

# Influence of Sudden Rise on Cortisol and Human Symptom in the Situation of Rescue at River

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## Article Info

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## Abstract:

This study was to analyze the effects of sudden rise on cortisol and human symptoms in the situation of rescue at river. The experimental results are as follows. The subjects were A, B and C and the values of cortisol elevation before and after diving were 6.30 ug/dl, 6.50ug/dland 6.57 ug/dl respectively. However, in the subject D, the elevation value of cortisol before and after diving was significantly elevated by 11.00 ug/dl. The reasons for this are thought to be the increased anxiety due to the inferiority of the underwater view and the depletion of physical strength through the tension during the sudden rise. The subject E showed significantly lower cortisol elevation before and after diving, as 4.28 ug/dl, because the age of E was the youngest of the subjects and the anxiety was low due to abundant experience of deep sea diving.

Fatigue is 7 to 8 and anxiety is 7 to 9. Both showed high values. Psychological strain increased fatigue in underwater search and poor visual field seemed to increase anxiety. The common symptoms of the subjects were dizziness. This is considered to be due to the fact that a small amount of nitrogen bubbles is generated due to the sudden pressure difference during the sudden rise, which causes the human body to be stressed, thereby influencing the increase of the cortisol concentration. If you have not only dizziness but also vomiting, you may be suffering from decompression sickness symptoms. The results of the study will be provided as empirical data on safe underwater search activities of rescuers.

## Article History

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## I. Introduction

According to Article 7 of the "Act on Search and Rescue on the Water," the fire commissioner of the National Fire Agency, the Director of the National 119 Rescue Headquarters and the fire chiefs are responsible for organizing and operating rescue teams to rescue people on the surface of inland waters and organizing and operating emergency medical services to provide first aid to emergency patients experiencing accidents arising on the surface of inland waters or urgently transfer them to medical institutions. The "surface of inland waters" means the water current or water surface of rivers, dams, lakes, marshes, reservoirs and other

artificially created fresh water or brackish water in accordance with Subparagraph 7 of Article 2 of the Water-related Leisure Activities Safety Act. Pursuant to this, rescue work on the surface of inland waters is carried out by fire chiefs [1]. There are rescue teams organized in the area of the surface of inland waters such as the Han River. They work with a full-time service system in preparation for water accidents. When a person drowns, falls, is isolated or drifts on the surface of inland waters, the life and the safety of the person are in danger. Especially, if there is a drowning person, a rescue team dives underwater, searching and exploring the area to rescue the person. When

a rescuer sees a person drowning or if it is not long after the person starts drowning, the rescuer descends rapidly to the water. The rescuer often rises suddenly to the surface of the water after finding the person. Rescuers breathe naturally and observing the rising speed of 9 m/min, as per the Korea Occupational Safety and Health Agency (KOSHA) Guide for Diving Operations. However, there are times when it is difficult for them to keep the rising speed at underwater accident sites due to the urgent situation of rescuing people. However, there are times when it is difficult for them to keep the rising speed at underwater accident sites due to the urgent situation of rescuing people. Rescuers can also be exposed to decompression sickness due to inadequate absorption, accumulation and release of nitrogen gas when rising suddenly to the surface of the water [2].

There has been no previous research in Korea on the sudden rise while rescuing people on the surface of inland waters. However, studies such as Pak Heon (2016) and Jo SeongJin (2017) show that the sudden rise to the surface of seawater causes a risk of decompression sickness [3][4]. Especially, findings of a study show that symptoms of decompression sickness occur even at an average depth of 10m or less [5]. In addition, there is an experiment to measure the change in cortisol after rising to the surface of the water at 20m depth while thoroughly keeping the rising speed of 9 m/min and performing safe decompression at 5m underwater. In this experiment, the rate of change of cortisol was 17.50 ug/dl before diving and 18.24 ug/dl after diving, which is insignificant [6]. However, there is no study on the rate of change in cortisol caused by the sudden rise of rescuers who perform underwater search activities with a short range of the underwater visual field on the surface of inland waters such as the Han River.

Hereupon, the purpose of this study is to analyze the change in cortisol and symptoms of the human body before and after the sudden rise.

## II. Cortisol and Human Symptoms

Two neuroendocrine systems have been noted in stress studies. One of them is the sympathetic nervous system, adrenal medulla, which is involved in secretion of epinephrine and norepinephrine. The other one is the hypothalamus-pituitary-adrenal (HPA) axis, which is involved in the secretion of cortisol. Endocrine responses to stress can be assessed by measuring hormone levels secreted through the blood or urine [7].

Cortisol has been reported to be elevated in response to negative emotions and usual stressful events (Brantley et al, 1988: Van Eck et al, 1996). It is known that negative emotions and everyday events as well as physical and mental stress related to work affect cortisol secretion. Acute stress and cortisol responses can actually activate the HPA axis (hypothalamic-pituitary-adrenal axis) due to physical and psychological stress factors such as electric shock. Severe traumatic experiences such as injury and severe or prolonged stressful conditions cause cortisol elevation [8]. Cortisol elevation is caused by a variety of conditions such as tension, fear and pain.

The characteristics of fatigue are identified as being tired, burdened, strained, exhausted, lethargic and unbalanced. Fatigue is an individual subjective feeling. Various kinds of internal and external physical and mental fatigue increase the burden and decrease efficiency in all kinds of work. Fatigue is usually experienced in the condition of energy imbalance [9].

Anxiety is a negative emotional state with restlessness, worry or fear associated with the activation or awakening of the body [10].

Dizziness is a subjective symptom of an equilibrium disorder accompanied by the sensation of spinning, not moving and complete darkness. Objective measurement of dizziness is difficult because these sensations are concurrent [11].

## III. Composition of Experiment of the Sudden Rise

### 3.1 Selection of Subjects and Blood Analysis

The subjects of this study were five male rescuers who were working as fire department rescuers with physical health and underwater rescue experience considering human dangers. They were rescuers who had served in the Military Special Forces sorted out for this study. They were selected after having in-depth interviews and giving their consent to

participate in this study. The participants consisted of 4 rescuers who had served in the special force and 1 rescuer who had served in the Underwater Demolition Team with abundant deep sea diving experience. The specific selection criteria were rescuers who were mentally robust, had underwater search experience more than 100 times. They were selected as the subjects since they have qualified as lifeguards, craftsman divers and emergency medical technicians with excellent underwater search skills. Obese rescuers were excluded by using BMI (body mass index, kg/m<sup>2</sup>) which is one of obesity indexes. Since there was a change in psychological stability when diving underwater depending on presence or absence of a buddy diving together, the underwater search principle of the buddy system was kept.

Medically, underwater search is an exercise that is allowed to do when rescuers' cardiovascular and circulatory systems are healthy. Especially, patients with lung, heart, brain, endocrine diseases, diabetes, asthma and seizures are forbidden to do underwater search. Therefore, their health conditions were checked by testing their blood pressure, pulse, respiration, body temperature and blood sugar and measuring their height and weight as shown in Table 1. The subjects were 47.4 years old on average. They had diving experience with average 220 diving operations. Their average height and weight were 176 cm and 71.60 kg respectively.

Table 1. Characteristics of Subjects

Subject	Sex	Age	H eight (cm)	Weight (kg)	Rescue (Year )	Diving (Times)	Blood Pressure (120 mmHg/80mmHg)	Pulse (60~80 times/min)	Breathing (12 ~ 20 times/min)	Body Temperature (36.5°C)	Blood Sugar (110 mg/dl)	Health Condition
A	Male	56	175	68	20	400	120/80	60	12	37	99	Normal
B	Male	51	177	72	15	300	115/80	62	12	36.5	95	Normal
C	Male	48	178	73	10	200	120/80	63	14	36.7	90	Normal
D	Male	47	180	80	7	100	125/85	61	13	36.5	92	Normal
E	Male	35	170	65	3	100	120/80	65	12	37	91	Normal
<b>Average</b>	<b>Male</b>	<b>47.40</b>	<b>176</b>	<b>71.60</b>	<b>11</b>	<b>220</b>	<b>120.00</b>	<b>62.20</b>	<b>12.60</b>	<b>36.74</b>	<b>93.40</b>	<b>Normal</b>

In order to prevent the coagulation of blood samples collected for the stress hormone cortisol test, a heparin-added bottle was used and a paramedic with a nurse qualification collected 3 cc of blood from the vein in their upper limbs using disposable syringes twice before and after the experiment. The blood was being refrigerated to prevent air contact before it was sent to the ○○ Medical Foundation which was certified by the College of American Pathologists (CAP). The rate of change in cortisol was analyzed by requesting the ○○ Medical Foundation to do the blood test.

### 3.2 Conditions of Experiment

The experiment was conducted on March 20, 2019 in order to maintain the appropriate average temperature among the four seasons considering the safety of the subjects.

The environment of the experiment is as shown in Table 2. The experiment was conducted where the

water depth was 5m in the Han River, Korea. The equipment used in the experiment was one that was commonly used by Korean rescuers. The equipment compresses air with high pressure. The compressed air is stored in a cylinder. The regulator changes compressed air into air under ambient pressure. Rescuers breathe this air. Buoyancy regulators were used for buoyancy control. Air pressure gages, depth gages, compasses and fins were also used. The person in need of rescuing was replaced by a 25 kg mannequin, which is used mainly by Korean rescuers. The subjects wore dry suits with the lining to keep warm. Their body temperature was maintained by wearing underwater gloves and hoods. The weather was cloudy with the air temperature of 10 °C, the water temperature of 12 °C, the wind speed of 3 ~ 5 m and the swell of 0.2 ~ 0.3 m. The underwater flow velocity was 0.8 m/s and the visual field was poor as it was 0.3 m.

Table 2. Environment of Experiment

Classification	Description
Place	Han River (Korea)
Weather	Cloudy
Air Temperature	10 °C
Water Temperature	12 °C
Flow Rate	0.8 m/s
Swell	0.2 ~ 0.3 m
Underwater Visual Field	0.3 m

#### IV. Results and Discussions

##### 4.1 Rate of Change in Cortisol Before and After Underwater Search

It was confirmed through questionnaire that the water depth which the Han River rescuers frequently mobilized at was about 5 m. As the result of checking the speed of a sudden rise of the subjects with a person in need of rescuing in an emergency situation, it took the subjects about 6 seconds to rise from the water depth of 5 m to the water surface. Converting it to minutes, the sudden rise was defined as the rise at the speed of 50 m/min.

However, it is difficult for teenagers to survive if they drown for more than 20 minutes except for some exceptional cases [12]. Therefore, this study is intended to check the change in cortisol after an underwater search for 20 minutes at the depth of 5 m followed by a sudden rise with a person in need of rescuing and analyze symptoms of the human body. Blood samples were collected before and after underwater diving to measure the change in cortisol.

Table 3 shows the change in cortisol under the experimental conditions. The average concentration of cortisol before diving was 10.17 ug/dl and it was elevated to 16.94 ug/dl after diving, showing a significant difference.

Cortisol of the subject A was 12.10 ug/dl before diving but it was elevated to 18.40 ug/dl after the sudden rise to the water surface. Cortisol of the subject B was elevated by 6.50 ug/dl. It was 12.00 ug/dl before diving. However, it was elevated to 18.50 ug/dl after the sudden rise. Cortisol of the subject C was also elevated from 6.63 ug/dl before diving to 13.20 ug/dl after the sudden rise. The subjects showed a similar rate of cortisol elevation respectively. However, cortisol of the subject D was elevated by 10.20 ug/dl from 11.00 ug/dl to 21.20 ug/dl, which was significantly higher. The reason for this is considered to be because the anxiety of the subject D arising from the poor underwater visual field was higher than the other participants and because he got nervous during the sudden rise to the water surface, thus leading to the exhaustion of physical strength, which influenced the rise of cortisol. Different from the subject D, the subject E showed a low rate of cortisol elevation of 4.28 ug/dl as it was elevated from 9.9 ug/dl before diving to 13.40 ug/dl after the sudden rise. It is considered to mean that the sudden rise was less stressful to the subject E because he experienced less anxiety as he was 35 years old and the youngest of the subjects and his experience of deep sea diving at the time of his military service was abundant.

Table 3. Change in Cortisol

Subject of Experiment	Underwater Depth(m)	Rising Speed(m/min)	Before Diving(ug/dl)	After Diving(ug/dl)	Elevated Value(ug/dl)
A	5	50	12.10	18.40	6.30
B	5	50	12.00	18.50	6.50

C	5	50	6.63	13.20	6.57
D	5	50	11.00	21.20	10.20
E	5	50	9.12	13.40	4.28
Average	5	50	10.17	16.94	6.77

#### 4.2 Symptoms Occurring to the Human Body after the Sudden Rise

Table 4 shows symptoms occurring to the human body due to the sudden rise. The degree of fatigue and psychological anxiety was classified into a scale from 1 to 10 respectively. As a result of checking the degree of fatigue that subjects felt after defining a 1 as not at all fatigued and a 10 as very fatigued, the subjects gave answers between 7 and 8. In terms of the anxiety, they gave answers with an average of 8. These results suggest that their psychological tension due to the sudden rise increased the degree of fatigue and the poor visual field increased their anxiety.

Table 4. Symptoms of the Human Body Due to the Sudden Rise

Subject of Experiment	Fatigue(1~10)	Anxiety(1~10)	Symptom
A	7	7	Dizziness
B	8	8	Dizziness
C	7	8	Dizziness
D	7	9	Dizziness
E	8	8	Dizziness
Average	7.4	8	-

#### V. Conclusions

The scope of this study was limited to the underwater search among the water accidents on the surface of inland waters in Korea. The change in cortisol before and after the sudden rise from 5 m underwater at the speed of 50 m/min was analyzed. The experimental results are as follows.

- (1) The subjects were A, B and C and the values of cortisol elevation before and after diving were 6.30 ug/dl, 6.50 ug/dl and 6.57 ug/dl respectively.
- (2) In the subject D, the elevation value of cortisol before and after diving was significantly elevated by 11.00 ug/dl. The reasons for this are thought to be the increased anxiety due to the inferiority of the underwater view and the depletion of physical strength through the tension during the sudden rise.

In addition, human symptoms of the subjects were observed after the sudden rise. All subjects from the subject A to E had dizziness in common. This is thought to be because some bubbles were generated due to the sudden pressure difference during the sudden rise, which affected the human body. The sudden rise to the surface of water from 5 m underwater can cause vomiting as well as dizziness if it is repeated without sufficient resting. As a result, it is considered that the sudden rise to the surface of the water together with the psychological anxiety resulting from it caused the elevation of cortisol.

- (3) The subject E showed significantly lower cortisol elevation before and after diving, as 4.28 ug/dl. It is because the age of E was the youngest of the subjects and the anxiety was low due to abundant experience of deep sea diving.

In addition, the results of analyzing human symptoms due to the sudden rise are as follows.

- (1) Fatigue is 7 to 8 and anxiety is 7 to 9. Both showed high values. Psychological strain increased fatigue in underwater search and poor visual field seemed to increase anxiety.
- (2) The common symptoms of the subjects were dizziness. This is considered to be due to the fact that a small amount of nitrogen bubbles is generated due to the sudden pressure difference during the sudden rise, which causes the human body to be stressed, thereby influencing the increase of the cortisol concentration. If you have not only

dizziness but also vomiting, you may be suffering from decompression sickness symptoms [13].

In terms of the future research tasks, it is necessary to survey rescuers who work on the surface of inland waters to see the current situation and present the improvement plan.

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