

Biological Effects of Far-Infrared-Ray Hot Compression on Superoxide Anions in Human

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Abstract

Among the infrared spectrum, the range of 4-14 μ m belonging to far-infrared (FIR) spectrum is named as "growth rays" due to many beneficial effects represented on organisms. Recently, many biomedical materials have been provided and manufactured based on the growth rays for health care as well as complimentary and alternative therapies. In this study, we probed the effect of FIR hot compress on antioxidation ability in human by determining the concentration of superoxide anions in blood. The results revealed that the level of superoxide anions in sympathetic, parasympathetic, and sympathetic plus parasympathetic group was decreased, rather than control group. This suggested that FIR exposure can significantly eliminate superoxide anions and provide protective effect against oxidative damage in human.

Introduction

Heat is a physical repression of infrared radiation released from molecular motion including vibration and rotation when a molecule relaxes from a higher quantum level. In Chinese medicine, heat was used to cure diseases by means of moxibustion for thousands of years. Heat transfer in organisms is difficult to estimate ascribed to difficulty in temperature measurement inside the organisms of body as well as the complexity resulting from the coexistence of heat radiation, conduction and convection (due to body fluid circulation); however, heat emitting from matter (including organisms and human body) expresses in a form of infrared radiation with different wavelengths. Among the infrared spectrum, the range of 4-14 μm belonging to FIR spectrum is named as “growth rays” [1] due to many beneficial effects represented on organisms [2-4]. Recently, many biomedical materials have been provided and manufactured based on the growth rays for health care as well as complimentary and alternative therapies [5-9]. The heat and the radiation transferred from the so called FIR materials exhibit several biological effects including blood circulation promotion, growth facilitation [2, 10], tissue regeneration [11-12], tumor suppression [13-14] and anti-depression [15-17]. In our previous study [18], hot compress with FIR materials was found able to increase the concentration of superoxide dismutase (SOD), which is responsible for the elimination of superoxide radicals involving many chronic diseases (e.g., hyper pressure, Parkinson's disease [19], arterial disease [20], Hepatitis [21-22] and others [22-23]) in human body. Furthermore, In Inoue and Kabaya's research, sleep modulatory effect was observed under FIR irradiation in rat experiment [2]. In this study, we probed the effect of FIR hot compress on antioxidation ability in human by determining the concentration of superoxide anions in blood.

Materials and Methods

Study Population and Testing Environment

The study subjects (46 students) were randomly selected from a university located in Chia-Yi County of Taiwan, whose ages ranged from 18 to 30 years. None of the subjects had a family history of heart or chronic disease. Recruitment of subjects was conducted from September 1, 2007, to December 31, 2008. In this study, these volunteers were grouped into the control (no FIR treatment), the sympathetic group (exposed to FIR on thoracic lumbar vertebra), the parasympathetic group (exposed to FIR on brain system and sacrum), as well as sympathetic plus parasympathetic group (exposed to FIR brain system, thoracic lumbar vertebra, and sacrum). Demographic variables were gender and age as listed in Table 1. These subjects were randomly divided into four experimental groups by stratified and simple sampling. Before performing the testing, no drug or coffee-containing food was taken. The testing environment was quiet, comfortable, and well controlled at temperature of 20-25°C and humidity of 40-60%. When performing the testing, only one subject was evaluated at a time. This study was reviewed and approved by the institutional review board of Dalin Tzu Chi General Hospital in Taiwan (i.e., approved informed consent was obtained). Written informed consents returned from all of the subjects were also obtained.

Equipments for Generating Far-Infrared Radiation

The FIR equipment obtained from Solano Semiconductor Technology, LTD. (R.O.C.) was structured as a compress pad (with a dimension of 40 cm×28 cm×3 cm) and embedded with FIR emitting materials (FIR emissivity=0.85) at whole compress surface.

Blood Preparation and Analysis for Superoxide Anions

With the availability of an ultraweak chemiluminescence analyzer, it is possible to monitor the production of superoxide anions. Peripheral blood was collected from each individual before and after FIR heat compress and the superoxide anions were determined within 24 hours. Briefly, an aliquot of 0.5 mL blood sample was placed on a glass tube, mixed, and analyzed under an air atmosphere at 37°C for 10 min. All the procedures for determining superoxide anions were performed in the dark. The chemiluminescence intensity was expressed in terms of average counts per minute and corrected for background.

Experimental Procedures

After agreeing to participate and being informed, subject was arranged to test. In order to evaluate the effects of FIR on superoxide anions, an ultraweak chemiluminescence analyzer (BJL-1-IC; Jye Horn Co., Taiwan) was used to measure the chemiluminescence intensity of blood samples before and after FIR exposure. Before test, an aliquot of 2-3 mL peripheral blood collected from the subject was measured to determine the concentration of superoxide anions in total blood. After a stabilization period of 5-10 minutes, the exposure of FIR was performed for 40 minutes. At the termination of test, another 2-3 mL of blood from the subject was conducted to evaluate the variation of superoxide anions. Therefore, except for FIR exposure, the procedure of control group was identical to other groups.

Statistical Analysis

The distributions of characteristics among the testing groups were expressed as percentages for categorical variables and means for continuous variables. The association of categorical data was estimated by chi-square test. The paired t test was used to analyze the difference of concentration of superoxide anions among the groups. The results of each group were compared by a repeated measurement analysis of variances statistic method followed by the Scheffe test for post hoc analysis of significance. A *P* value <0.05 was considered statistically significant. SPSS version 12.0 was used for statistical analysis in this research.

Results and Discussion

We analyzed the distribution of demographic characteristics among testing groups. No significant difference was shown in these groups (Table 1). It was previously showed that superoxide anions were influenced by age [25]. To avoid the effect of age, the subjects over 30 years old were excluded from the participation.

Table 1
Demographic characteristics of the study population (N=46)

Variable	Group No (%)				P-value
	Control 11 (24)	SP 11 (24)	PSP 12 (26)	SP plus PSP 12 (26)	
Sex					0.934 ^a
Male	6 (27)	5(23)	6(27)	5 (23)	
Female	5 (21)	6 (25)	6 (25)	7 (29)	
Age (yr)	20.7±2.4	20.9±2.0	21.7±1.8	20.4±2.1	0.514 ^b

Note: SP, sympathetic; PS, parasympathetic; SP plus PSP, sympathetic plus parasympathetic.

^a one-way ANOVA.

^b chi-squared test.

As listed in Table 2, the superoxide anions in control (without FIR exposure) were significantly increased after 10 minutes, however, those in sympathetic, parasympathetic, and sympathetic plus parasympathetic group (with FIR exposure at different region) were apparently decreased. The difference of superoxide anions before and after FIR exposure for each group reached its statistical significance ($p < 0.05$). In addition, to evaluate the significance of decreased level among these groups, the decrease percentage of superoxide anion level for the FIR-exposure groups was statistically significant as compared to control group (Fig. 1). These results in this study demonstrate that the treatment of FIR can effectively decrease the generation of superoxide anions.

Table 2
Comparison of superoxide anions before and after FIR exposure in each group

Group	Difference (after minus before) Mean±SD (%)	P-value ^a
Control	18.7±20.0	0.014
SP	-17.2±20.8	0.028
PSP	-15.2±26.2	0.079
SP plus PSP	-17.3±15.1	0.007

Note: SP, sympathetic; PS, parasympathetic; SP plus PSP, sympathetic plus parasympathetic.

^a pair t test

To the best knowledge, this is the first report indicating that FIR treatment can effectively decrease the generation of superoxide anions. In organisms, superoxide anions are deleteriously produced as a byproduct of mitochondrial respiration, as well as several other enzymes, for example xanthine oxidase [25]. It is known to play an important role in different form of disease, including

chronic diseases (e.g., hypertension, arterial disease), Parkinson's disease and hepatitis. In this study, all the groups treated with FIR revealed apparent effect on decreasing the generation of superoxide anions.. Oppositely, an increased level of superoxide anions was observed in control group (Table 2). The mechanism is possibly, due to that hot compress with FIR materials stimulates the production of superoxide dismutase (SOD) [18], which is responsible for the elimination of superoxide anions [26]. Moreover, since the heat generated from FIR irradiation is able to affect the autonomic nervous system [18], the observed results may also be ascribed to the regulation of autonomic nervous system on the elimination of superoxide anions. The reduction of superoxide anions may further prevent human from oxidative damage and many chronic diseases.

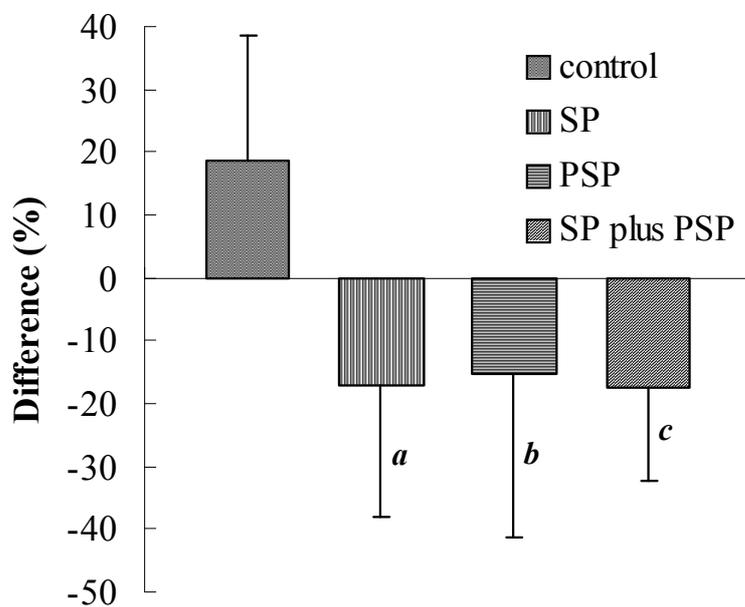


Fig. 1. Relative difference of superoxide anions before and after FIR exposure among the groups. Abbreviations: SP, sympathetic; PS, parasympathetic; SP plus PSP, sympathetic plus parasympathetic. The results were performed in independently triplicate experiments. The bars indicate the standard deviation. The letters (a, b, c) stand for reaching statistical significance in comparison with control group ($P < 0.05$).

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