urine Cortisol and Serum DHEA Sulfate among City Bus Drivers: A Cross-sectional Study

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Objectives: The questionnaire of occupational stress index (OSI) has been popular in the workplace, and it has been tailored for bus drivers in Taiwan. Nevertheless, its outcomes for participants are based on self-evaluations, thus validation by their physiological stress biomarker is warranted and this is the main goal of this study.
Methods: A cross-sectional study of sixty-three city bus drivers and fifty-four supporting staffs for comparison was conducted. Questionnaire surveys, 24-hour urine cortisol testing, and blood draws for dehydroepiandrosterone-sulfate (DHEA-S) testing were performed. The measured concentrations of these biological measures were logarithmically transformed before the statistical analysis where various scores of stressor factors, moderators, and stress effects of each OSI domain were analyzed by applying multiple linear regression models.
Results: For drivers, the elevated 24-hour urine cortisol level was associated with a worker's relationship with their supervisor and any life change events in the most recent 3 months. The DHEA-S level was higher in drivers of younger age as well as drivers with more concerns relating to their salary and bonuses. Non-drivers showed no association between any stressor or satisfaction and urine cortisol and blood DHEA-S levels.
Conclusion: Measurements of biomarkers may offer additional stress evaluations with OSI questionnaires for bus drivers. Increased DHEA-S and cortisol levels may result from stressors like income security. Prevention efforts towards occupational stress and life events and health promotional efforts for aged driver were important anti-stress remedies.

Key Words: Driver, Stress, Cortisol, DHEA, Life change events

Introduction

The occupational stress index (OSI) [1] that is used in European countries has been applied to workers in Taiwan and Chinese people since more than 10 years ago. Originally, targeting blue or white collar workers [2,3], it has also been specifically tailored to measure occupational stress among bus companies, either city bus or free way bus drivers in Taiwan, and its validity has been well tested within questionnaires [4,5]. Drivers' occupational stresses and their physiological or psychological effects were noted in those studies by the driver OSI (D-OSI) questionnaire, however, objective stress testing that may reflect long term stress, such by the physiological biomarkers, is lacking.

Among the Hypothalamus-Pituitary-Adrenal (HPA) axis of stress effects, the adrenocortex stress profile, e.g. cortisol and dehydroepiandrosterone (DHEA), are secreted from the adre-

Received: January 17, 2011, **Accepted:** May 3, 2011
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nal gland. Though they are responsible for growth, immunity, metabolism, and maintaining cardiovascular function, they may also well reflect acute, sub-acute, or chronic stress and have been commonly mentioned as stressor markers [6,7]. In a review of physiological markers among drivers, including truck drivers, bus drivers, and subway drivers, among the catabolic indicators, including catecholoamine, cortisol, cholesterol, and HbA1c, all except cholesterol were noted to have significant effects as stress biomarkers. Among them, catecholamine is quickly elevated during stress and decreases soon after stress and is more suitable to reflect acute stress. HbA1c may be a promising indicator for stress; however, it is also correlated with metabolic syndrome or obesity, which is quite prevalent among bus drivers. The choice of cortisol as a main stress marker has fewer problems. On the other hand, the anabolic indicators, such as testosterone, estrogen, and DHEA-S were less studied [8]. DHEA thus may be concurrently measured with cortisol as HPA axis indictors reflecting both catabolic and anabolic stress.

Moreover, the simultaneous comparison of the D-OSI questionnaire and stress markers of cortisol DHEA may give DHEA an alternative validation. In addition to blood and salivary cortisol, measurement of 24-hour urinary assays of free cortisol is a good surrogate for the original secretion of cortisol; also, serum dehydroepiandrosterone-sulfate (DHEA-S) is the main component in blood for DHEA. Both biomarkers were also were affected less by the circadian cycle. To compare the work stress component among drivers and non-drivers in the city bus industry, the supporting staff may also be recruited as a control group.

Materials and Methods

From two bus companies, 63 drivers, 30 maintenance technicians, and 24 administrative officers were recruited. The OSI questionnaire in Chinese, which was already tailored for bus drivers, was distributed to every study subject on their workdays. The D-OSI questionnaire consisted of eight domains. Among them, part I (stressor) included 27 fine questions about the different stressors at work, and nine major stressors items were further categorized (as in Table 2); parts II was about job satisfaction and it included the job itself, current position, and company structure; part III related to physical health (9 items); and part IV was about mental health (7 items). Part V included personal characteristics, such as personality types (A, B) and locus of control (internal, external). Part VI was about stress coping methods, such as entertainment, exercise, body relaxation, and stress debriefing. Part VII was an open question for workers' suggestion to the company to reduce workplace stress. VIII included recent life events (total of 24 items and multiple choices were permitted).

All of the above domains except for part VII were utilized in the statistical analysis. By antecedent factor analysis [4], each domain had been further subdivided into several major factors, each covering 3-4 questions. Questions were filled in Likert four scales (min. 1, max. 4) for respondents to answer with their degree of agreement. The scores were dichotomized to above or below average according to cut off values, for example, the average score of more than 2.5 means a higher perception of work stress, job dissatisfaction, or poor mental health. Scores of questions with the opposite answer were calculated as appropriate. An individual life event score that ranged from 12-48 was added (this was adopted from the Taiwanese survey results [9]), and in the analysis each subject was categorized as an above or below average score.

One day earlier before the health examination, urine samples of participants were collected in large plastic containers and brought to the bus company in the morning, and during the rest of the working time the urine of drivers was collected before driving, after driving, and at their rest period and each container was advised to be kept in a cool corner. During the health examination day, 10 mL of venous blood was drawn and collected in EDTA tubes and prepared in a refrigerator. These samples were sent to a teaching hospital laboratory on the same day and were examined via radioimmunoassay (RIA) methods. For data analysis, administrative and maintenance workers were merged as the non-driver group. Data analysis was performed using SAS 9.0® software, a chi-square test was used to compare the urine cortisol and blood DHEA-S level by stressors, and simple linear regression and a multiple regression model using stepwise procedures were used to examine the predicting power of stress factors of D-OSI.

Results

One of the 24-hour urine samples was below and nine were higher than the reference cortisol level (for male: 80-560 μg/day), but none of these workers had major illness/surgery, including endocrine disease or known use of corticosteroid or diagnosed with major depression disorder. On the other hand, six samples of serum DHEA level were lower than the reference level (28.5-213.7 μg/dL).

Basic demographic data has shown that the drivers, compared with non-drivers, were slightly younger and with less tenure and lower education levels (Table 1). The correlation between urine cortisol, blood DHEA-S, and individual factors of the stressor domain is shown in Table 2. For regression

Table 1. Basic demographic data among drivers and non-drivers

	Driver (n = 63)		Non-driver (n = 54)		p-value
	Frequency	%	Frequency	%	
Sex					
Male	63	100	54	100	
Age (years)					0.3077
< 30	4	6.35	1	1.85	
31-40	13	20.63	18	33.33	
41-50	24	38.10	21	38.89	
> 51	19	30.16	12	22.22	
Missing data	3	4.76	2	3.70	
Tenure (years)					0.0243
< 2	15	23.81	2	3.70	
2-10	12	19.05	11	20.37	
11-20	23	36.51	19	35.19	
> 20	6	9.52	9	16.67	
Missing data	7	11.11	13	24.07	
Education					0.0013
Junior high or below	23	36.51	13	24.07	
Senior high	22	34.92	10	18.52	
College and above	12	19.05	28	51.85	
Missing data	6	9.52	3	5.56	
Marital status					0.0368
Unmarried	3	4.76	8	14.81	
Married	50	79.37	41	75.93	
Other*	4	6.35	0	0.00	
Missing data	6	9.52	5	9.26	

*Including divorced, widowed, or in separation.

analysis, the DHEA-S level was log-transformed to fit a normal distribution. Log-transformation of the urine cortisol level, after deleting two extreme values, was also normally fitted. The univariate analysis between urine cortisol, blood DHEA-S, and individual factors of the stressor domain (that is, domains of job satisfaction, mental health, and personal character) was first performed, then multiple linear regression analyses were executed and results are shown in Table 3. When the drivers' biological markers were analyzed as dependent variables, the results showed that recent life events and the D-OSI factors relating to the relationship with a worker's supervisor were of serious concern and were associated with higher urine cortisol levels. A higher blood DHEA-S level was associated with age and the D-OSI factors relating to salary and bonus were more correlated with the stress levels of workers. The explaining power (R-square) is lower in the cortisol model. Other factors of physical health, mental health, personal characteristics, or stress coping of the D-OSI questionnaire showed no effect on cortisol or DHEA-S levels. For non-drivers, no association between any stressor or satisfaction and urine cortisol and DHEA-S levels was observable.

Discussion

The occupational stress index adopts a psychological approach and focuses on individual occupational stress, which is moderated by personal characteristics, such as a type A personality, internal control locus, and coping behavior, and finally the index measures the physical and mental health effects. From the previous D-OSI study [5], such a "stress-moderator-effect" model, (Fig. 1) has shown to be effective in describing the structure of work stress by analyzing key stressors and hence provoking managerial attention and intervening actions. In addition to work stress, life events may also correlate with body or mental dysfunction and this was also noted for these and many studies, however, health effect of biomarkers, such as cortisol, related to OSI stressors or moderators have not been studied before.

Cortisol has been recognized as a biomarker of stress in the general population as well as in bus drivers. Urban bus drivers were noted to have increased cortisol secretion in their acute stress phase than comparison groups [10], and long distance lorry drivers were noted to have cortisol levels that may gradually return to baseline after a commuting journey [11]. Cortisol may reflect a stress effect of even longer duration, such as in a company merge and bus route outsourcing [12]. Life events are known to be obvious stressors [9] and may even cause depression if the stress score is high enough [13]; life events were found in this study to correlate with elevated urine cortisol. We also noted that the urine cortisol levels of bus drivers are higher among those concerned about road traffic accidents (Table 1), which in Taiwan usually causes cuts to the driver's bonus or liability to recompense for the property or casualty damage. Bus drivers' relationships with their supervisors may be associated with different penalties or bonuses. Besides, since there were no known accidents or emergent events during the sample collection period, we proposed that the D-OSI questionnaire is better interpreted as the chronic effect of drivers' stress.

Table 2. Frequency analysis of 24-hour urine cortisol and blood DHEA-S levels with driver stressors

Stressors	Urine cortisol		p-value	Blood DHEA-S		p-value
	Below the mean	Above the mean		Below the mean	Above the mean	
Too much time spend on work						
Agreed	19	6	0.20	18	7	0.08
Less agreed	23	15		19	19	
Poor work/driving environment						
Agreed	9	2	0.31	7	422	1.00
Less agreed	33	19		30		
Worry about route incidents*						
Agreed	23	5	0.02	17	11	0.77
Less agreed	19	16		20	15	
Poor relationship with co-worker						
Agreed	37	18	1.00	33	22	0.71
Less agreed	5	3		4	4	
Poor relationship with supervisor						
Agreed	37	15	0.10	30	22	1.00
Less agreed	5	6		7	4	
Unreasonable company discipline						
Agreed	17	10	0.59	14	13	0.34
Less agreed	25	11		23	13	
Conflict among family & work						
Agreed	31	13	0.33	28	16	0.23
Less agreed	11	8		9	10	
Poor career achievement/esteem						
Agreed	20	8	0.47	13	15	0.07
Less agreed	22	13		24	11	
Imbalanced salary and bonus†						
Agreed	19	7	0.37	21	5	0.003
Less agreed	23	14		19	21	

DHEA-S: dehydroepiandrosterone-sulfate.
p-values were calculated by a chi-square test.
*p-value of Chi-Square test for the variable cortisol less than 0.05.
†p-value of Chi-Square test for the variable DHEA-S less than 0.01.

In this study, only two independent factors were significant predictors of DHEA-S, i.e., occupational stressors (concern about salary/bonus) and non-occupational factors (young age). While DHEA-S may serve as another stress biomarker, it has been well known as a marker of young adulthood [14]. Decreased DHEA-S was found to correlate with the age of the population [15,16] and insulin resistance may contribute to the age-related decline in DHEA synthesis [17]. Recently, anti-stress effects of DHEA among rats were noted [18] and this may also be effective in antagonizing cortisol, which may pos-

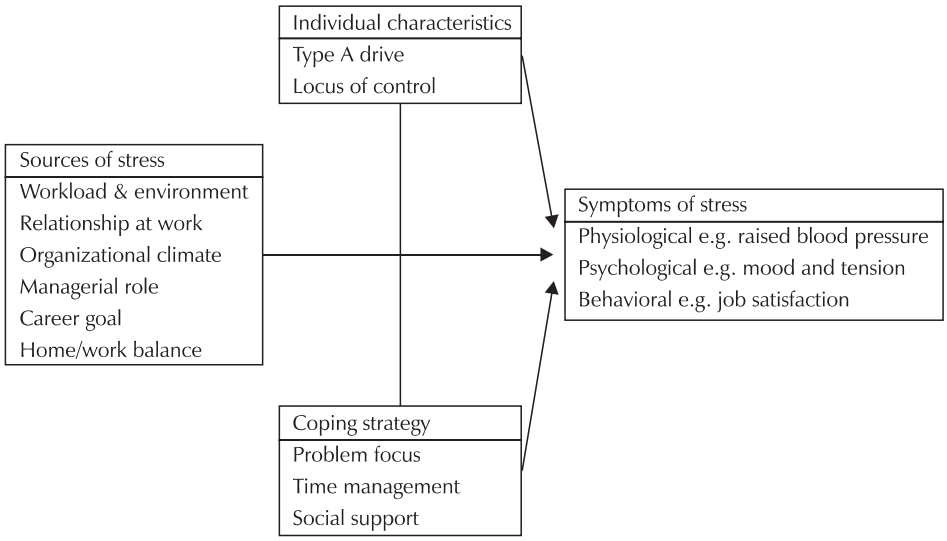

Fig. 1. The conceptual model of occupational stress index.

Table 3. Multiple regression analysis of modeling Log-serum DHEA-S and 24-hour urine cortisol levels on factors of age, tenure, education, marital status, personal character, stressor factors, physical and mental ealth, job satisfaction, and life events from D-OSI questionnaire domains from bus drivers

Variable	Log (DHEA-S)		Log (cortisol)	
	Parameter	p-value	Parameter	p-value
Drivers				
Age (years)				
< 30				
31-40	-0.05443	0.7929		
41-50	-0.20541	0.3008		
> 50	-0.76322	0.0003		
Life events in recent 3-month			0.38217	0.0201
Stressor				
Relationship with superior			0.35532	0.0201
Imbalanced salary and bonus			0.20347	0.0394
Model R-Square	0.47		0.21	

D-OSI: driver occupational stress index, DHEA-S: dehydroepiandrosterone-sulfate.

sibly modify emotional stress for humans [19,20]. In this study, DHEA-S, in addition to the age effect, also showed significance with the concern related to salary in drivers. Although the drivers are slightly younger and more evenly distributed than the reference group, there is no significant difference. However, probably because of the small sample size, in the final regression model, age only significantly affected the DHEA level among drivers, but not among the reference group.

In another study of salary and stress among Taiwan metropolitan bus drivers [21], their salary structure was divided into a fixed part (19-46% of total salary) and variable parts, which included incentive (e.g. mileage, passengers) and punishment (e.g. safety violations, absence) payments. Such a payment structure was found to be both inspiring and stressful. In addition, a recent study in Taiwan also revealed inappropriate ways of paying workers is associated with stress, esp. among workers in pay-per service systems [22]. The daily earning of a taxi driver is a strong stressor [23]. Thus we proposed that DHEA-S, in addition to the age effect, may be triggered by work stressors, and among them the stressor of income security should be prominent. Stress or strain of financial origin has been noted to influence health and cortisol secretion [24,25]. Though in this study the stress of income insecurity is not directly associated with increased cortisol secretion, a worker's relationship with their supervisor and worry about road traffic accidents may indirectly reflect stress related to income security. Besides the antagonizing effect of DHEA, previous studies have found that an increased serum cortisol/DHEA ratio may be proposed as a surrogate for poor stress protection [18,19], but this was not revealed in our analysis, even after fitting with a lognormal transformation (results not shown). This may be caused by the different sampling times and different body fluid sampling (urine, blood) in our study.

In conclusion, we concluded that among bus drivers, their life events and their relationships with their supervisors might influence the urine cortisol stress biomarker. While DHEA may decrease among aged workers, it could also increase upon concern of salary imbalance and probably act as a mood-

elevating anti-stressor. The increased stress from income insecurity may simultaneously increase DHEA as well as cortisol, and this deserves further study. The main limitation of this study was the relatively small numbers of investigated persons, and even some of the participants refused to fill in their basic demographic data (Table 2), probably from fear of being identifiable. However, this study may contribute to measuring work stress between the OSI questionnaire and stress biomarkers. It is also suggested that beyond the occupational stress scope, employers and occupational health managers in the transportation industry should also pay attention to aged drivers and be alert of life stress factors; and employers need to design reasonable payment structures and offer good workplace environments with good supervisor support [26] and employment assistant programs [27] to reduce workers' stress levels. An exercise program that could increase physical activity and increase DHEA secretion [28,29] may also be encouraged. Since this is a pilot study, further study focusing on a comparison of pre- and post-effects of drivers' chronic stressors and stress biomarkers, for example during a merger process of a bus company, may be warranted.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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