

Investigating the effect of acute physical activity in healthy and polluted air on ST-segment in non-athletic men

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Abstract: The aim of this study was to investigate the effect of physical activity in healthy and polluted air on ST-segment in non-athletic men. In this study, 12 healthy subjects with mean age of $21/12 \pm 1/8$ years were randomly selected, and then running according to the Bruce test in healthy (PSI=70) and polluted air (PSI=135). To analyze the data, dependent t-test with significance level of $p \leq 0/05$ was used. Measurement results showed that physical activity in healthy and polluted air, there was no significant effect on the segment ST.

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1. Introduction

Epidemiologic studies show that growing of emergency hospital admission, acute cardiorespiratory complications and mortality is associated with increasing the concentration of suspended particles and toxic inhalable gases in the air (1). As various studies showed that there is a direct relationship between respiratory diseases and air pollution. Based on statistics, annual mortality due to air pollution throughout the world is about 800000 people (2).

Physiological adaptations of the heart in athletes can be characterized by electrocardiogram (3). The researchers used electrocardiogram to detect potential diseases as well as electrical changes after short or long duration exercise.

Study of Chahine et al (1976) on the application of electrocardiogram in diagnosis of diseases, indicate that ischemic responses of ST segment to exercise in apparently healthy individuals (asymptomatic) is a strong prognosis for coronary problems (such as angina pectoris, myocardial infarction or sudden cardiac death) (4). Also in asymptomatic people, the ischemic changes of ST segment which start after the training session have the same significant and substantial predicting value for the coronary problems that the changes of the ST segment has whose changes appear while training. In the other words, any changes in ST segment (changes during exercise or post-exercise changes), is associated with a 2.5-fold independent risk factor for coronary problems compared with those with a normal exercise ECG (5). ECG ST-segment (starts at the J point and ends at the beginning of the T wave), is an isoelectric segment (on the electric zero line), and any deviation from the isoelectric line in this segment, refers to a pathological condition; so that, ST segment elevation (ST segment

is abnormally high above the baseline) occurs in the acute myocardial infarction and hyperkalemia, and ST depression (ST segment is under the isoelectric line) occurs in ischemic heart disease and hypokalemia (6). In the event of emphasizing on the physiological importance of heart's electrical changes that is created after short or long duration physical activity, as well as the diagnostic value of ST segment changes after exercise (7), Researchers have demonstrated having regard to the type and intensity of physical activity at the time of the EKG, helps to a better understanding of the EKG changes in athletes (8). Actually, any physical activity depending on the type, intensity and duration, creates changes in EKG both during and after the activity (5).

It is noteworthy that regular physical activity plays an important role in human health (including the operation of cardiorespiratory) (9). Increased physical activity increases the respiration rate, thus more air enters the lung that it may lead to an increased risk of contaminants uptake through the respiratory system (10). Anyway, the benefits of sport for all will be optimized only when sports and physical activities done by taking health considerations including environmental conditions (9). Therefore, hypothesis is that air pollution may limit the beneficial effects of exercise on health (11). All investigations have concluded that air pollutants lead to deaths and hospitalization (12). Type of air pollutants, rate and time of exposure, and the fact that humans are often exposed to a combination of pollutants not just a particular type, can cause health problems such as dizziness, nausea, allergic reactions, throat irritation; skin rashes and headache. Other effects of air pollution can be birth difficulties, developmental delay in children, immunosuppression, cancer and

some other diseases. There is little research on the impact of physical activity in polluted air on properties of electrocardiogram (in particular ST-segment as an important diagnostic and pathological implement) as well as the pathological consequences of their possible potential. Therefore, there are many unanswered questions on the physiological and pathological importance of electrocardiographic changes followed by exercise in polluted air. According to the above-mentioned, in this study the effect of physical activity in polluted air on the ST segment response was investigated.

2. Material and Methods

Subjects Population

Twenty non-smoking male students were volunteered to participate in the present study. Twelve volunteers were blindly and randomly selected. The study group was all those aged 18–23 years (BMI 24.41 ± 2.47). Procedures were performed in accordance with the Helsinki Declaration for the ethical treatment of human participants. Written informed consent and medical history questionnaire was provided to all participants prior to their participation in the study.

Study Design

Exercise test was conducted in a clean day (Pollutant standards index (PSI=70)) and it was

repeated in a dirty day (PSI=135). The average pollution rate of healthy and unhealthy environments were calculated by HORIBA (made in Japan) in 24-hour. Also exercise tests were done according to the Bruce test on treadmill (model TMX 425, made in America). Electrocardiogram (ECG) tests were done by a cardiologist using Stress PC ECG-Version 5.0.3, made in America.

Statistical Analysis

Descriptive study (mean and standard deviation) was used for classifying data and inferential statistics including variance analysis with repeated measurement and dependent t-test were used to determine the difference between two tests. In order to checking the normality of data, Kolmogorov-Smirnov test was also used. All statistical operations were conducted by SPSS version 16 and the significance level was defined as $P < 0.05$.

3. Results

Mean and standard deviation of ST segment at polluted and fresh air, have been shown in table 1 that different numbers for S-T segment achieved in different environments; but as can be seen in table 2, physical exercises in polluted air did not have a significant statistical effect on ST ($\text{sig}=0.459$). The result in table 2 were obtained from dependent t-test to determine the difference between two tests.

Table 1. Mean and standard deviation of ST segment at polluted and fresh air

Environmental condition	Mean and standard deviation
fresh air	-0.0031 ± 0.014
Polluted air	0.0051 ± 0.025

Table 2. Result of dependent t-test to compare the ST segment between two tests

Variable	T	df	Sig
ST segment	-0.791	9	0.459

4. Discussions

Clinical exercise test is an effective way to assess cardiovascular response to stress of controlled physiological exercise activity (13) and is considered as a non-invasive procedure. There is various graded exercise testing protocols that Bruce protocol is a known protocol in the clinical environments and standard Bruce protocol is common in healthy individuals (14). Bruce exercise test consists of a multi-step protocol which is done on rotation band. In this protocol, Intensity of the exercise increases by changing the speed and slope. In this study, exercise test on each of the subjects was repeated 2 times and to prevent the impact of circadian rhythm, electrocardiographic ST segment response from each

of the subjects in two tests were assayed at the same time (15).

In present research, physical activity on ST segment in polluted air showed no significant difference. Pekkanen et al. performed the submaximal exercise test for 45 subjects, 342 times over a 6-month period the six months that in 72 tests, ST segment showed depression ≥ 1.0 mV. It is mentionable that above result do not match with our results (16). In a study, with protocol included 5 minute rest in the sitting position, 5 minute rest in the standing position, 5 minute walk down the gentle slope and 5 minute recovery, it was found that the air pollution had no effect on the ST changes from rest to exercise and

exercise to recovery mode (17). The result of this research is consistent with our work. It is worth noting that the acceptable reason for observation of different results in various researches can be differences in the type and amount of pollution and also the applied protocol.

ST segment depression during exercise ECG testing is a symptom of heart muscle ischemia. ST segment depression is the main anomalies during exercise. When due to disproportion between supply and demand, insufficient blood is delivered to the heart muscle; at first the inner layer of the heart (endocardium underside part) is involved. At the beginning of ischemia, reduced oxygen supply causes the normal functions of cell change due to the displacement of ST segment below the baseline. ST segment depression due to physical activity usually appears in the form of endocardial underside part ischemia (13). Particulate air pollutants can reduce providing oxygen of the heart muscle or increase muscle oxygen demand or lead to both of them (16). Blood flow in the coronary system almost is entirely adjusted by local arteriole dilation in response to food needs of the heart muscle. In the other words, when the contracting power of the heart muscle (regardless of its cause) increases, coronary blood flow also increases. Conversely, reduction of activity is associated with decrease of coronary blood flow. Blood flow in the coronary arteries almost is exactly regulated according to the energy needs of the heart muscle. Even in normal resting mode, about %70 of oxygen in the coronary artery blood is removed during passing blood from the heart. Thus, since there is not a lot of oxygen, more oxygen delivery is not possible unless coronary blood flow increases. Fortunately, coronary flow also increases approximately proportional to oxygen metabolic consumption by the heart (18). However, it is not exactly clear yet how increasing oxygen consumption can cause coronary dilation. Many experts believe that the depression of oxygen concentration in the heart causes the release of vasodilator substances from heart cells. Adenosine is a substance that shows the most vasodilating effect. If the oxygen concentration in muscle cells becomes very low, much of adenosine triphosphate is converted to adenosine monophosphate. Then, a small amount of adenosine monophosphate turns into adenosine that is released into the tissue fluids of the heart muscle. Again, a lot of adenosine absorbed into the heart muscle cells after dilating blood vessels to be reused. Adenosine is not the only substance known as vasodilator. Substances such as adenosine phosphate compounds, potassium ions, hydrogen ions, carbon dioxide, Brady Kane and prostaglandins also have this property. At present, the vasodilation hypothesis has some drawbacks. First, the materials that neutralize

vasodilating effect of adenosine fully or partially are unable to prevent the coronary arteries dilation in response to increased activity of the heart muscle. Secondly, studies on the skeletal muscle have shown that continuous infusion of adenosine can only keep vasodilatation for 1 to 3 hours. While even after finishing the effect time of adenosine, heart muscle activity can also dilate local blood vessels singly (18).

So it can be concluded that the range of pollution have no effect on the ST segment during physical activity and the heart eliminates its need to oxygen with increasing coronary blood flow. The reduction in oxygen saturation may be a marker of oxidative stress which may result in neural feedback to the heart or alter cardiovascular physiology through local pulmonary and cardiac vascular inflammation and blood coagulability. Particulate pollution-related pulmonary inflammation and cytokine cascades may influence autonomic responses via stimulation of pulmonary vagal receptors (19). The reduction in oxygen saturation during exercise may result in decreasing delivery of oxygen to the active tissues and influence the activity of active tissues. The results of present work show that polluted air may lead to decrease in arterial oxygen saturation.

Research studies on humans showed that air pollution is related with increasing C-reactive protein (CRP) (20), plasma fibrinogen (21) and plasma viscosity (22). A number of studies report that air pollution is associated with increasing heartbeat (23) which is the result of an imbalance in autonomic nerves activity and thereby may lead to the increase of mortality (24).

Potential mechanism of exposure to PM is the inflammation including ROS generation and oxidative stress (25). Evidence shows that ROS may play an important role in the mechanism of injury. It has been proven that PM and emissions from the diesel engine, causes the production of ROS in target cells such as macrophages, tracheal epithelial and endothelial cells (26).

In this study, the effect of physical activity in polluted air on ST segment examined, it was clear that exercise in polluted air had no significant effect on the ST segment, this result is probably due to the low percentage of pollution and type of pollutants.

Therefore, with regard to the importance and the role of physical activities in maintaining and improving the physical health, decreasing the obesity, increasing cardiorespiratory preparation, and increasing the muscular power, and considering the fact that it is impossible to forbid people doing physical activities, one should try to benefit from the useful advantages of physical activities by providing the required facilities and utilizing scientific and systematic training methods.

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