건식 사우나와 저온욕 후 혈중 호르몬 및 면역반응에 미치는 영향

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Effects of blood hormone and immune response after the dry sauna and the cold water bath

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요약

이 연구는 수영선수와 비수영선수(일반대학생)을 대상으로 건식 사우나와 저온의 물에 노출을 시킨 후 인체의 호르몬과 면역세포 반응에 어떠한 차이가 있는지를 규명하는데 있다. 연구결과, 혈장 레닌과 안지오텐신Ⅱ 호르몬 농도는 사우나 노출 후 안정시에 비해 통계적으로 유의하게 증가하였고, 저온노출 후에는 사우나 후와 비교하여 통계적으로 유의하게 감소하였다. 그러나 코티졸 호르몬은 두 환경모두에서 변화가 없었다. 휴식시의 경우에 일반인들의 자연살해세포 수 비율이 수영선수군보다 높았지만, 유의한 차이는 없었다. 반면, 비수영선수군은 사우나 노출 후와 저온노출 후에 자연살해세포 수 비율에 있어서 통계적으로 유의하게 감소하였다. 그리고 면역글로불린 농도의 경우에는 두 환경 모두에서 통계적인 차이가 없었다.

Abstract

Objective: The purposes of this study were to verify the effects of blood hormone levels and immune system during dry sauna bath and cold water bath in highly trained swimmers and non-swimmers. **Results**: The present results showed that the hormone responses were changed after the dry sauna bath and cold water bath. The plasma angiotensinⅡ and renin levels were significantly increased after sauna bath in the both groups, which were decreased after cold water immersion. But there was no significant difference on serum cortisol level after the dry sauna bath and cold water bath in the both groups. And at rest, non-swimmers showed higher percentage of NK cell than swimmers did but, no significant differences were found. Whereas, non-swimmers were significantly decreased in the percentage of NK cell after sauna bath and after cold water immersion. Moreover, there were no changes of immunoglobulin levels.

Ⅰ. Introduction

Environmental stress such as warm or cold temperature is often considered a

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challenge to human health and homeostasis, but the human body also physiologically adapts to heat and cold environments at least to some extent. Furthermore, recent paper have also elucidated that particularly heat stress may even be beneficial for human health, independently of other lifestyle factors(8).

The dry sauna bath has a long Finnish tradition. The oldest written record dates back to about 912 A. D. Traditionally the use of dry sauna is for hygiene health in Finland(23). Sauna has emerged as a popular form of wellness treatment around the world in recent decades. Despite the above, many people visit saunas out of curiosity or the desire to follow the latest trends, and not all of them use saunas regularly. Finland has a population of 5.2 million, and nearly 2 million Finns use saunas regularly, whilst other Scandinavians also take the dry sauna baths at least once a week for health impronement(16, 19).

Sauna baths are conductive to the treatment of locomotive organ inflammation, nonspecific ailments of the upper respiratory system(9). Thermal treatment and rapid cooling after sauna were also found to exert a complex and positive effect on vascular and cardiac functions. After a brief review of general acute cardiovascular response and long-term adaptation in responses to heat stress(8).

If the body exposure to the hot and cold environment, the function of homeostasis activates to attempt for keeping a normal body temperature which leads to profuse sweating. Despite the sauna-induced dehydration, changes in serum electrolyte levels are small and are not considered to be clinically significant(11). As a acute exercise, heat stress, and hypoxia, cold stress also challenges physiological systems and may detrimental to human health acutely(4). When entering a cool environment, the human body will adjust to maintain heat balance(3). The physiological and health effects of cold exposure such as winter swimming in ice-cold water has been investigated in many studies. They indicate that they are generally not harmful for health when, for instance, antioxidant capacity or hormonal function is considered, but they can lead to reduction in skinfold thickness, meaning that cold exposures can be beneficial in reducing body adiposity.

However, modern dry sauna as a traditional way of relaxing, cleansing, thermal therapy and reduce soreness. Sauna bath has become an increasingly popular leisure activity during recent years.

When the body exposed heat and cold environment, many changes of physiological and biochemical changes can be witnessed. The influences of the sauna on the circulation and secretion of hormones were mainly resulted from the stimulation of the sympathetic nervous system (SNS) and the activation of the hypothalamus -pituitary-adrenal hormonal axis(5, 11). The physiological and hormonal changes that occur

during sauna bath are transient (7, 23, 30). The decrease in the blood volume and the loss of sodium in the sweat resulted in the activation of the renin-angiotensin-aldosterone system(15). Leppaluoto, Arjamaa, Vuolteenaho & Ruskoaho (1991) reported that renin was increased 1.5 to 2 fold and angiotensinⅡ levels were increased 3 to 6 fold compared to those of before sauna bath(20).

As described in the classic studies of Selye(1936), chronic exposure to stress is accompanied by an involution of the thymus gland, a decrease in size of the lymph nodes, lymphopenia and eosinopenia. However, Brenner, Severs, Shek, & Shephard(1996) and Severs, Brenner, Shek, & Shephard(1996) saw no changes of immune function in response to an 0.7 ℃ increase of 2 ℃ was induced by water bath immersion at 39.5 ℃. But Sauna and cold water stress, as a natural stressor, may have its own unique pattern of neuroendocrine changes because of the accompanying body temperature variations which may influence immune function(1, 20).

Currently, the data are lacking on how the immune system adapts to the cold water and hot sauna bath. However, it is certain that the level of adaptability may show the different immune response after hot sauna bath and cold water exposure. Thus, the purpose of this study were to determine the physiological responses and immune system on the dry sauna bath cold water bath for trained swimmers and non-swimmers.

Ⅱ. Methods

1. Subjects

All subjects were volunteered and they had given written informed consent to participate in this study. None of them has chronic illness and use of any medication during the week before the experiment. Seven highly trained male swimmers and seven untrained male non-swimmers participated in the study. They were aged 16 to 24 years old. The trained male swimmers were undertaking 20 to 30 hour of pool training six days per week. Non-swimmers were not participate in any kinds of sport or physical activity other than physical education class.

2. Experimental design

1) Body composition

The measurement factors of body composition were % body fat, fat mass and lean body mass. These forms were measured by the bio-electrical impedance device (Tanita, Japan).

2) Dry sauna bath

Dry sauna bath was used for 10 min. The subjects worn short pants and then sat quitely on the bench in the chamber during the exposure. The temperature of dry sauna in the chamber was 100-110℃ of fahrenheit(C 37.7~40℃) and the humidity was 22 %.

3) Cold water bath

All subjects rested 10 minutes after the dry sauna bath, and then head-out cold water immersion for 10 minutes. The temperature of cold water exposure was 22-24℃.

4) Blood sampling

Blood sample were drawn at 07-10 A.M on the overnight fasted. At each sampling time, 10 ml blood was collected. Venous blood samples were collected prior to the sauna bath, immediately after sauna bath and cold water immersion, respectively, 5 ml blood sample was collected by heparinized tube (Becton Dickinson, U. S. A) for analysis of lymphocytes and it's subsets, immunoglobulin (IgA, IgG, IgM) and natural killer (NK) cell.

3. Statistics

An independent t-test with between groups(swimmers vs. non-swimmers) was used to determine the differences in physical characteistics ($p<.05$). Two-way ANOVA with repeated measures was also used to determine the differences in physiological variables and immune responses ($p<.05$).

Ⅲ. Results

Table 1. Physical characteristics of the subjects

Group	Age (yr)	Height (cm)	Weight (kg)	Fat (%)	LBM (kg)	Fat mass(kg)
Swimmers (n=7)	17.86 ±1.67	170.45 ±2.60	63.42 ±2.76	17.25 ±4.06	53.40 ±4.50	11.00 ±5.42
Non-swimmers (n=7)	20.57 ±1.51	174.86 ±5.34	68.58 ±9.30	19.46 ±3.83	54.00 ±7.30	13.60 ±4.53

Values are mean±standard deviations.

Table 1 summarized subject characteristics. Compared with the non-swimmers, the swimmers were slightly lower in height, weight, % fat, LBM and fat mass.

Table 2. Changes of hormone after the dry sauna and cold water bath

Group	Parameters	Rest (1)	Sauna bath (2)	Cold water bath (3)
Swimmers (n=7)	Cortisol(ug/dl)	10.65±2.58	10.78±2.92	9.84±2.59
	Angiotensin II (pg/ml)	9.43±4.08	29.86±10.49***	14.28±8.38
	Renin(ng/ml/hr)	1.81±1.12	2.68±1.71***	1.61±1.17
Non-swimmers (n=7)	Cortisol(ug/dl)	14.58±5.18	10.29±4.21	11.53±5.59
	Angiotensin II (pg/ml)	11.14±4.67	34.00±18.72***	13.57±6.58
	Renin(ng/ml/hr)	1.15±1.17	4.09±1.96***	1.94±1.14

Values are mean±standard deviations.

***p<. 001 : compared to the rest and after the cold water bath within group

Table 3. Changes of percentage on the leukocytes and subset during dry sauna and cold water bath.

Group	Parameters	Rest (1)	Sauna bath (2)	Cold water bath (3)
Swimmers (n=7)	Leukocyte(10^{-9}/cell)	4.86±.72	5.01±.92	5.47±1.13
	Lymphocyte(%)	41.28±9.09	42.57±6.55	42.57±6.05
	Monocyte(%)	4.14±4.57	3.71±1.60	4.71±3.30
	Neutrophil(%)	51.71±10.06	51.43±6.65	50.43±5.71
	Eosinophil(%)	.86±1.07	1.57±.97	1.00±.82
	Basophil(%)	.57±.79	.71±.95	.71±.95
Non-swimmers (n=7)	Leukocyte(10^{-9}/cell)	5.83±1.12	5.58±.75	6.11±.86
	Lymphocyte(%)	34.28±10.11#	30.86±9.21#	30.86±8.31#
	Monocyte(%)	4.00±1.00	4.57±1.62	4.86±2.27
	Neutrophil(%)	59.71±10.06	63.71±10.42#	61.00±8.87#
	Eosinophil(%)	1.14±.89	1.14±.69	1.86±1.57
	Basophil(%)	.57±.79	.43±.53	.43±.53

Values are mean±standard deviations.

*p<.05 : compared to the rest within group #p<.05 : between groups

The serum cortisol hormone and plasma angiotensinⅡ, renin level was displayed in Table 2. Cortisol level was slightly lower in the swimmers than in the non-swimmers (10.65±2.58 vs 14.58±5.18; NS). Compared with the rest, both groups showed no significant differences in terms of hormone change. AngiotensinⅡ and renin levels were increased after the dry sauna bath (p<. 001), but there were no significant differences in cold water bath compared with the rest. Moreover, renin and angiotensinⅡ levels were decreased after the cold water bath compared with the sauna bath (p<.001). However, there were no significant differences in cortisol, renin and angiotensinⅡ levels between the groups.

Table 3. indicates changes in the leukocyte, their subsets and monocyte in response

to the dry sauna and cold water bath. Compared with the rest, the swimmers and non-swimmers group showed no significant differences in all parameters after the dry sauna and cold water bath. But compared between the groups, non-swimmers showed higher in the lymphocyte at rest, after dry sauna and cold water bath than those of swimmers ($p<.05$). In addition, the level of neutrophil of the non-swimmers was higher after dry sauna and cold water bath compared to those of the swimmers ($p<.05$).

Table 4. Changes of serum immunoglobulin levels and NK cell proportion after dry sauna and cold water bath.

Group	Parameters	Res t(1)	Sauna bath (2)	Cold water bath (3)
Swimmers (n=7)	IgA(mg/dl)	181.14±72.65	172.00±61.32	178.43±70.13
	IgG(mg/dl)	1280.00±199.67	1334.28±225.89	1237.14±171.44
	IgM(mg/dl)	207.57±56.72	196.86±52.95	192.71±51.26
	NK cell(%)	7.91±4.44	7.18±4.30	7.84±4.05
Non-swimmers (n=7)	IgA(mg/dl)	167.14±36.22	174.14±47.03	168.57±53.97
	IgG(mg/dl)	1185.71±276.82	1257.14±394.36	1208.57±291.17
	IgM(mg/dl)	192.43±53.25	190.86±52.07	191.43±55.67
	NK cell(%)	13.28±8.05	10.18±7.19*	9.93±5.79*

Values are mean±standard deviations.
*$p<.05$: as compared to the rest within the group

Table 4. presents changes in the serum IgA, IgG, IgM levels and the percentage of NK cell in response to the dry sauna bath and cold water bath. Compared with the rest, the swimmers showed no significant difference in serum changes after sauna bath. Whereas, the percentage of NK cell of the non-swimmers were decreased after dry sauna bath and cold water bath ($p<.05$). There were no significant differences in serum IgA IgG, IgM levels and a percentage of NK cell between the groups.

Ⅳ. Discussion and Conclusion

This study was to examines the effect of dry sauna and cold water bath on the blodd hormon and immune responses. Relatively a short time exposure (10 minutes) of swimmers and non-swimmers to the dry sauna bath were associated with marked increase in plasma renin and angiotensin Ⅱ levels. But there were significantly decreased after the cold water bath (see, Table 2).

Previous reported, Lammintausta, Syvalahti & Pekkarinen(1976) found that plasma

renin activity was increased during dry sauna bath(18). Kosunen, Pakarinen, Kuoppasalmi & Adlercreutz (1976) also found that the concentration of the plasma angiotensinⅡ was increased by the sauna(14). In the present study, no changes in lymphocyte, leukocyte and their subsets, and monocyte after the dry sauna bath and the cold water bath were found. However, the lymphocyte levels of the non-swimmers were lower in rest after the dry sauna and after cold water bath compared with those of the swimmers. Whereas, the neutrophil level of the non-swimmers were higher after the dry sauna and cold water bath compared with those of swimmers. This present results are in disagreement with the data of Dugue, & Leppanen (2000). Interestingly, Dugue et al. (2000) report that the monocyte level of the habitual winter swimmers were decreased after the dry sauna and cold stress compared with those of the non-habitual winter swimmers(6). Neutrophil and monocyte counts were also increased during and for two hours following this stimulus (12, 13).

We observed that at rest, the concentration of serum IgA, IgG, IgM levels in the swimmers are higher than those in the non-swimmers. Whereas the percentage of NK cell of the swimmers was lower than those of the non-swimmers. However, no significant differences were found between the groups. This results are in agreement with data of Pedersen, Rohde, & Zacho (1996), Mackinnon (2000) and Reid, Drummond, & MacKinnon (2001). MacKinnon et al. (2000) concluded report that high performance athletes are generally not clinically immune deficient. However, there is evidence that several immune parameters are suppressed during prolong periods of intense exercise training. These include decrease in neutrophil function, serum and salivary immunoglobulin concentrations and natural killer cell number and possibly cytotoxic activity in peripheral blood. Moreover, the incidence of symptoms of upper respiratory tract infection increase during periods of overtraining.

The percentage of NK cell was no change after the sauna bath and cold water bath in swimmers whereas it decreased in non-swimmers(see, Table 4). The heat exposure may either increase or decrease NK cell activity, depending on the magnitude of the increase in temperature, the duration of exposure to the hot environment, and the intensity and duration of any associated physical activity(28).

On the contrary, Lackovic, Borecky, Bigas & Rovensky (1988) exposed subjects to 4°C air for 30 min. This stimulus led to release of NK cell cytolytic activity(17). Jansky ,Pospislova, Honzova, Ulicny, Sramek, Zemen, & Kaminkova (1996) exposed healthy men to 14°C water for 1 hour three times per week for six weeks(10). This stimulus induced a considerable increase in leukocyte count. If exposed to cold air precipitates bronchospasm, levels of the immunoglobulin associated with anaphylatic reactions (IgE) may also be increased. Subsequent cold exposure induced a leukocytosis and

granulocytosis, an increase in natural killer cell count and activity, and a rise in circulating levels of interleukin-6(2).

The present results have shown that the physiological and hormone responses were changed after dry sauna and cold water bath. In addition, at rest, the percentage of NK cell of the non-swimmers showed higher value than that of the swimmers. This percentage of NK cell was significantly decreased in the non-swimmers after the sauna bath and cold water bath.

Overall, these results indicate that acute heat and cold exposure has immunostimulating effect. But changes in the immune system after single or repeated the dry sauna and cold water bath seem to be relatively small and their biological significance is not clear, and it is as yet unclear how interindividual differences in fitness, and heat or cold acclimatization affect immune responses in the hot and cold environment.

However, it is certain that those who are non-adapted on the cold water or cold environment may have more chance to increase the risk on the health status after acute hyperthermia and cold environment exposure, and that would be increased risk of viral infectious specially.

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