Usefulness of Regular Intake of the Reduced Form of CoQ10 for Stress Management for Workers

■

Yasutaka Kawaharada[1)]　Kouji Toyomasu[2)]

ABSTRACT

Objectives The purpose of the study was to determine whether its regular intake of the reduced form of CoQ10 was useful in managing workers' stress.

Methods Nineteen nurses working at a university hospital received soft capsule containing 100 mg of the reduced form of CoQ10 for 4 weeks. Based on test food intake during the study, the subjects were divided into two groups : a "good intake group" composed of those who took the test food every day, and "poor intake group" composed of the remaining subjects. The basic attributes, lifestyle, working conditions, job stress level, and work engagement of the groups were analyzed. Job stress level and work engagement were investigated using Brief Job Stress Questionnaire (BJSQ) and Utrecht Work Engagement Scale Japan (UWES-J), and levels of cortisol, VMA and 8-0HdG, respectively. Intragroup and intergroup comparison of the variables was performed.

Results In the good intake group, a significant increase in "job satisfaction" in the BJSQ ($P=0.009$), a significant decrease in "physical complaint" ($P=0.024$), and a significant increase in the UWES-J score ($P=0.017$) were observed, although poor intake group showed no significant difference at either time point. No adverse events or clinically significant changes in the physical examination and blood test were observed in either group.

Conclusion The results suggest that regular intake of the reduced form of CoQ10 may reduce physical symptoms due to job stress and thereby enhance work engagement, indicating usefulness for stress management for workers.

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KEY WORDS Reduced form of CoQ10, Worker, Stress management, Job stress, Work engagement

INTRODUCTION

Currently, people live under much stress, as indicated by the term "the stressed society" often used to describe the current social condition. In particular, stress in the workplace and resultant stress-related health disorders are important problems. For instance, as many as 60.9% of workers responded that "he or she is highly uneasy, distressed, or stressed about job and/or occupational life",[1)] and the number of workers approved for compensation for mental disorders is increasing year by year.[2)] Thus, stress not only poses health problems to individual workers, but also causes great loss to relevant companies and to society as a whole.[3,4)] Therefore, measures for workers' mental health are extremely important and are being addressed as a major issue in industry-academia-government projects.

Stress management is very important for coping with stress individually, and methods for this include regular exercise, aromatherapy, massage, and autogenic training, which have been reported to be useful in reducing stress,[5-8)] but may not be feasible on a daily basis, because time and place are required. In

[1)]Kurume University Graduate School of Medicine　[2)]Institute of Health and Sports Science, Kurume University

recent years, therefore, stress management through intake of supplements, which may be highly feasible on a daily basis, has been of high interest. Taking well-balanced nutrients that support antioxidation in the body through intake of supplements is intended to enhance stress tolerance and create a virtuous cycle of health by producing a proper physical and mental balance. In the current society, in which eating out has become much more popular than it used to be, it is difficult to consume a variety of nutrients in a balanced manner, and convenience, which intake of supplements can provide, may be an important factor to correct it.

Coenzyme Q10 (hereinafter referred to as CoQ10) is a biological component discovered by Crane, et al.[9] as a component of the mitochondrial electron transport system in 1957, and has been known to produce ATP by activating mitochondria[10] and to have antioxidant effects in the reduced form of CoQ10.[11] In recent years, this reduced form of CoQ10 has been reported to be useful in many ways since it became commercially available, including prevention and alleviation of lifestyle-related diseases ; antihypertensive effect in patients with hypertension[12,13] ; improvement of glycemic control in patients with type 2 diabetes[14] ; LDL cholesterol-lowering effect in healthy individuals[15] ; and improvement of cardiac function in patients with end-stage congestive heart failure.[16] In addition, it has been suggested that the reduced form of CoQ10 may be useful not only for physical health, but also for mental health, as exemplified by a few reports of the antidepressant effect in rats under chronic stress[17] and improvement in the QOL in elderly humans.[18]

To further evaluate the usefulness of the reduced form of CoQ10 for mental health, the present study was conducted in female nursing personnel at a university hospital to verify the usefulness of regular intake of the reduced form of CoQ10 in reducing workers' job stress.

STUDY METHOD

1 Subjects

Female nursing personnel at University Hospital A in Fukuoka Prefecture were included in this study. After study participants were recruited through posters and leaflets, those who gave informed consent to participate in the study following a detailed oral and written explanation of the study, including its purpose and method, were selected.

Of these candidates, 20 subjects were selected for the study, after excluding those who had a risk of allergy to the test food and those who regularly used oral drugs or supplements that may affect the study results. In addition, 1 subject who dropped out from the study due to treatment of fracture was excluded, and the remaining 19 subjects (all females, mean age : 34.7±10.3 years) were included in the final analysis.

2 Study design

This was an open-label study. The test food was ingested after breakfast every day for 4 weeks. After the completion of the study, test food intake during the study was investigated, and subjects were divided into two groups : a "good intake group" composed of those who took the test food every day, and "poor intake group" composed of the remaining subjects. Comparisons within the same group and between the two groups before test food intake (baseline) and at 4 weeks after the start of test food intake (completion of test food intake) were performed.

3 Test food and intake method

The test food was a soft capsule containing 100 mg of the reduced form of CoQ10. It was ingested with cold or hot water at a dose of 1 capsule once daily after breakfast. Subjects were instructed to maintain their normal daily life behavior, including diet and exercise, except for intake of the test food.

4 Investigation items and method

1) Written questionnaire

The basic attributes, lifestyle, working conditions, job stress level, and work engagement were investigated before and 4 weeks after the start of test food intake. The Brief Job Stress Questionnaire (hereinafter referred to as BJSQ),[19] which was developed by a stress research group commissioned by the former Japanese Ministry of Labour as an instrument to comprehensively assess job stress among workers, was used to investigate job stress. The 9-item Japanese version of Utrecht Work Engagement Scale (hereinafter referred to as UWES-J), which was originally prepared by Schaufeli, et al.,[20] translated into Japanese by Shimadzu, et al.,[21] and validated in Japan, was used to investigate work engagement.

The BJSQ consists of the following 20 items : (1) 9 job stressors (Quantitative mental workload, Qualitative mental workload, Self-assessed physical workload, Job control, Skill utilization, Interpersonal conflict, Physical environment, Job suitability, and Job satisfaction)；(2) 6 stress responses (5 psychological stress responses：Vigor, Irritability, Fatigue, Anxiety, and Depression；1 physical stress response：Physical complaint)；(3) 3 social supports (Supervisor support, Coworker support, and Family/Friend support)；and (4) 2 items (Job and life satisfaction levels). All questions were answered on a four-grade scale, and the grade for each question was used as an interval scale to obtain the scale score. The scale score was designed to indicate the stress level.

The UWES-J was used to measure the questionee's willingness to work. All questions were answered on a seven-grade scale, and the grade for each question was used as an interval scale to obtain the total score of 9 items as the UWES-J score. In principle, a higher UWES-J score indicates that the questionee is more energetic and satisfied with his or her job.

2) Blood cortisol, urinary vanillyl mandelic acid (VMA), and urinary 8-hydroxydeoxyguanosine (8-OHdG)

Blood (fasting) and urine samples were collected before and 4 weeks after the start of test food intake to measure and assess the following 3 substances, which are objective variables of stress：blood cortisol, urinary vanillyl mandelic acid (VMA), and urinary 8-hydroxydeoxyguanosine (8-OHdG).

Cortisol is a typical stress hormone and its level in blood increases according to the change in the hypothalamic-pituitary-adrenal axis in response to increased stress. VMA is the end metabolite of catecholamines, and 8-OHdG is intracellularly formed as a result of oxidation of deoxyguanosine, a component of DNA, by free radicals such as active oxygen. Both VMA and 8-OHdG have been reported to be useful in quantifying physical or mental stress and fatigue biochemically.[22,23]

3) Safety variables

To evaluate the safety of the test food, adverse events were collected by means of a written questionnaire during the study, and physical examination and blood test were conducted before and 4 weeks after the start of test food intake.

(1) Physical examination

The following 3 variables were measured：BMI, blood pressure at rest, and heart rate.

(2) Blood test

The following 27 variables were measured：white blood cell count (WBC), red blood cell count (RBC), hemoglobin (HGB), hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), platelet count (Plt), total protein (TP), albumin (Alb), aspartate aminotransferase (AST), alanine aminotransferase (ALT), γ-glutamyl transpeptidase (γ-GTP), alkaline phosphatase (ALP), serum creatinine (Crea), urea nitrogen (BUN), uric acid (UN), serum amylase (AMY), total cholesterol (T-cho), HDL cholesterol (HDL-C), LDL cholesterol (LDL-C), triglyceride (TG), fasting blood glucose (Glu), glycohemoglobin (HbA1c), serum sodium (Na), serum potassium (K), and serum chloride (Cl).

5 Statistical analysis

Results were expressed as the mean ± standard deviation.

For the basic attributes, lifestyle and working conditions, group comparison was performed by unpaired *t*-test and Fisher's exact test.

For the BJSQ, UWES-J, cortisol, VMA, 8-OHdG, body index, and blood test variables, the change from baseline (before test food intake) at the completion of test food intake in the same group was assessed using paired *t*-test, and group comparison at 2 time points (before and 4 weeks after the start of test food intake) was performed using unpaired *t*-test.

The Pearson product-moment correlation coefficient was calculated to evaluate the correlation between each subjective variable of stress (6 stress responses in the BJSQ and the UWES-J score) and each objective variable of stress (cortisol, VMA, and 8-OHdG), and the correlation among cortisol, VMA, and 8-OHdG at baseline using the data from all subjects.

To evaluate the safety of the test food, adverse events were tabulated, and the change from baseline in the physical or blood test variables at the completion of test food intake was analyzed using paired *t*-test.

SPSS Statistics 17.0 (SPSS Japan Inc.) was used for statistical analysis, and a two-sided significance level of 5% was used in all tests.

6 Ethics

This study was approved by the Ethics Committee of Kurume University prior to conduction (Study No. 164). Before the start of the study, a detailed explanation of the study, including its purpose and method, was given to each subject, and written

Table 1　Test food intake rate

Test food intake rate	Total (n=19)	Good intake group (n=10)	Poor intake group (n=9)
100%	10 (52.6)	10 (100.0)	0
99 to 75%	6 (31.6)	0	6 (66.7)
74 to 50%	2 (10.5)	0	2 (22.2)
<50%	1 (5.3)	0	1 (11.1)

Table 2　Basic attributes and lifestyle

	Good intake group (n=10)	Poor intake group (n=9)
Age	40.3±11.1*	28.4±4.3**
Marriage		
No	3 (30.0)	1 (11.1)
Yes	7 (70.0)	8 (88.9)
Regular exercise		
No	4 (40.0)	1 (11.1)
Yes	6 (60.0)	8 (88.9)
Regular dietary		
No	5 (50.0)	3 (33.3)
Yes	5 (50.0)	6 (66.7)
Snacking		
No	5 (50.0)	2 (22.2)
Yes	5 (50.0)	7 (77.8)
Smoking		
No	10 (100.0)	8 (88.9)
Yes	0	1 (11.1)
Excessive drinking		
No	7 (70.0)	8 (88.9)
Yes	3 (30.0)	1 (11.1)
Sleep duration of 7 to 8 hrs/day		
No	2 (20.0)	1 (11.1)
Yes	8 (80.0)	8 (88.9)
Resolution of stress		
No	9 (90.0)	5 (55.6)
Yes	1 (10.0)	4 (44.4)
Proper body weight		
No	8 (80.0)	5 (55.6)
Yes	2 (20.0)	4 (44.4)

Mean±SD for age, and number of subjects (%) for others.
Comparison between groups before test food intake.
*$P<0.05$, **$P<0.01$

informed consent was obtained in accordance with the Declaration of Helsinki. In addition, data analysis was performed in a manner such that each the individual identities of subjects would not be revealed.

RESULTS

1　Test food intake

Test food intake was investigated, and 10 (52.6%) and 9 subjects (47.4%) were classified into the good intake group and poor intake group, respectively. Test food intake is shown in **Table 1**.

Table 3　Work situation

	Good intake group (n=10)	Poor intake group (n=9)
Hrs of holiday/extra work		
<80 hrs/mo	10 (100.0)	8 (88.9)
80 to 100 hrs/mo	0	1 (11.1)
>100 hrs/mo	0	0
Frequency of holiday/extra work		
None or little	7 (70.0)	6 (66.7)
Much	3 (30.0)	2 (22.2)
Very much	0	1 (11.1)
Occurrence of medical incidents within 1 month		
No	6 (60.0)	5 (55.6)
Yes	4 (40.0)	4 (44.4)
Sleepiness during work time		
None or little	7 (70.0)	6 (66.7)
Some	3 (30.0)	3 (33.3)
Much	0	0
Sleepiness during off-duty time		
None or little	2 (20.0)	1 (11.1)
Some	6 (60.0)	5 (55.6)
Much	2 (20.0)	3 (33.3)
Job insecurity		
No	2 (20.0)	2 (22.2)
Yes	8 (80.0)	7 (77.8)
Stress by interpersonal conflict		
No	4 (40.0)	5 (55.6)
Yes	6 (60.0)	4 (44.4)

Number of subjects (%)

2　Comparison of basic attributes, lifestyle, and working conditions

The basic attributes, lifestyle and working conditions at baseline were compared between the good intake group and poor intake group, showing that the mean age was significantly higher in the good intake group ($P=0.009$). As shown in **Table 2**, **3**, no significant differences were observed in any other variables between the two groups. The basic attributes, lifestyle and working conditions did not change from baseline after test food intake in either group (no data provided).

3　Comparison of BJSQ and UWES-J scores (Table 4)

The BJSQ total score and UWES-J score at baseline and 4 weeks after the start of test food intake were compared between the good intake group and poor intake group, showing no significant difference at either time point.

Subsequently, the change from baseline in the BJSQ total score and UWES-J score after test food intake in the good intake group and poor intake group were analyzed. In the good intake group, a significant increase in "job satisfaction" in the BJSQ ($P=0.009$), a significant decrease in "physical complaint"

Table 4 BJSQ and UWES-J before test food intake and at 4 weeks after start of intake

	Good intake group（n=10）		Poor intake group（n=9）	
	Before intake	At 4 weeks	Before intake	At 4 weeks
Quantitative mental workload	9.5±1.8	9.0±1.7	10.1±1.4	9.4±1.9
Qualitative mental workload	9.8±2.0	9.5±1.6	10.7±1.4	10.4±1.6
Self-assessed physical workload	3.4±0.7	3.3±0.8	3.6±0.7	3.6±0.5
Job control	8.2±1.8	8.3±1.9	7.4±1.4	7.7±1.0
Skill utilization	3.1±0.9	3.1±0.6	2.7±0.5	2.9±0.6
Interpersonal conflict	5.4±0.8	5.5±1.4	5.9±1.8	6.0±2.0
Physical environment	1.5±0.7	1.6±0.5	2.0±0.5	2.0±0.5
Job suitability	2.5±0.7	2.7±0.5	2.8±0.4	2.8±0.4
Job satisfaction	2.6±0.7	3.3±0.7††	3.2±0.4	3.4±0.5
Vigor	6.7±2.8	7.1±2.5	6.1±0.6	6.1±1.7
Irritability	5.7±2.2	5.6±1.3	7.2±1.9	6.4±1.8
Fatigue	7.6±2.5	6.3±2.2	7.9±1.6	7.8±1.8
Anxiety	6.6±3.1	5.7±2.0	7.3±1.3	7.0±1.6
Depression	10.6±2.9	9.8±2.7	11.4±2.2	11.9±2.8
Physical complaint	21.3±5.6	20.1±5.2†	22.6±5.4	21.7±3.5
Supervisor support	9.6±2.1	9.2±2.3	8.6±2.4	9.0±2.1
Coworker support	9.2±1.6	9.1±1.7	8.6±2.4	9.0±2.1
Family/friend support	10.0±2.4	11.1±1.4	11.2±1.3	11.6±1.0
Job satisfaction level	2.7±0.7	3.0±0.8	2.7±0.5	2.9±0.6
Life satisfaction level	3.0±0.8	2.9±0.3	2.9±0.8	3.0±0.7
UWES-J score	26.8±6.3	31.0±7.8†	27.7±4.4	28.4±7.1

Mean±SD
*Comparison between before and after test food intake intergroup and intragroup（paired t-test）：$^{†}P<0.05$, $^{††}P<0.01$

Table 5 Levels of cortisol, VMA and 8-0HdG

	Good intake group（n=10）		Poor intake group（n=9）	
	Before intake	At 4 week	Before intake	At 4 week
Cortisol	6.0±2.9	8.1±2.0	8.7±6.0	7.4±1.9
VMA	4.0±0.9	4.3±1.0	3.9±0.8	4.1±0.9
8-0HdG	3.0±1.3	2.4±0.9	2.9±2.0	1.9±1.1

Mean±SD

（P=0.024）, and a significant increase in the UWES-J score（P=0.017）were observed 4 weeks after the start of test food intake.

4 Comparison of cortisol, VMA, and 8-0HdG（Table 5）

The mean cortisol, VMA, and 8-0HdG level at baseline and 4 weeks after the start of test food intake were compared between the good intake group and poor intake group, showing no significant difference at either time point.

Subsequently, the change from baseline in cortisol, VMA, and 8-0HdG after test food intake in the good intake group and poor intake group were analyzed, showing no significant change in either group.

5 Correlation between stress response and UWES-J score and cortisol, VMA, and 8-0HdG（Table 6）

Correlations between each of 6 stress responses in the BJSQ or UWES-J score and cortisol, VMA, and 8-0HdG were evaluated, showing no significant correlation between any of the sets of two variables. In addition, correlation between cortisol and VMA, between cortisol and 8-0HdG, and between VMA and 8-0HdG were evaluated, showing no significant correlation between any of the sets of two variables.

Table 6 Relationships between stress response variables and UWES-J score and cortisol, VMA and 8-OHdG

	Cortisol	VMA	8-OHdG
Cortisol	—	—	—
VMA	0.06	—	—
8-OHdG	−0.13	0.31	—
Vigor	−0.22	0.35	0.12
Irritability	0.01	−0.20	−0.12
Fatigue	0.42	−0.13	−0.39
Anxiety	0.15	−0.23	−0.37
Depression	0.03	−0.26	−0.30
Physical complaint	0.08	−0.16	−0.14
UWES-J score	−0.27	−0.00	−0.11

Data of all subjects（n=19）obtained before test food intake. *Pearson product-moment correlation coefficient

6 Comparison of the occurrence of adverse events during the study, physical examination, and blood test（Table 7）

No adverse events were observed in any subjects during the study. In the physical examination, no variables changed significantly from baseline after test food intake in either group. In the blood test, no clinically significant changes were observed, although some variables changed significantly from baseline after test food intake, but only slightly and within the normal range.

DISCUSSION

In the present study, subjects were classified into two groups according to the intake of the reduced

Table 7 Results of physical and blood tests

	Total（n=19）		Good intake group（n=10）		Poor intake group（n=9）	
	Before intake	After intake	Before intake	At 4 week	Before intake	At 4 week
BMI	20.3±2.9	20.3±2.7	21.4±3.2	21.4±3.0	19.0±1.8	19.0±1.6
Systolic BP	112.0±9.9	110.5±11.5	112.8±9.2	113.1±10.7	111.1±11.2	107.6±12.2
Diastolic BP	66.9±7.9	66.9±7.7	67.4±8.6	70.4±7.9	66.3±7.4	63.0±5.4
HR	71.0±9.8	72.5±12.3	71.6±11.0	73.0±14.9	70.3±8.8	71.9±9.4
WBC	66.2±12.6	61.2±13.5	64.0±11.9	60.2±15.9	68.7±13.5	62.4±11.0
RBC	433.4±38.2	434.8±45.1	430.8±26.7	440.2±40.3	436.3±49.6	428.9±51.8
HGB	12.9±0.8	13.1±1.1	13.2±0.7	13.5±1.1	12.6±0.8	12.5±0.9
HCT	39.0±1.9	39.0±2.8	39.7±1.8	40.3±2.8	38.2±1.7	37.6±2.0
MCV	90.4±6.5	90.2±6.1	92.2±3.6	91.8±3.8	88.4±8.5	88.4±7.8
MCH	29.9±2.6	30.1±2.5††	30.7±1.3	30.8±1.2	29.1±3.4	29.5±3.4††
MCHC	33.1±0.9	33.4±1.0††	33.3±0.9	33.5±0.8	32.8±0.9	33.3±1.1††
Plt	24.9±4.7	25.4±5.6	26.0±5.0	26.6±5.8	23.7±4.4	24.0±5.3
TP	7.5±0.3	7.4±0.4	7.6±0.3	7.5±0.3	7.5±0.2	7.4±0.5
Alb	4.6±0.2	4.7±0.3	4.6±0.2	4.7±0.2	4.7±0.2	4.7±0.4
AST	17.3±3.0	17.4±3.7	18.2±3.1	17.7±2.2	16.2±2.6	17.1±5.0
ALT	14.9±7.7	16.9±11.4	15.6±9.3	16.0±7.9	14.2±6.0	18.0±14.9
γ-GTP	19.7±10.3	19.6±9.3	22.8±11.8	21.2±8.6	16.2±7.4	17.8±10.3
ALP	14.9±7.7	16.9±11.4	183.7±58.2	187.5±50.6	159.1±34.6	168.6±43.1
Crea	0.6±0.1	0.6±0.1	0.6±0.1	0.6±0.1	0.6±0.1	0.6±0.1
BUN	12.4±3.2	11.5±2.7	12.9±3.0	11.1±2.1	11.8±3.5	11.9±3.4
UN	4.2±0.7	4.4±0.6	4.3±0.9	4.5±0.5	4.2±0.5	4.2±0.7
AMY	80.7±21.1	87.9±40.7	78.1±17.5	89.5±52.2	83.7±25.3	86.1±25.8
T-Cho	197.8±38.9	193.2±40.4	206.2±39.9	210.2±43.8	188.4±37.8	174.2±27.3*
HDL-C	68.3±13.6	67.1±12.2	69.1±14.3	68.4±12.7	67.4±13.6	65.7±12.2
LDL-C	113.0±27.7	110.1±30.5	118.4±28.9	123.6±34.5	107.0±26.5	95.1±16.6
TG	98.4±62.5	100.4±65.1	126.4±73.0	128.2±69.6	67.3±26.9	69.6±35.3
Glu	91.3±7.8	101.1±12.2††	93.2±6.5	104.3±15.6†	89.1±9.0	97.6±5.7††
HbA1c	4.9±0.2	5.0±0.2††	4.9±0.3	5.0±0.2	4.9±0.2	4.9±0.2
Na	140.3±1.9	141.1±1.7	140.8±1.0	141.3±1.1	139.8±2.5	140.9±2.2
K	4.1±0.4	4.0±0.2	4.3±0.5	4.0±0.2	4.0±0.2	3.9±0.2
Cl	104.6±2.1	105.4±1.8	104.6±1.6	104.5±1.6	104.6±2.7	106.4±1.4

Mean±SD
*Comparison between before and after test food intake intergroup and intragroup（paired t-test）: †P<0.05, ††P<0.01

form of CoQ10 during the study to determine whether its regular intake was useful in reducing workers' stress based on subjective and objective variables. The subjective variables were BJSQ, which is designed to indicate the degree of job stressors and stress responses, and UWES-J, which is designed to indicate work engagement. The objective variables were cortisol, VMA, and 8-OHdG, which can quantify the degree of stress responses biochemically. These variables were measured and compared between the two groups and within the same group.

Among the subjective variables of stress, the working conditions, BJSQ score, and UWES-J score were not significantly different between the two groups at baseline (before test food intake). As for the change from baseline after test food intake, however, no variables changed significantly in the poor intake group, but "physical complaint" in the BJSQ significantly decreased after test food intake in the good intake group. The reduced form of CoQ10 is a coenzyme essential for mitochondrial ATP production. It exists in the body and contributes to energy production. It is known that the production of the reduced form of CoQ10 in the body is decreased due to various causes such as aging, stress, and disease,[24-26] and a decrease in the reduced form of CoQ10 in the body directly results in a decrease in ATP production, which in turn results in an increase in active oxygen in the body and various physical problems. Therefore, a significant improvement in physical complaint at 4 weeks after the start of test food intake in the good intake group in the present study may have resulted from increased ATP production and decreased active oxygen, resulting from increased concentrations of the reduced form of CoQ10 in the body after regular intake of the test food.

Of the other variables, "job satisfaction" in the BJSQ and the UWES-J score also significantly increased after test food intake in the good intake group. Demerouti, et al.[27] reported that physical and mental discomfort was correlated with work engagement, that is, less physical and mental discomfort was associated with increased work engagement. Increased "job satisfaction" and UWES-J score after test food intake in the good intake group in the present study suggested that regular intake of the test food resulted in an improvement in subjective physical and mental discomfort, which in turn resulted in increased work engagement.

Among the objective variables of stress, more specifically among cortisol, VMA, and 8-OHdG, none significantly changed from baseline after test food intake in the good intake group or poor intake group, and none were significantly different between the two groups. In addition, correlation among cortisol, VMA, and 8-OHdG at baseline, and correlation between cortisol, VMA, or 8-OHdG and each stress response in the BJSQ was analyzed, showing no significant correlation between any of the sets of two variables. It is generally known that the sympathetic nervous system and adrenal medulla are activated in response to physical/mental stress on the body to reduce stress and physical/mental fatigue or maintain and enhance mental tension, resulting in an increase in secretion of cortisol as well as urinary excretion of VMA, the end metabolite of catecholamines.[28] In addition, 8-OHdG, which is excreted into urine as a result of oxidative damage to the guanine base of gene DNA caused by active oxygen, is known to increase when the active oxygen concentration increases in response to physical/mental stress on the body.[29] Lack of consistency in these tendencies in the present study may be explained as follows : (1) when the sensitivity of the hypothalamic-pituitary-adrenal axis is not substantially affected, overall change in the hypothalamic-pituitary-adrenal axis cannot be completely explained by the change in cortisol, because the change in cortisol is limited and less detectable compared with that in catecholamines[30] ; (2) VMA and 8-OHdG were analyzed using spot urine in this study, rather than 24-hour urine, which is generally said to provide the highest precision for these analytes that show diurnal variation ; and (3) consumption of phenolic acid-rich foods such as banana, citrus and ice cream, proteins, or cereals, which affect the urinary excretion of VMA, was not restricted in this study. Therefore, we would like to carefully evaluate the relationship between regular intake of the reduced form of CoQ10 and cortisol, VMA, and 8-OHdG under strict measurement conditions in the future.

This study showed that regular intake of the reduced form of CoQ10 may contribute to reduction in workers' job stress. In addition, no adverse events or abnormal findings in the physical examination or blood test that were related to the reduced form of CoQ10 were observed during the study. These results indicate that the reduced form of CoQ10 can be used safely for a long period of time, and its regular intake is expected to reduce physical symptoms due to job stress and thereby enhance work engagement.

However, this study had the following limitations：(1) it was unknown to what degree the concentration of the reduced form of CoQ10 in the body increased after test food intake or whether the concentration of the reduced form of CoQ10 differed between the good intake group and poor intake group, because the blood CoQ10 concentration was not measured；and (2) since it is known that the blood CoQ10 concentration decreases with age, the measurement results may have been affected by age, because the mean age was significantly higher in the good intake group. We would like to carefully address these issues in the future.

CONCLUSION

The efficacy of regular intake of the reduced form of CoQ10 for reducing job stress was evaluated in female nurses based on the subjective and objective variables of stress after 4-week intake of soft capsule containing 100 mg of the reduced form of CoQ10. The results suggest that regular intake of the reduced form of CoQ10 may reduce physical symptoms due to job stress and thereby enhance work engagement. In addition, no adverse events or abnormal findings in the physical examination or blood test were observed during the study, indicating that the reduced form of CoQ10 is a safe and useful food material.

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