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Field Study

Interactive Effects of Job Stress and Body Mass Index on Over-eating

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Abstract: Interactive Effects of Job Stress and Body Mass Index on Over-eating: Jiro TAKAKI, *et al*. Department of Public Health, Okayama University Graduate School of Medicine, Dentistry and Pharmaceutical Sciences—Objectives: Recent prospective evidence drawn from the Whitehall II cohort reported by Kivimäki *et al*. implies that stressful situations are related to decreased body weight in thin men and increased body weight in obese men, whereas no corresponding interactive effects are observed in women. The mechanism underlying this phenomenon remains unknown, and the purpose of this study was to confirm our hypothesis that the relevant mechanism is behavioral (e.g., over-eating). **Methods**: The subjects of this survey were 607 Japanese workers (response rate: 60.5%) in four organizations. The questionnaire solicited demographic information and included the Bulimia scale of the Eating Disorder Inventory-EZ to measure tendencies toward over-eating as well as the Japanese version of the Effort-Reward Imbalance Questionnaire (ERIQ). Body mass index (BMI) was calculated on the basis of data obtained during medical check-ups. We tested for linear and interactive effects with hierarchical regression analyses. **Results:** BMI was significantly (p<0.05) associated with over-eating both univariately and after adjusting for age in both sexes. Significant (p<0.05) interactions showed that ERIQ effort scores and effort-reward ratios were more positively associated with over-eating in men with higher BMIs, and ERIQ reward and financial remuneration scores were more negatively associated with over-eating in men with higher BMIs. No corresponding interactive effects were observed among women. **Conclusions:** The results demonstrate that stressful situations are more associated with over-eating in men with higher BMIs. This might explain, in part, the mechanism underpinning the interactive effects proposed by Kivimäki *et al*.
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When stressed, some people lose and other people gain weight[1)]. Although some studies have found associations between stressful work environments and increased body mass index (BMI)[2–7)], others have reported no associations between these variables[8–13)]. Moreover, a highly stressful work environment was associated with low BMIs in several samples[14, 15)]. A review and a cross-sectional study showed that the association between a stressful work environment and BMI were inconsistent and differed by sex[16, 17)]. Recent prospective evidence drawn from the Whitehall II cohort implies that stressful situations are related to decreased body weight in thin men (BMI<22 kg/m^2) and increased body weight in obese men (BMI>27 kg/m^2), whereas no corresponding interactive effects are observed in women[18)]. These interactive effects might explain, in part, the aforementioned inconsistent findings, but the mechanism by which these effects operate remains unknown. We hypothesized that the mechanism underlying this phenomenon was behavioral (e.g., over-eating). If the interactive effects of stressful work situation and BMI on over-eating were significant, and stressful situations were associated with over-eating more strongly in the men with higher BMIs, but no corresponding interactive effects were observed in the

women, our hypothesis would be supported.

Subjects and Methods

Subjects

The participants in this study were recruited from 1,003 Japanese workers in four organizations. A self-administered questionnaire was attached to a notice of a medical examination during the period from September 2007 to December 2007. Approximately two weeks after distribution, completed questionnaires were collected from 607 subjects (response rate: 60.5%) at their medical examinations. The purpose and procedures of this survey were explained to the participants, and written informed consent was obtained from all members of the sample. This study was approved by the ethics committee of the Okayama University Graduate School of Medicine, Dentistry, and Pharmaceutical Sciences.

Measures

The questionnaire collected data on age, sex, socioeconomic status, and life style. We used the Bulimia scale of the Eating Disorder Inventory (EDI)-EZ[19, 20] to measure tendencies toward over-eating. The EDI is a self-report measure of symptoms related to eating disorders[19, 20]. The EDI-EZ, a version of the EDI that is easier to understand[20], involves responses on a 6-point Likert scale ranging from "never" to "always"[19, 20]. The Bulimia scale used in this study was comprised of seven items: "I eat when I am upset," "I stuff myself with food," "I eat large amounts of food and feel that I cannot stop," "I think about eating too much food," "I eat okay in front of others and then stuff myself when I am alone," "I feel so bad after eating that I can't stand it," and "I eat or drink in secret." Scores on the Bulimia scale range from 0 to 35, and higher scores indicate a greater tendency toward overeating[20]. The reliability and validity of the EDI-EZ have been confirmed in Japan[20].

Siegrist suggested that situations in which people believe that they have expended great effort but perceive themselves to have been minimally rewarded lead to states of emotional distress[21, 22]. The effort-reward imbalance model is a well-known psychosocial job stress model. We used the Japanese version of the Effort-Reward Imbalance Questionnaire (ERIQ) developed by Tsutsumi et al.; this measure is comprised of two main scales, extrinsic effort and reward[23]. Extrinsic effort refers to the demanding aspects of the work environment (subjective evaluation of workload)[23]. Reward refers to three subscales: financial remuneration, esteem, and career opportunities, including job security[23]. A score for the effort-reward ratio is obtained by calculating the logarithmic-transformed ratio between extrinsic effort and reward as a continuous measure; higher scores indicate greater imbalance[24, 25].

BMI was calculated from height and weight measurements obtained during the medical check-up.

Statistical analyses

Differences between men and women were assessed by unpaired *t*-tests, and the data for men and women were then separately analyzed because previous studies have suggested sex differences[16, 17]. We also calculated Pearson's correlation coefficients for study variables. Associations between BMI and over-eating after adjustment for age were assessed with regression analyses. We tested for linear and interactive effects utilizing hierarchical regression analyses to examine the hypothesis that BMI functioned as an effect modifier in the relationship between psychosocial work environment and over-eating. Step 1 involved entering age, psychosocial work environment, and BMI in a multiple regression model with over-eating as the dependent variable. Step 2 involved entering the product of the variables representing psychosocial work environment and BMI. In accordance with Jaccard *et al*.[26], the independent variables were mean-centered prior to the two-way interaction analysis as a method of testing the interactive effect of two continuous variables on another continuous variable. We also created graphical displays of the regression models based on the recommendations by Cohen *et al*.[27] to further examine the form of the interaction. Scores were plotted at the mean, low (1 standard deviation below the mean), and high (1 standard deviation above the mean) values[27]. All the *p* values were two-tailed, and $p<0.05$ was established as the threshold for significance. All statistical analyses were performed with SPSS 11.0J (SPSS Tokyo, Japan).

Results

Table 1 presents sample characteristics by sex. On average, men were significantly older, had higher BMIs, and demonstrated less pronounced tendencies toward over-eating than did women. The men also obtained significantly higher ERIQ reward scores than did the women. Tables 2 and 3 show Pearson's correlation coefficients for study variables among the men and women, respectively. Age was significantly correlated with over-eating scores in both sexes. We therefore included age as a potential confounding variable in all regression models employing over-eating as the dependent variable. BMI was significantly positively correlated with over-eating scores (Tables 2 and 3). Associations between BMI and over-eating scores after adjustment for age were also significantly ($p<0.001$) positive for both sexes. No significant positive correlations were found between ERIQ scores and BMI (Tables 2 and 3).

Tables 4 and 5 present testing the results of the modifying effects of BMI on the relationships between ERIQ and over-eating scores in men and women,

Table 1. Sample characteristics

Variables	Men (n=298)		Women (n=309)		p[b]
	Mean	SD[a]	Mean	SD	
Age (yr)	43.5	10.2	40.4	10.6	<0.001
Body mass index (kg/m^2)	23.8	3.5	21.7	3.6	<0.001
Over-eating score[c]	7.5	5.2	9.6	6.6	<0.001
ERIQ[d] scores					
Extrinsic effort	13.5	4.3	13.4	4.7	0.814
Reward	44.1	7.0	42.2	8.1	0.002
Financial remuneration	15.3	2.8	14.5	3.3	0.002
Esteem	20.6	3.4	19.8	4.3	0.012
Career opportunities	8.2	1.6	7.8	1.8	0.006
Effort-reward ratio	–0.3	0.2	–0.3	0.2	0.381

[a]: Standard deviation. [b]: Differences between men and women were assessed by unpaired *t*-tests. [c]: Eating Disorder Inventory-EZ Bulimia score. [d]: Effort-Reward Imbalance Questionnaire.

Table 2. Pearson's correlation coefficients for study variables among men

		1	2	3	4	5	6	7	8
1. Age	r[a]								
	p								
2. Body mass index	r	0.06							
	p	0.295							
3. Over-eating score[b]	r	–0.19	0.30						
	p	0.001	<0.001						
4. ERIQ[c] extrinsic effort	r	–0.22	–0.14	0.15					
	p	<0.001	0.019	0.009					
5. ERIQ reward	r	0.01	0.01	–0.13	–0.52				
	p	0.835	0.930	0.021	<0.001				
6. ERIQ financial remuneration	r	0.10	0.07	–0.11	–0.46	0.90			
	p	0.074	0.199	0.065	<0.001	<0.001			
7. ERIQ esteem	r	–0.02	–0.06	–0.13	–0.47	0.93	0.73		
	p	0.768	0.281	0.023	<0.001	<0.001	<0.001		
8. ERIQ career opportunities	r	–0.09	0.03	–0.12	–0.49	0.80	0.62	0.66	
	p	0.113	0.646	0.043	<0.001	<0.001	<0.001	<0.001	
9. ERIQ effort-reward ratio	r	–0.17	–0.09	0.17	0.94	–0.77	–0.68	–0.70	–0.68
	p	0.003	0.109	0.004	<0.001	<0.001	<0.001	<0.001	<0.001

[a]: Pearson's correlation coefficient. [b]: Eating Disorder Inventory-EZ Bulimia score. [c]: Effort-Reward Imbalance Questionnaire.

respectively, using hierarchical multiple regression analyses. In other words, these tables depict testing the results of the interactive effects of two continuous variables (i.e., each ERIQ score and BMI) on a third continuous variable (the over-eating scores). Among men, the interactions of particular ERIQ scores (i.e., extrinsic effort, reward, financial remuneration, and effort-reward ratio) and BMI significantly contributed to the regression models for the over-eating scores (Table 4). Among women, only the interaction of the ERIQ financial remuneration score and BMI significantly contributed to the regression model (Table 5).

The regression lines and predicted values illustrating the significant interactions were constructed from the unstandardized regression coefficients and are depicted in Fig. 1. The ERIQ effort score and effort-reward ratio were more positively associated with over-eating in men with higher BMIs, and the ERIQ reward and financial remuneration scores were more negatively associated with over-eating in men with higher BMIs. No corresponding

Table 3. Pearson's correlation coefficients for study variables among women

		1	2	3	4	5	6	7	8
1. Age	r[a]								
	p								
2. Body mass index	r	0.20							
	p	<0.001							
3. Over-eating score[b]	r	–0.27	0.17						
	p	<0.001	0.003						
4. ERIQ[c] extrinsic effort	r	0.03	0.09	0.06					
	p	0.613	0.118	0.331					
5. ERIQ reward	r	–0.05	–0.05	–0.06	–0.47				
	p	0.427	0.394	0.276	<0.001				
6. ERIQ financial remuneration	r	0.03	–0.03	–0.04	–0.38	0.87			
	p	0.568	0.656	0.497	<0.001	<0.001			
7. ERIQ esteem	r	–0.12	–0.09	–0.04	–0.43	0.92	0.65		
	p	0.028	0.134	0.454	<0.001	<0.001	<0.001		
8. ERIQ career opportunities	r	0.03	0.03	–0.11	–0.41	0.73	0.53	0.56	
	p	0.555	0.586	0.059	<0.001	<0.001	<0.001	<0.001	
9. ERIQ effort-reward ratio	r	0.03	0.09	0.09	0.91	–0.77	–0.64	–0.70	–0.60
	p	0.549	0.105	0.131	<0.001	<0.001	<0.001	<0.001	<0.001

[a]: Pearson's correlation coefficient. [b]: Eating Disorder Inventory-EZ Bulimia score. [c]: Effort-Reward Imbalance Questionnaire.

interactive effects were observed in women.

Discussion

Because BMI was significantly associated with over-eating both univariately and after adjustment for age in both sexes, this association emerged as robust. Otherwise, most relationships between BMI and each ERIQ score were not significant in this study. These results might not be surprising because they are consistent with many of the aforementioned previous studies[8–17]. One explanation for the inconsistency in the relationships between stressful situations and BMI is the interactive effects suggested by Kivimäki *et al*., who proposed that stressful situations are related to decreased body weight in thin men and increased body weight in obese men, whereas no corresponding interactive effects are observed in women[18]. We demonstrated that stressful situations were associated with over-eating more strongly in men with higher BMIs, whereas no corresponding interactive effects were observed in women, which might partially explain the mechanism underlying the interactive effects suggested by Kivimäki *et al*.

This study has several limitations. As a cross-sectional study, it did not permit determination of causal relationships. Thus, these results should be confirmed in prospective cohort or intervention studies. Because this study used convenience sampling, the results might not be applicable to the entire work force in Japan. However, because we investigated four organizations and obtained a response rate over 60%, some generalizability can be expected. Our findings might explain the interactive effect behind the finding that stressful situations are related to increased body weight in obese men, but cannot directly explain the interactive effect behind the finding that stressful situations are related to decreased body weight in thin men. A direct explanation of the latter would require measurement of the eating habits leading to decreased body weight. Despite these limitations, we believe that these results can contribute to the development of interventions to prevent obesity in highly stressed working men.

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Table 4. Testing the modifying effects of body mass index (BMI) on the relationships between the Effort-Reward Imbalance Questionnaire scores (exposure) and the over-eating score[a] (outcome) using hierarchical multiple regression in men

Step and variable	B[b]	β [c]	p for β	R^2	p for $\triangle F$
Step 1					
Extrinsic effort	0.195	0.16	0.004		
BMI	0.501	0.34	<0.001	0.158	
Step 2					
Extrinsic effort	0.220	0.18	0.001		
BMI	0.488	0.33	<0.001		
Extrinsic effort × BMI	0.047	0.14	0.011	0.177	0.011
Step 1					
Reward	–0.100	–0.13	0.014		
BMI	0.472	0.32	<0.001	0.151	
Step 2					
Reward	–0.108	–0.14	0.008		
BMI	0.439	0.29	<0.001		
Reward × BMI	–0.026	–0.12	0.028	0.165	0.028
Step 1					
Financial remuneration	–0.208	–0.11	0.042		
BMI	0.483	0.32	<0.001	0.146	
Step 2					
Financial remuneration	–0.244	–0.13	0.018		
BMI	0.460	0.31	<0.001		
Financial remuneration × BMI	–0.067	–0.12	0.029	0.159	0.029
Step 1					
Esteem	–0.177	–0.12	0.033		
BMI	0.461	0.31	<0.001	0.148	
Step 2					
Esteem	–0.183	–0.12	0.027		
BMI	0.426	0.29	<0.001		
Esteem × BMI	–0.043	–0.10	0.065	0.158	0.065
Step 1					
Career opportunities	–0.473	–0.15	0.007		
BMI	0.479	0.32	<0.001	0.155	
Step 2					
Career opportunities	–0.481	–0.15	0.006		
BMI	0.471	0.31	<0.001		
Career opportunities × BMI	–0.089	–0.09	0.094	0.163	0.094
Step 1					
Effort-reward ratio	4.612	0.17	0.002		
BMI	0.492	0.33	<0.001	0.148	
Step 2					
Effort-reward ratio	5.020	0.18	<0.001		
BMI	0.469	0.31	<0.001		
Effort-reward ratio × BMI	1.089	0.14	0.011	0.167	0.004

[a]: Eating Disorder Inventory-EZ Bulimia score. [b]: Unstandardized regression coefficient. [c]: Standardized regression coefficient. All the models were adjusted for age.

Table 5. Testing the modifying effects of body mass index (BMI) on the relationships between the Effort-Reward Imbalance Questionnaire scores (exposure) and the over-eating score[a] (outcome) using hierarchical multiple regression in women

Step and variable	B[b]	β [c]	p for β	R^2	p for $\triangle F$
Step 1					
Extrinsic effort	0.062	0.04	0.408		
BMI	0.413	0.23	<0.001	0.128	
Step 2					
Extrinsic effort	0.061	0.04	0.419		
BMI	0.422	0.23	<0.001		
Extrinsic effort × BMI	–0.012	–0.03	0.569	0.129	0.569
Step 1					
Reward	–0.053	–0.07	0.221		
BMI	0.415	0.23	<0.001	0.130	
Step 2					
Reward	–0.060	–0.07	0.168		
BMI	0.454	0.25	<0.001		
Reward × BMI	0.021	0.10	0.059	0.140	0.059
Step 1					
Financial remuneration	–0.045	–0.02	0.675		
BMI	0.418	0.23	<0.001	0.126	
Step 2					
Financial remuneration	–0.028	–0.01	0.795		
BMI	0.445	0.25	<0.001		
Financial remuneration × BMI	0.059	0.11	0.048	0.138	0.048
Step 1					
Esteem	–0.099	–0.06	0.235		
BMI	0.412	0.23	<0.001	0.130	
Step 2					
Esteem	–0.112	–0.07	0.179		
BMI	0.449	0.25	<0.001		
Esteem × BMI	0.029	0.08	0.133	0.136	0.133
Step 1					
Career opportunities	–0.384	–0.10	0.051		
BMI	0.425	0.23	<0.001	0.137	
Step 2					
Career opportunities	–0.412	–0.11	0.037		
BMI	0.440	0.24	<0.001		
Career opportunities × BMI	0.075	0.08	0.136	0.143	0.136
Step 1					
Effort-reward ratio	2.319	0.08	0.155		
BMI	0.407	0.22	<0.001	0.132	
Step 2					
Effort-reward ratio	2.320	0.08	0.155		
BMI	0.434	0.24	<0.001		
Effort-reward ratio × BMI	–0.566	–0.07	0.175	0.137	0.175

[a]: Eating Disorder Inventory-EZ Bulimia score. [b]: Unstandardized regression coefficient. [c]: Standardized regression coefficient. All the models were adjusted for age.

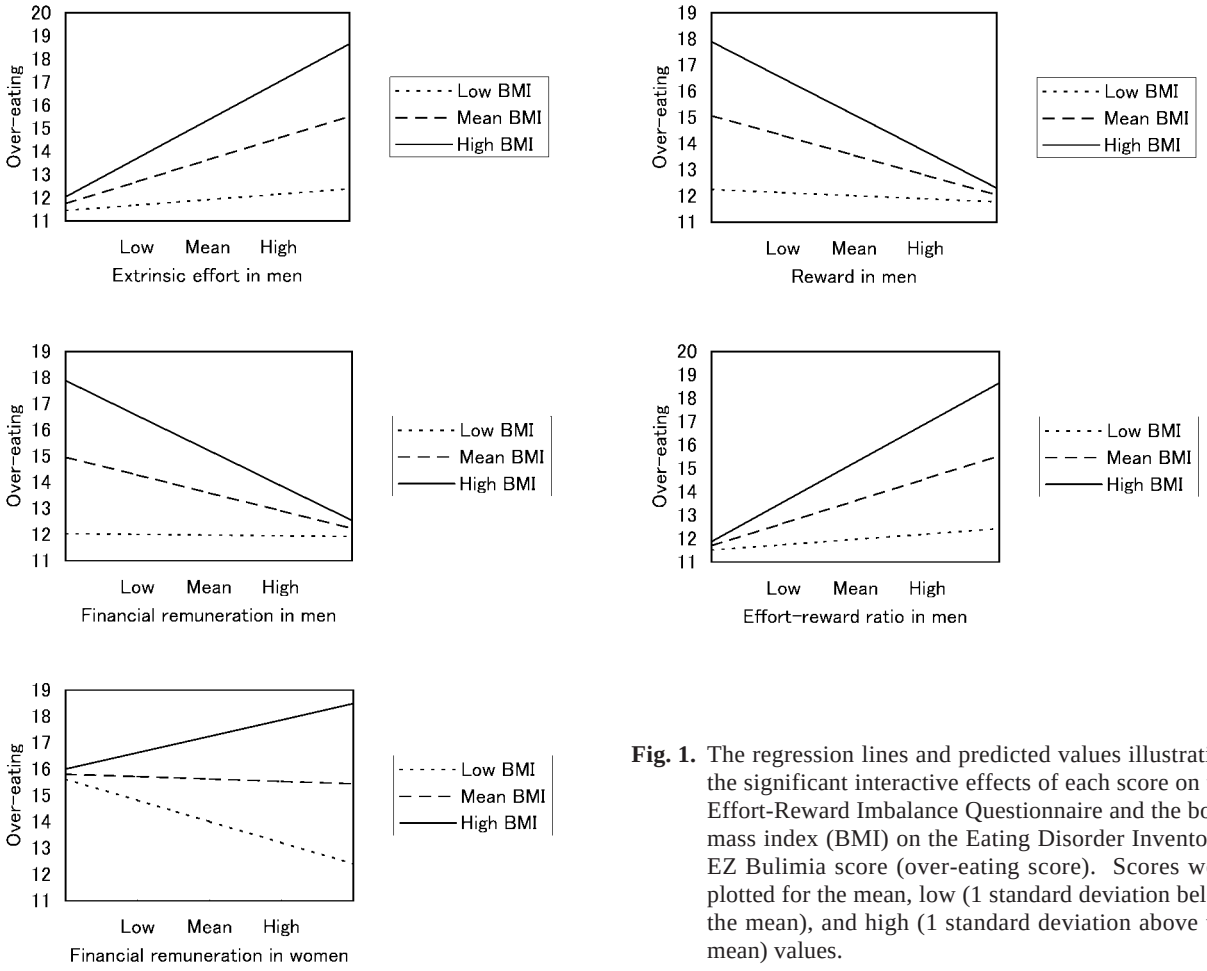

Fig. 1. The regression lines and predicted values illustrating the significant interactive effects of each score on the Effort-Reward Imbalance Questionnaire and the body mass index (BMI) on the Eating Disorder Inventory-EZ Bulimia score (over-eating score). Scores were plotted for the mean, low (1 standard deviation below the mean), and high (1 standard deviation above the mean) values.

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