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## Abstract

### Effects of Physical Workload on Salivary Cortisol Level

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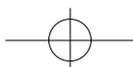
**Objectives:** Workload is known to affect the hypothalamus-pituitary-adrenal axis. Although many studies had revealed that job stress related factors could affect the neuroendocrine system among blue-collar workers, these studies had limitations as they had not evaluated the workload by objective methods which took into consideration individual physiological differences. This study was conducted to evaluate the effects of physical workload adjusted job stress on cortisol regulation by using objective tools for workers having various job tasks.

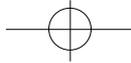
**Methods:** Among 110 foundry workers, shipyard workers, and fine machine assemblers for whom saliva samples were obtained, 102 without any past history of conditions that could affect hormonal regulation such as diabetes, and hypertension were included in this study. Among the 102 study participants, 15 workers whose saliva for morning or afternoon or heart rate monitoring data was not attained were excluded from the final analysis. Workload was evaluated by RHR (relative heart rate) using a heart rate monitor, and job stress was evaluated by Karasek's Job Content Questionnaire. Saliva samples were gathered during 8~9 am and 5~6 pm, and salivary cortisol levels were analysed by radioimmunoassay.

**Results:** After adjusting several variables which could effect cortisol secretion including job stress, among the higher RHR group morning salivary cortisol level was increased ( $\Delta = 60.32$ , S.E.=26.35,  $p=0.0266$ ), afternoon salivary cortisol level was decreased ( $\Delta = -7.43$ , S.E.=29.73,  $p=0.8044$ ), and salivary cortisol level difference between morning and afternoon was increased ( $\Delta = 72.10$ , SE=35.50,  $p=0.0509$ ).

**Conclusions:** As physical workload increases morning cortisol level, which is caused by the effect of arousal, and decreases afternoon cortisol level, which is caused by exhaustion, physical workload enlarges the width of diurnal cortisol variance. Therefore, physical exhaustion due to excessive workload could have adverse effects on the neuroendocrine system.

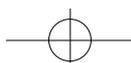
**Key Words:** Salivary cortisol, Physical workload, Relative heart rate



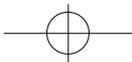


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가 (neuroendocrine system)가 Okenfels (1995) (hypothalamus-pituitary-adrenal: HPA) (Frank 8~9 ) , Steptoe enhaeuser et al., 1989; Henry, 1992; Folkow, (1998) 가 Steptoe (1998) 가 (Kirschbaum & Hellhammer, 1989). 가 (Mosnier-Pudar et al., 1995), . Schulz (1998) 100 (1~2 ) 가 Steptoe (2000) 가 (Kirschbaum & Hellhammer, 1989; Meeran et al., 1993). 가 Schulz (1998) Steptoe (2000) 가 가 Zeiter (1996) (Franke- enhaeuser et al., 1989; Harenstam & Theorell, 1990; Lundberg et al., 1989; Pollard et al, 1996). 가 가







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Poly-propy

len tube

가

Gamma counter (COBRA

, Hewlett packard, USA) Radio Immuno Assay (DPC's Coat-A-Count Cortisol kit)

4)

가

relative heart rate (RHR) (Wu & Wang, 2002)

(Wieber, 2003)

$$RHR(\%) = (HR_{work} - HR_{rest}) / (HR_{max} - HR_{rest}) \times 100$$

RHR Wu Wang (2002)

가

8, 8~10

, 10~12

, RHR

3.

24.5%, RHR 20%, RHR 16%

RHR

SAS (version 8.1)

2)

가

Job Content Questionnaire

(Karasek, 1988)

t-test

가 5

paired t-test

3

6

Pearson

4

4

4 Likert

,

0

3

Karasek (1988)

p 0.05

Cronbach

가 0.48,

0.56,

0.90,

0.89,

0.81

1.

3)

39.3±8.1

23.3±2.2 (kg/m<sup>2</sup>),

8

11.0±6.1

50.4±8.0

9

80.5%,

14.9%,

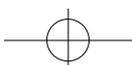
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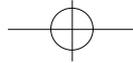
6

2cc

4.6%

25.3%,





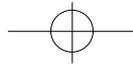
가  
 19.5%, 55.2% 22.9, 32.0, 52.0, 19.0  
 37.9%, 49.4%,  
 12.7% ,  
 27.6%, 41.4%, 3.  
 31.0% (Table 1).  
 2. ( 0.26)  
 가 ( 0.25)  
 0.33±0.11 µg/dl -0.26) 가 RHR  
 , 0.16±0.08 µg/dl ( 0.24)  
 (p<0.0001). - 가 ( )  
 0.17±0.12 µg/dl (Table 2). -0.31) 가  
 RHR 21.3± RHR  
 9.5 %, 31.9±5.7, ,  
 52.1±9.7, 19.0±4.1 (Table 4).  
 (Table 3).

**Table 1.** Characteristics of the participants

Items	frequency	%
Age (yrs)	39.3 ± 8.1*	
Body mass index (kg/m <sup>2</sup> )	23.3 ± 2.2*	
Job tenure (yrs)	11.0 ± 6.1*	
Work hour/week (hrs)	50.4 ± 8.0*	
Marital status		
Married	70	80.5
Not-married	13	14.9
Others	4	4.6
Smoking		
Non-smoker	22	25.3
Ex-smoker	17	19.5
Smoker	48	55.2
Alcohol drinking (frequency/week)		
Non	27	31.0
One to two	57	65.5
Three to five	3	3.5
Exercise		
Regular	33	37.9
Irregular	43	49.4
No	11	12.7
Types of industry		
Foundry	24	27.6
Ship building	36	41.4
Machine assembly	27	31.0
Total	87	100.0

\* Mean ± S.D.





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4. 가 - 가 (Table 5). RHR (Mean ± S.D: 0.36 ± 0.10) 가 (Mean ± S.D: 0.31 ± 0.09)

**Table 2.** Morning and afternoon salivary cortisol concentrations and differences between morning and afternoon cortisol levels

Items	Mean ± S.D.	Median	Range
Morning cortisol ( µg/dl)	0.33 ± 0.11	0.33	0.10-0.61
Afternoon cortisol ( µg/dl)	0.16 ± 0.08	0.16	0.02-0.36
Difference between morning and afternoon cortisol ( µg/dl)	0.17 ± 0.12	0.17	-0.10-0.45

**Table 3.** Scores of relative heart rate and job stress items

Items	Mean ± S.D.	Median	Range
Relative heart rate (%)	21.3 ± 9.5	22.9	4.2-38.1
Job demand	31.9 ± 5.7	32.0	18.0-48.0
Job control	52.1 ± 9.7	52.0	24.0-74.0
Social support	19.0 ± 4.1	19.0	8.0-32.0

**Table 4.** Pearson 's correlation coefficients between characteristics, physical work load, job stress items and salivary cortisol levels

Items	Age	Work hour/week	RHR <sup>a</sup>	Job demand	Job control	Social support	Morning <sup>b</sup>	Afternoon <sup>c</sup>	Difference <sup>d</sup>
Age	1.00								
Work hour/week	0.07	1.00							
RHR <sup>a</sup>	-0.15	-0.01	1.00						
Job demand	-0.15	0.25*	0.12	1.00					
Job control	0.26*	0.05	0.05	-0.19	1.00				
Social support	0.14	0.08	0.03	-0.12	0.09	1.00			
Morning <sup>b</sup>	-0.17	0.00	0.24*	0.05	-0.08	-0.03	1.00		
Afternoon <sup>c</sup>	-0.07	-0.26*	0.05	-0.31*	-0.03	0.04	0.18	1.00	
Differenced	-0.07	0.13	0.12	0.20	-0.06	0.00	0.81 <sup>†</sup>	-0.43 <sup>‡</sup>	1.00

\*, p<0.05, †, p<0.01, ‡, p<0.001

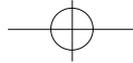
<sup>a</sup>, Relative heart rate (%)

<sup>b</sup>, Salivary cortisol concentration in the morning (8 - 9 am) ( µg/dl)

<sup>c</sup>, Salivary cortisol concentration in the afternoon (5 - 6 pm) ( µg/dl)

<sup>d</sup>, a - b ( µg/dl)





가  
 (p=0.0294). 가 0.14±0.12)  
 (Mean±S.D: 0.33±0.09) (p=0.0577).  
 (Mean±S.D: 0.31±0.11)  
 (p=0.0660). 4.  
 가 (Mean±S.D: 0.14±0.06)  
 (Mean±S.D: 0.18±0.08)  
 (p=0.0123). - , RHR  
 RHR (Mean± S.D: =26.35, p=0.0266) 가 (=60.32, S.E.  
 S.D: 0.20±0.11) (Table 6),

**Table 5.** Salivary cortisol levels according to physical work load and job stress items

		Low (Mean ± S.D.)	High (Mean ± S.D.)	p-value
Morning <sup>a</sup>	Relative heart rate	0.31 ± 0.09	0.36 ± 0.10	0.0294
	Job demand	0.33 ± 0.10	0.34 ± 0.10	0.9414
	Job control	0.33 ± 0.08	0.35 ± 0.11	0.2656
	Social support	0.33 ± 0.09	0.31 ± 0.11	0.0660
Afternoon <sup>b</sup>	Relative heart rate	0.17 ± 0.09	0.16 ± 0.08	0.8523
	Job demand	0.18 ± 0.08	0.14 ± 0.06	0.0123
	Job control	0.17 ± 0.08	0.16 ± 0.07	0.4691
	Social support	0.17 ± 0.06	0.16 ± 0.09	0.3902
Difference <sup>c</sup>	Relative heart rate	0.14 ± 0.12	0.20 ± 0.11	0.0577
	Job demand	0.17 ± 0.12	0.19 ± 0.09	0.4103
	Job control	0.16 ± 0.11	0.20 ± 0.11	0.2094
	Social support	0.17 ± 0.10	0.18 ± 0.12	0.5674

<sup>a</sup>, Salivary cortisol concentration in the morning (8 - 9 am) ( µg/dl)

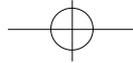
<sup>b</sup>, Salivary cortisol concentration in the afternoon (5 - 6 pm) ( µg/dl)

<sup>c</sup>, a - b ( µg/dl)

**Table 6.** Factors affecting morning salivary cortisol level

Variable		S.E.	p-value
Intercept	381.28	248.35	0.1314
Age (yrs)	-2.72	2.01	0.1823
Body mass index (kg/m <sup>2</sup> )	-2.53	7.05	0.7216
Current smoke : yes vs no	6.82	16.86	0.6876
Marital status : yes vs no	55.84	33.32	0.1004
Work hour/week (hrs)	-0.65	1.80	0.7179
Job demand	0.40	2.18	0.8540
Job control	0.04	1.37	0.9782
Social support	-4.21	3.50	0.2345
Relative heart rate: high vs low	60.32	26.35	0.0266





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( =-7.43 S.E.=29.73 p=0.8044) (Brantley et al., 1988; Van Eck et al., 1996).  
(Table 7), -

가 ( =72.10 SE=35.50,

p=0.0509)

(Table 8).

RHR

, 가  
가 ,

가  
가

VO<sub>2max</sub>

33%가

(Ilmarinen, 1992).

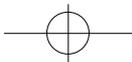
**Table 7.** Factors affecting afternoon salivary cortisol level

Variable		S.E.	P-value
Intercept	396.34	285.46	0.1749
Age (yrs)	1.62	2.10	0.4472
Body mass index (kg/m <sup>2</sup> )	-1.58	8.04	0.8459
Current smoke: yes vs no	-4.99	19.71	0.8019
Marital status: yes vs no	2.38	33.10	0.9432
Work hour/week (hrs)	-1.89	1.84	0.3100
Job demand	-3.29	2.32	0.1674
Job control	-0.33	1.54	0.8313
Social support	-2.40	3.72	0.5243
Relative heart rate: high vs low	-7.43	29.73	0.8044

**Table 8.** Factors affecting difference between morning and afternoon salivary cortisol level

Variable		S.E.	P-value
Intercept	-196.12	340.86	0.5692
Age (yrs)	-3.11	2.51	0.2246
Body mass index (kg/m <sup>2</sup> )	3.11	9.60	0.7480
Current smoke: yes vs no	22.35	23.53	0.3495
Marital status: yes vs no	52.72	39.52	0.1919
Work hour/week (hrs)	1.58	2.19	0.4776
Job demand	2.88	2.78	0.3079
Job control	1.02	1.84	0.5808
Social support	-2.73	4.44	0.5429
Relative heart rate: high vs low	72.10	35.50	0.0509





가

%VO<sub>2max</sub>, RHR relative oxygen uptake allostatic system  
 (RVO<sub>2</sub>) (Wu & Wang, , ,  
 2002). RHR  
 VO<sub>2</sub> , ,  
 , ,  
 RHR , Allostatic

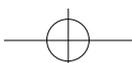
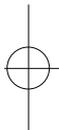
load model

RHR 가  
 ( , , ) .  
 , 가  
 RHR %VO<sub>2max</sub>  
 가 (ACSM 1995, Sjøgaard et  
 al. 1996), allostatic system  
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 Leutholtz 1997; Pollock et al. 1998). , allostatic system

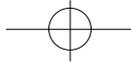
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 60 60  
 ( ,  
 8~9 ) 가 , Schulz (1998) .  
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 . Schulz (1998) 가 가 (p=0.0509),  
 Okenfels (1995) Schulz (1998)

Mason (1968) 가 , 가  
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 1998) . McEwen (1998) . Okenfels (1995)





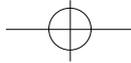


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 Zeiter (1996) Sluiter (2000) 110 ,  
 가  
 가 102 , 110  
 , 15 87  
 가 RHR (relative heart rate)  
 RHR Wu Wang 가 Karasek  
 (2002) Job Content Questionnaire  
 RHR 8 ~ 9 , 5 ~ 6  
 , :  
 RHR , RHR  
 가 ( =60.32,  
 Wu Wang (2002) S.E.=26.35, p=0.0266) ,  
 RHR ( =-7.43 S.E.=29.73 p=0.8044)  
 가 가 가 ( =72.10  
 SE=35.50, p=0.0509) .  
 RHR : 가  
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