Investigation of Stress on Seafarers by Biochemical Inspections and Heart Rate Measurements

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Abstract

It is naturally to be expected that occupational stress on seafarers has specific characters compared to workers engaged in other industries. Because the physical rigors of working and living at sea has been endured as a part of job. The purpose of this paper is to figure out physical changes on seafarers resulted from ordinary shipboard life on the ocean-going cargo vessel. To do this, we performed biochemical inspections testing blood and urine for 28 crews, and measured heart rate of officers engaging in some bridge duties. The tests showed that creatinine, uric acid, total cholesterol, HDL-C, LDL-C of some crews fell down to level which could make a bad impact on human body. And the heart rate of deck officers had vibrated with rather wide amplitude whenever they have got some work-related psychological pressure.

Keywords: physical change, stress, shipboard life, biochemical inspection, blood, urine, heart rate

1. Introduction

A fact that “human factors” have been major causes of numerous marine accidents, was proven by lots of analysis and studies. Among these factors, fatigue and stress have been considered as important things in human error. Specially, the stress can lower physical capabilities and mental wellbeing of crew members and bring about an error in judgment leading to severe marine accidents such as collision, sinking etc. It is naturally to be expected that occupational stress of seafarers has some specific characters compared to worker who are laboring on other industries. Because the physical rigors of working and living at sea has been endured as a part of job.

Usually degree of stress in seafarers depends on lots of personal characteristics such as age, sex, nationality, position in the ship etc. Even though the accurate degree can not easily measured, but original factors and occurrence trend of the stress are needed to find out fundamental root of human error and reduce the marine accidents.

This paper is intended as an investigation of physical changes on seafarers resulted from ordinary shipboard life and performing their duties. To do this, biochemical inspections testing blood and urine were conducted and the heart rate of deck officers on duty was measured to develop a profile of correlation between the stress and the work.

2. Biochemical Inspection

2.1 Blood and Urine Test

Approximately 45 percent of blood is blood corpuscle consisted of blood platelets, red/white blood cells which are responsible for nourishing and cleansing the body. And 55 percent is blood plasma, a straw-colored clean liquid, which carries the solid cells and the blood platelets. The blood is the fluid of health, transporting disease fighting matters to the tissue and waste to the kidneys. The blood tests are one of the most important tools evaluating various body functions of the liver, kidney, hematopoiesis etc. Items of blood tests are classified into three major fields. The blood test items of the number of red/white blood cells, blood platelets, hemoglobin and hematocrit are used to evaluate process and recuperation of illness. And items of serum protein, electrolyte, blood sugar, lipid etc are helpful to make diagnoses of illness. The physiologic test measuring the metabolite such as lactate, ammonia, inorganic phosphate etc, is needed to estimate the fatigue. But the root and analysis of fatigue are very difficult, because it depends on various physical environments and conditions such as strength and method of physical exercise, skeletal muscle etc.

Urinalysis is carried out to acquire necessary information intended for the diagnosis and treatment of infection or illness. And it is one of the very popular tests in health examination. Because metabolite infiltrated into urine shows the health status of whole body.

The blood and urine tests were performed for 28 seafarers, engaging in training ship ‘HANNARA’ of Korea Maritime University, who had served at sea for 40days(May 6, 2005 - Jun 14, 2005). The blood and urine samples were gathered at May 4, 2005 and June 16, 2005. At that time, the seafarers were requested to keep fasting for at least 10 hours. Each 10ml blood sample was collected at vein of below elbow and analyzed by Autohumalysis 900S(EC) model. And the urinalyses were done by Clinitek 100. Items of blood tests were glucose, creatinine, uric acid, urea nitrogen, total cholesterol, HDL-C, LDL-C, triglyceride, total protein, albumin, AST(GOT), ALT(GPT), r-GTP. And the urine test items are bilirubin(BIL), urobilinogen(UBG), ketone body(KET), ascorbi acid(ASC), glucose(GLU), protein(PRP), blood(BLD), specific gravity(S.G) etc.

Analyzed data were processed using SPSS-PC Window 10.0 program and carried out Paired t-test, T-test, One-factor analysis of variance.

2.2 Inspection Result

Table 1 shows the biochemical changes in blood constituents of all seafarers before and after voyage. There are meaningful changes in the items of creatinine, Uric acid, total cholesterol, HDL-C, LDL-C, triglyceride, total protein, albumin.

Table 1 Biochemical Changes in Blood Constituents

Ailment	Test Item	1st M±SD 2nd M±SD	t-test	Normal value
-carbohydrate -glycosuria	Glucose	102.03±14.50 98.21 ± 21.13	0.84	80～120 ㎎/㎗
-renal function -polymyositis -uric acid, gout	Creatinine	0.28 ± 0.02 0.31 ± 0.05	-2.89 **	M 0.8~1.2 ㎎/㎗ F 0.6~0.9 ㎎/㎗
	Uric acid	4.56 ± 1.47 5.79 ± 1.43	-6.49 **	M 3.6~8.1 ㎎/㎗ F 2.4~5.6 ㎎/㎗
	Urea nitrogen	11.76 ± 2.43 11.58 ± 2.57	0.43	M 8~20 ㎎/㎗ F 6~18 ㎎/㎗
-endocrine illness -arteriosclerosis -cardiovascular illness -hyperlipidemia	holeste-rol	180.71 ± 28.85 149.72 ± 34.89	5.63 **	120~220 ㎎/㎗
	HDL-C	48.27 ± 7.01 42.53 ± 6.68	7.25 **	M 37~50 ㎎/㎗ F 44~66 ㎎/㎗
	LDL-C	119.34 ± 32.11 108.86 ± 30.85	2.73 *	M 55~165 ㎎/㎗ F 55~155 ㎎/㎗
	Triglyce-ride	116.46 ± 69.24 153.19 ± 75.94	-3.72 **	70~170 ㎎/㎗
-protein malnutrition -enzyme	Total protein	7.90 ± 0.53 7.54 ± 0.66	4.34 **	6.8~8.5g/㎗
	Albumin	4.98 ± 0.38 4.63 ± 0.40	7.59 **	4.09~5.5g/㎗
-hepatocellular injury -heart disease -liver function -kidney disease	AST (GOT)	28.75 ± 7.73 29.84 ± 8.13	-0.83	8~40
	ALT (GPT)	29.41 ± 19.39 25.69 ± 14.57	1.49	5~35
	r-GTP	40.24 ± 20.96 42.14 ± 21.98	-1.05	M 7~40 IU/L F 4~25 IU/L

* : P<.05 ** : P<.01 1st : before voyage 2nd : after voyage

Table 2 shows the blood constituents changes according to officers and sailors. Only the Urea nitrogen item has a meaningful change in the level.

Table 2 Blood Analysis According to Officers and Sailor

Test Items	Before voyage			After voyage		
	officers n=11	sailors n=17	t-test	Officers n=11	sailors n=17	t-test
Glucose	98.37 (14.42)	104.41 (14.48)	-1.08	96.74 (26.55)	99.16 (17.62)	-0.29
Creatinine	0.28 (0.02)	0.28 (0.02)	0.72	0.29 (0.02)	0.32 (0.06)	-1.21
Uric acid	5.13 (1.83)	4.20 (1.09)	1.71	6.30 (1.59)	5.46 (1.25)	1.57
Urea nitrogen	10.81 (2.25)	12.37 (2.41)	-1.72	10.30 (2.32)	12.41 (2.43)	-2.29 *
chole-sterol	178.12 (34.64)	182.39 (25.43)	-0.38	141.39 (39.44)	155.11 (31.67)	-1.02
HDL-C	47.01 (8.93)	49.10 (5.60)	-0.77	40.20 (7.14)	44.04 (6.10)	-1.52
LDL-C	116.54 (37.38)	121.14 (29.29)	-0.36	108.99 (31.92)	108.78 (31.13)	0.02
Tri-glyceride	115.72 (74.64)	116.94 (67.87)	-0.04	139.83 (76.01)	161.83 (76.93)	-0.74
Total protein	8.03 (0.36)	7.82 (0.60)	1.06	7.70 (0.38)	7.44 (0.79)	1.03
Albumin	5.06 (0.36)	4.92 (0.39)	0.91	4.72 (0.29)	4.56 (0.45)	1.00
AST (GOT)	26.96 (9.95)	29.91 (5.95)	-0.98	28.17 (10.46)	30.92 (6.34)	-0.87
ALT (GPT)	29.05 (25.59)	29.64 (14.99)	-0.08	25.41 (20.11)	25.88 (10.25)	-0.08
r-GTP	38.37 (29.40)	41.46 (14.05)	-0.37	36.43 (22.99)	45.84 (21.17)	-1.11

* : P<.05

Table 3 Result of Biochemical Inspection According to Ship's Three Departments

Test Items	Before voyage				After voyage			
	Deck Dep. n=12	Engine Dep. n=10	Culinary Dep. n=6	F-test	Deck Dep. n=12	Engine Dep. n=10	Culinary n=6	F-test
Glucose	98.12 (10.69)	104.89 (16.95)	105.11 (17.38)	0.75	92.95 (18.81)	108.08 (17.27)	103.94 (31.18)	0.67
Creatinine	0.28 (0.02)	0.28 (0.03)	0.27 (0.01)	0.39	0.31 (0.07)	0.31 (0.03)	0.29 (0.02)	0.31
Uric Acid	3.89 (0.64)	4.91 (1.21)	5.32 (2.47)	2.56	5.47 (1.08)	6.02 (1.24)	6.04 (2.29)	0.50
Urea Nitrogen	10.93 (1.78)	12.83 (3.04)	11.63 (2.07)	1.78	10.98 (1.50)	12.44 (3.45)	11.36 (2.62)	0.91
Chole-sterol	178.9 (26.53)	183.93 (39.44)	178.98 (10.62)	0.09	152.06 (27.11)	151.56 (47.36)	141.99 (28.81)	0.18
HDL-C	46.88 (5.84)	50.14 (9.41)	47.96 (4.42)	0.58	41.24 (5.82)	44.80 (8.41)	41.34 (4.77)	0.89
LDL-C	115.13 (32.42)	125.07 (39.45)	118.19 (18.56)	0.25	106.75 (27.58)	116.86 (33.92)	99.76 (33.99)	0.61
Trigly-ceride	113.58 (60.07)	136.41 (86.94)	88.98 (51.18)	0.89	36.17 (55.89)	184.80 (88.47)	134.55 (84.08)	1.39
Total Protein	7.95 (0.34)	7.99 (0.45)	7.66 (0.89)	0.85	7.83 (0.39)	7.46 (0.49)	7.11 (1.07)	**2.93 ***
Albumin	5.02 (0.41)	5.14 (0.36)	4.59 (0.49)	**5.63 ***	4.79 (0.22)	4.65 (0.32)	4.25 (0.58)	**4.70 ***
AST (GOT)	27.53 (7.82)	29.80 (8.89)	29.45 (6.29)	0.25	27.87 (8.22)	32.12 (9.82)	29.99 (3.91)	0.73
ALT (GPT)	32.02 (17.55)	31.31 (25.93)	21.02 (5.86)	0.70	24.91 (11.69)	31.42 (19.36)	17.71 (5.17)	1.79
r-GTP	33.81 (11.27)	49.01 (30.81)	38.49 (11.31)	1.52	35.31 (17.36)	51.39 (28.92)	40.41 (12.40)	1.54

* : P<.05

Table 4 Blood Analysis According to Age

Test Items	Under 30s(n=10)		40s(n=15)		Over 50s(n=3)	
	1st M±SD 2nd M±SD	t-test	1st M±SD 2nd M±SD	t-test	1st M±SD 2nd M±SD	t-test
Glucose	96.05(11.57) 91.05(20.38)	0.76	104.91(15.9) 104.33(21.5)	0.08	107.59(13.3) 91.44(17.8)	1.26
Creatinine	0.28(0.03) 0.29(0.02)	-1.22	0.27(0.02) 0.32(0.06)	-2.66 *	0.28(0.02) 0.29(0.02)	-0.46
Uric acid	4.71(1.16) 5.99(1.22)	-3.10 *	4.41(1.78) 5.61(1.66)	-5.19 **	4.83(0.79) 5.98(1.06)	-6.14 *
Urea nitrogen	11.41(2.75) 10.51(2.44)	1.21	12.04(2.38) 12.09(2.48)	-0.10	11.53(2.16) 12.64(3.15)	-0.74
chole-sterol	181.12(41.1) 153.52(40.4)	8.07 **	180.49(22.6) 154.11(27.5)	3.78 **	180.48(5.54) 148.47(28.3)	2.12
HDL-C	47.43(10.27) 40.97(8.50)	6.68 **	48.83(5.11) 43.13(5.81)	4.52 **	48.32(0.83) 44.71(4.32)	1.43
LDL-C	119.57(44.9) 110.48(37.3)	1.90	120.47(26.0) 110.06(29.1)	1.67	112.91(2.43) 97.46(21.28)	1.30
Tri-glyceride	119.07(80.2) 150.64(84.1)	-3.96 **	119.12(70.1) 146.88(71.3)	-1.89	94.47(22.94) 193.25(87.8)	-2.45
Total protein	8.08(0.42) 7.73(0.42)	2.79 *	7.78(0.60) 7.42(0.81)	2.73 *	7.92(0.37) 7.53(0.49)	3.00
Albumin	5.13(0.36) 4.71(0.28)	4.89 **	4.91(0.40) 4.61(0.48)	4.96 **	4.78(0.15) 4.39(0.23)	2.95
AST (GOT)	26.56(10.27) 29.54(11.44)	-1.75	30.81(5.85) 29.97(6.58)	0.41	25.75(4.88) 30.18(0.70)	-1.76

ALT (GPT)	29.20(26.82) 27.67(21.19)	0.48	30.68(15.79) 25.15(10.37)	1.34	23.70(5.66) 21.79(6.72)	0.50
r-GTP	40.93(32.19) 41.67(29.01)	-0.20	38.30(12.50) 39.09(17.08)	-0.38	47.64(8.04) 58.99(14.0)	-3.21

* : P<.05 ** : P<.01

Table 3 represents the analyzed results of biochemical changes of seafarers of deck, engine and culinary departments. The total protein and albumin only made some meaningful changes. And table 4 shows the analyzed results according to age. The blood constituents having meaningful biochemical changes were creatinine at 40s, total cholesterol and HDL-C below 30s and 40s, triglyceride below 30s, Total protein and albumin below 30s and 40s, uric acid at all age.

Table 5 Analysis Result of Urine

Reaction	Biliru-bin	Urobili-nogen	ketone body	Ascorbi Acd	Gluco-se	Protein	Blood	Leuk ocyte
1st positive	2	8	3	7	1	9	0	14
2nd positive	1	15	2	4	1	12	1	25
1st, 2nd positive	0	7	0	0	1	5	1	14

Table 5 represents the number of seafarers showing a positive reaction in the urine tests. The positive reaction on the urobilinogen which is used to make a diagnosis of hepatocellular function has occurred in 8 crews before the voyage and 15 crews after the voyage. 7 crews showed the positive reaction on it before and after the voyage. And the positive reaction on the protein indicating the status of the kidney function has occurred in 9 crews before the voyage and 12 crews after voyage. 5 crews showed the positive reaction on the protein in every test.

2.3 Analysis of Blood Test

The blood glucose is used to detect both hyperglycemia and hypoglycemia and to confirm a diagnosis of diabetes. Generally 80-120㎎/㎗ is normal level of the blood glucose. Epinephrine which is secreted by adrenal medulla has a role of increasing the blood glucose and of phosphorylation at liver and muscle. And adrenal cortex promotes the secretion of protease which let the liver produce new glucose. Adrenocorticotropic hormone increases the blood glucose indirectly, because it stimulates the adrenal gland to secrete glucocorticoid to body. Thyroid hormone promotes absorption of glucose at bowel. In this inspection, the mean value of blood glucose was decreased 102.03㎎/㎗ to 98.21㎎/㎗ after the voyage. But they had no meaningful changes, because they are within the limits of normal values. And also the analyses of blood glucose according to the ship's departments and age had no remarkable differences between two tests. But the measured glucose values on several seafarers were increased. Therefore it is considered that they had better take precise inspections for diabete mellitus.

The non-protein nitrogen constituents such as creatinine, uric acid, blood urea nitrogen are used to figure out the diseases of the kidney(Lee et al, 2001). The creatinine and uric acid had been increased 0.0.3㎎/㎗ and 1.23㎎/㎗ after the voyage. The creatinine on the 40s recorded the highest value and the trend of increasing of uric acid was revealed in all age. Even though the urea nitrogen was no meaningful change between the tests, the officer's value was decreased and the sailor's value was increased. It was considered that the shipboard life causing depression of the kidney and drinking of liquor had shown up the results of increasing urea nitrogen on sailors and uric acid on all crews. Usually the depression of the kidney brings up the malfunction or overload in filtration operation of the body. Furthermore the stress could make the depression grow worse and increase serum uric acid in the body. Therefore a new program or method which could relieve seafarer's stress should have developed.

The blood test on cholesterol, HDL-C, LDL-C and triglyceride are used to find out the disease of arteriosclerosis, cardiovascular system, endocrine system. The cholesterol is a soft and waxy substance found among the lipids in the bloodstream and in all body's cells. And also it's an important part of a healthy body because it forms cell membranes, some hormones and is needed for other functions. It can not dissolve in the blood directly but have to be transported by special carriers called lipoproteins. Usually cholesterol is taken by two ways. One is self production method which the mainly liver produces about 1,000milligrams a day. The other is to obtain from food(Hyun, 1990). A opinion that aerobic exercise can not make any meaningful change in the total cholesterol without weight loss, is reported(Dudlesteon & Bennion, 1970). On the other hand, there was a contrary opinion that the aerobic exercise could reduce the total cholesterol without weight loss(Kannel et al., 1979). But nowadays the most studies have insisted that regular aerobic exercise could fall the quantity of total cholesterol in blood.

Among the lipoproteins LDL(low-density lipoprotein) is a major carrier of cholesterol in blood and very important clinic factor at arteriosclerosis. And HDL(high-density lipoprotein) carrying about one-third to one-fourth of blood cholesterol, is known to remove excess cholesterol from plaques and thus slow their growth. Therefore the low HDL level is one of the important factor developing arteriosclerosis, hyperlipidemia, obesity, diabete mellitus, hepatism etc. The HDL level can be raised through the adequate exercise(Jin et al., 1998).

If excess energy intake occurs over a more prolonged period, most of the surplus is stored in the body as fat. This fat is dissolved into blood as free fatty acid(FFA) which is used for physical activity. And fatty acid used for muscular activity, is produced by the hydrolysis of eater linkages in various kind of triglycerides such as triglyceride in muscle-cell, triglyceride dissolved in tissue, lipoprotein triglyceride in blood etc. The high blood triglyceride level can cause the atherosclerosis, peripheral vascular disease. The reduction effect of blood triglyceride with a prolonged aerobic exercise, is occurred by harmonized metabolic regulation associated with holdback of oxidative enzyme activity in mitochondria and high myoglobin level(Lehtonean & Viikari, 1978). Even though the blood triglyceride level is associated with dietary and lifestyle such as smoking, drinking of alcohol etc, only regular exercise can decrease 16-19% blood triglyceride with the weight loss(Tompson et al., 1980).

In the blood tests according to hyperlipidemia, the mean levels of TC(total cholesterol), HDL-C, LDL-C were meaningfully reduced after the voyage, but triglyceride level was increased. And there were no meaningful changes in the TC, HDL-C, LDL-C, TG analysis according to the ship's position and departments. But the triglyceride and HDL-C levels were decreased meaningfully at the 30s and 40s, the triglyceride level has increased at the 30s. Especially the 30s several seafarers were considered to suffer from hyperlipidemia(Park et al, 1997). As it turned out, the fact that the TC, HDL-C, LDL-C were decreased and the triglyceride was increased after the voyage, has been considered which all seafarers had been under stress and insufficient exercise, ingested high fat diet during the voyage.

Protein, albumin, GOT(Glutamic Oxalaceti Transaminase), GPT(Glutamic Pyruvate Transaminase), r-GTP(gamma-Gluanosine Triphosphate) are used to make a diagnosis of liver function(Lee et al.,2001). A serum protein has a lot of important

roles which are the transportation of insolubility substances, billirubin, lipid, vitamin, hormones, carbon dioxide and balancing of serum osmotic pressure, blood pH etc(Rho, 1996). The total serum protein and albumin were decreased 0.36g/dℓ and 0.35g/dℓ after the voyage. And there was no statistically significant change between the officer and sailor groups.

The albumin tests on seafarers of culinary department have showed the lower level than deck and engine department before and after the voyage. And the total serum protein and albumin of the 30s and 40s were measured at the lowest level. Usually the albumin can be found in milk, meat, soybean, white egg etc. Therefore these results on blood albumin have indicated that the seafarers could not take enough food including albumin. In the tests on liver function, most seafarers were surveyed to be with the normal condition. But then a few crews should have been inspected with great exactitude, because the measured levels soared after the voyage.

2.4 Analysis of Urinalysis

Urinalysis is very useful inspections which can reveal diseases developing without striking signs or symptoms. Often, substances such as protein or glucose will begin to appear in the urine before patients are aware that they may have a problem. A cloudy urine or hematuria means that a malfunction and disease have been developing in kidney, ureter, urinary bladder, urethra etc. And also the screening urine tests are helpful to make a diagnosis of whole body, because metabolite of whole body is wasted into the urine.

The first part of a urinalysis is physical inspection such as a direct visual observation, trubidimery etc. The second method is chemical analysis using a paper or plastic dipstick which is the most cost-effective device. The items of the urine dipstick test are bilirubin, urobilinogen, ketone body, ascorbic acid, glucose, protein, pH etc(Choo et al., 2001). In this study, the chemical analysis using the dipstick were carried out.

As a urinalysis, before the voyage 9 crews reacted as positive for urine protein associated with kidney function. After the voyage 12 crews reacted and 5 crews reacted in both tests positively. Normal urine includes a little of protein. But the urine protein is increased in the case of urinary tract disorder. Of course, there are so many reasons to increase the protein in urine. Hyperthermia, strenuous exercise, exposure to severe cold will be causes of the temporary phenomenon. So the positive reaction for urine protein would not indicate that they had a disease or disorder in kidney. But they had better take accurate examination.

And before the voyage 8 crews reacted as positive for urobilinogen associated with hepatocellular function. But then 15 crews reacted after the voyage, and 7 crews reacted in both tests. The urobilinogen decreases by obturation of bile duct and increases with hemolytic anemia having a lot of the bile. In general, hemolytic jaundice and neonatal jaundice are reacted positive in urine urobilinogen test and negative in bilirubin test. But the jaundice associated with hepatitis, liver cirrhosis, hepatoma, is reacted positive in both urobilinogen and bilirubin tests. Therefore, it seems reasonable to conclude that shipboard life could make a bad impact on liver functions, and seafarers are demanded to take some precaution activities such as stop drinking and adequate physical exercise.

3. Heart Rate and Work-related Stress

Most people are under some stress in the workplace. Usually some stress originated from external pressure can be a positive factor, helping us to be more productive. However, excessive and prolonged stress can produce physical and emotional health problems. There is no single cause of work-related stress. Many causes such as concentration and responsibilities on performance of duties etc, are associated with the work-related stress. And also the stress can be differentiated by the personal characteristics and environmental factors. For these reasons, stress measurement questionnaires are universally chose to figure out the psychological level of stress. But in this study, we have measured the heart rate of seafarers to reveal an aspect or correlation between the duties and psychological stress. The measurements have been conducted in real time when the vessel have entered into or departed from ports. At the experiments, master and third officer were selected. The master had been going to sea for about 20 years and the third officer about 2 years.

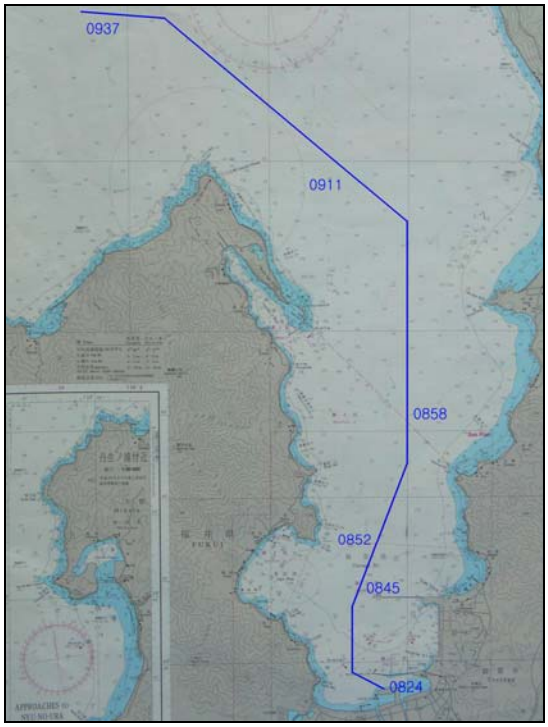

Figure 1 Ship's track of departure from TSURUGA

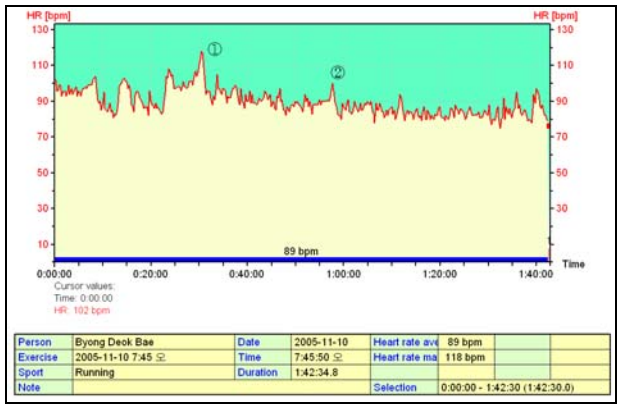

Figure 2 Measured heart rate of master

Figure 1 shows the ship's departure track at harbor of Tsuruga, Japan. It was approximately redrawn on the basis of accurate information from bell book, course recorder, engine telegraph log, fixed position and time on chart. Figure 2 indicates the changes of master's heart rate. The data had been collected for about 100 minutes, from 07:45 LST(local standard time) to

09:25 LST. The maximum heart rate was measured as 118 bpm(beats per minute) at 08:15 LST(Figure 1-①). The master's heart rate has jumped up and down rather severely for about 40 minutes, from 07:45 LST to 08:25 LST. During this time, the master had endeavored to make a safe unberthing and navigation under the psychological tension. And also the heart rate had increased to about 100bpm at the point of Figure 1-② when the vessel had passed outer breakwater. Then the heart rate has stabilized to about 80 bpm by 09:15 LST.

Figure 3 Ship's track of departure from MANILA

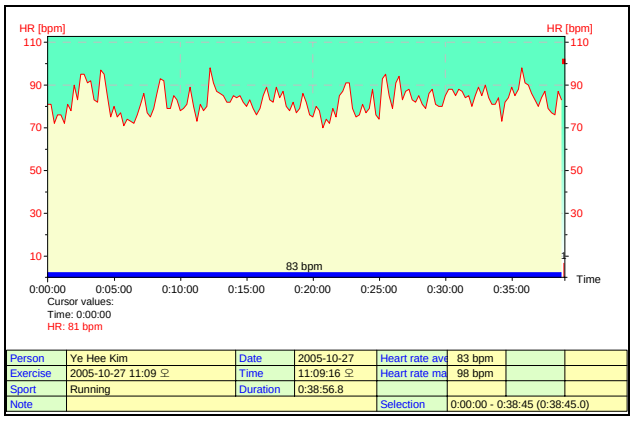

Figure 4 Measured heart rate of third officer

Figure 3 shows the ship's departure track at harbor of Manila, the Philippines. Measured heart rate of third officer appears in Figure 4. The heart rate had been measured for about 40 minutes, from 10:09 LST(ZD -8) to 10:49 LST. Mean heart rate was 83 bpm and the maximum 98 bpm. As the figure indicates, the heart rate of third officer has recorded rather abrupt changes within a range of 30 bpm through the measurement. It is estimated that these changes were caused from performing various duties following the captain's orders, assisting in the navigation of the vessel, operating many bridge equipments such as radar, engine telegraph under the psychological pressure.

When resting, the adult human heart beats at about 70 bpm(males) and 75 bpm(females). Considering one mistake or error of deck officers in navigation can lead to huge marine accidents, casualties and economic loss, it is natural that officers shall perform their duties under excessive psychological pressure when the vessel navigates on the coast or entering/leaving ports, the area having heavy traffic, narrow channel etc. As a result, the work-related psychological stress causes the heart rate to increase above the resting rate. Of course, the high heart rate is not any sign of illness or abnormal condition of the body. But it is considered that the stress can lose the seafarer's health with other factors such as irregular sleep and eating, personal characteristics etc.

4. Conclusion

The biochemical inspections and measurement of heart rate on seafarers were carried out to confirm what kind of changes had been arisen from shipboard life and their duties.

In the blood tests, there were meaningful changes of the creatinine, uric acid, urea nitrogen on seafarers after the voyage. These changes would be liable to depression of kidney which was considered to be caused from the shipboard life and brought up the malfunction or overload in filtration operation of the body. And also the mean levels of TC, HDL-C, LDL-C were reduced and triglyceride increased after the voyage. These results were considered that all seafarers had been kept the shipboard life under some stress and insufficient exercise, ingested high fat diet during the voyage. In the urine tests, the number of crews has increased who had reacted as positive for urine protein and urobilonogen associated with kidney and hepatocellular. Even though the positive reactions are not any definite signs of disease or disorder in function of body, the accurate examinations should be done. And the results of heart rate measurement have revealed that seafarers have strong possibility of performing their duties under the psychological stress.

These results lead us to the conclusion that prolonged shipboard life and work-related psychological stress could lead to a bad impact on seafarer's health as well as reduction of competence for the job. Therefore, it seems necessary for seafarers to take some precaution activities such as stop drinking and adequate physical exercise etc. And also a new program or endeavor which could relieve seafarer's stress is needed to be developed in the near future.

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