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The characteristic of endothelium-dependent vasodilatation in athletes and untrained volunteers

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ABSTRACT

Relevance. It is shown that strength-trained athletes and track and field athletes have endothelial dysfunction. However the vascular endothelium activity is not related to the type of physical exercises.

The aim of the study is to characterize the endothelium-dependent vasodilatation in athletes and untrained persons during the physical activity. Apparently, it can be the adaptive response to regular high-intensity physical exercises or a risk factor for acute vascular disorders.

Materials and methods. The study involved 27 young man aged 18 to 25 years. None of the subjects had acute or chronic pathologies and cardiovascular disorders in their anamneses. This study employed three groups of young men:

Group 1: elite endurance-trained athletes – track and field (middle-distance running) (N = 10).

Group 2: elite strength-trained athletes – weightlifting (N = 7).

Group 3: control group – healthy untrained volunteers (N = 10).

A Doppler study was performed using the Angiodin-PC. We also carried out background measurement of blood flow indicators in the brachial artery during exercise, and did an occlusive test.

Results. In athletes of high qualification, the functional activity of the endothelium is inhibited, and these changes are not related to the nature and direction of physical exertion. At the same time, a single physical exercise of a dynamic nature potentiates the vasodilatation function of the endothelium in all the examined groups.

Key words: high-intensity physical exertion, acute vascular disorders, adaptive reactions.

INTRODUCTION.

Regular physical exercises stimulate phenotypic modifications of the vascular endothelium and smooth muscles. Also physical exercises induce the processes of the vascular adaptation [1,2]. Physical exercises have a positive effect on the cardiovascular system and reduce the risk of cardiovascular diseases. Also physical exercises activate the endothelial function [3-8]. At the same time, regular high-intensity physical loads morphofunctional changes, can

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increase the risk of cardiovascular pathologies. The factors can stimulate such changes is unclear nowadays. It is also unclear whether the changes in the vascular system depend on the type, direction and intensity of physical exercises.

The aim of the study is to characterize the endothelium-dependent vasodilatation in athletes and untrained persons during the physical activity.

MATERIALS AND METHODS

The study involved 27 young man aged 18 to 25 years. None of the subjects had acute or chronic pathologies and cardiovascular disorders in their anamneses. This study employed three groups of young men:

Group 1: elite endurance-trained athletes – track and field (middle-distance running) (N = 10).

Group 2: elite strength-trained athletes – weightlifting (N = 7).

Group 3: control group – healthy untrained volunteers (N = 10).

We measured brachial artery blood flow by Doppler (Angiodin-PC). The right hands of volunteers were subjected to 5 min ischemia followed by a postocclusive hyperemia test. The pressure rose above the level of systolic blood pressure by 50 mm Hg. in subject at rest. After 5 minutes, the pressure was quickly relieved and the diameter of the artery was measured immediately after the ischemia, after 15, 30, 60 and 90 seconds. All the time of the study, the ultrasonic sensor was located strictly in one position. To assess the degree of growth in the diameter of the brachial artery, we took the ratio of the original diameter to the maximum at 0, 15, 30.60 or 90 seconds. Then, all subjects performed PWC170 test. The postocclusive hyperemia test was performed again after the physical exercise.

For statistical analysis the STASTIKA 8.0 application software package was used. A non-parametric Wilcoxon test for coupled samples was used. A statistically significant level was $p<0.05$. Data are presented as a median (Me), the 25th and 75th percentiles (Q25, Q75).

RESULTS AND DISCUSSION

The results are shown in the table 1. In the control group, we identified the vasodilatation of the brachial artery after the hyperemia test by 13.6% before dynamic exercise and by 17% after the dynamic exercise. According to the literature, in healthy people vasodilatation after the hyperemia test is 10-14% or more, a lesser degree of vasodilatation is pathological [10]. Thus, in the control group was a normal reaction to a test with reactive hyperemia. Dynamic exercise promotes the endothelial function. Dynamic exercises have a positive effect on the vascular system.

In groups of athletes we observed the abnormal reaction of vascular endothelium before and after dynamic exercise [10]. Probably, athletes have endothelial dysfunction. Endothelial dysfunction is characterized by a decrease of vasodilatation, proinflammatory state and prothrombotic properties. In the group of strength-trained athletes there was no change in the diameter of the brachial artery before exercise. After the dynamic exercise the diameter of the brachial artery was decreased by 5.3%. In the group of athletes before exercise, the diameter of the brachial artery increased by 2.9%. After the physical exercise, the vasodilatation was over 4.1%.

The vascular endothelium in strength-trained athletes adapts to the regular force loads with the phenomenon of straining. During this state muscles compress the vessels and cause temporary ischemia. Significant endothelium-dependent vasodilatation in such conditions would lead to the steal syndrome.

Endurance-trained athletes also showed a decrease in endothelial activity. According to the literature, cyclic sportsmen (rowing, cross-country skiing, cycling) have the signs of early atherosclerosis and a tendency to thrombosis in 60.5% of cases [11].

Table

The change of brachial artery diameter during the hyperemia test (% of basal level). Data are presented as a median (*Me*), the 25th and 75th percentiles (Q_{25}; Q_{75})

Characteristic	Тяжелоатлеты, $n = 7$ Weightlifters, $n = 7$	Легкоатлеты, $n = 10$ Track and field athletes, $n = 10$	Контроль, $n = 10$ Controls, $n = 10$
Before physical exertion	1,0 (0,5; 2,8)	2,9 (1,3; 4,8)*	13,6 (10,4; 15,7)*
After physical exertion	−5,3 (2,5; 9,7)*#	4,1 (3,5; 6,9)*#	17,0 (13,9; 19,6)*#

* statistically significant changes after the occlusion test ($p < 0.05$).
\# statistically significant changes after physical exercise ($p < 0.05$).

The data obtained the decreased endothelial reaction and endothelial dysfunction in athletes. However, it is important that dynamic exercise activates the endothelial function.

The endothelial and vascular system adaptation may be due to a number of factors. Physical exercise induces the increases of systolic pressure [12]. The pressure in the vessels can affect the endothelial cells. First, the change in pressure can affect the growth rate of endothelial cells [13]. Secondly, the pressure stretches the arteries, thereby stretching the endothelial cells. In response shear stress and mechanical stimuli in endothelial cells activates the intracellular signaling pathways, which leads to the activation of transcription factors and can affect endothelium and smooth muscle cells [13].

According to some researchers, mechanical stress, blood pressure alteration, endothelium-dependent factors can stimulate the atherosclerosis [14]. Shear stress and arterial pressure induce the NO and ROS expression, which can cause disadaptation [13].

eNOS induce the production of NO. In earlier studies, it was shown athletes in power and cyclic sports have difference eNOS production [15]. Strength-trained athletes have the decrease of eNOS expression after the physical exercise, and endurance-trained athletes increased eNOS plasma content. In addition, studies have shown that after a test with reactive hyperemia, NO-mediated vasodilatation in the brachial artery is induced [16]. The differences of eNOS expression can explain the various reactions to the hyperemia test before and after physical exercise in strength-trained and endurance-trained athletes.

CONCLUSION

The results of the study show that elite athletes have the inhibition of endothelial function. These changes in athlete's endothelial function are not related to the direction of physical exercise. In this case, a single dynamic exercise induces the endothelium-dependent vasodilatation in all groups. Apparently, it can be the adaptive response to regular high-intensity physical exercise. At the same time it is a risk factor for acute vascular disorders. There are numerous studies described the beneficial effect of physical exercise on the vascular endothelium and the prevention of diseases [3, 17]. However, given our results the intensity and regularity of physical exercise is the most important factor. It is also possible to recommend using acute exercise test for the endothelium characteristic in the athletes.

CONFLICT OF INTEREST

The authors declare the absence of obvious and potential conflicts of interest related to the publication of this article.

SOURCE OF FINANCING

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CONFORMITY WITH THE PRINCIPLES OF ETHICS

The study was approved by the local ethics committee under the SSMU.

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Характеристика эндотелий-зависимой вазодилатации у спортсменов и нетренированных мужчин

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РЕЗЮМЕ

Актуальность. Показано, что у спортсменов тяжелоатлетов и легкоатлетов имеет место эндотелиальная дисфункция, при этом активность сосудистого эндотелия не связана с характером и направленностью физических нагрузок.

Цель исследования – оценить характер эндотелий-зависимой вазодилатации у спортсменов различных специализаций и нетренированных лиц на фоне физической нагрузки. По-видимому, это можно рассматривать как приспособительную реакцию к регулярным высокоинтенсивным нагрузкам и одновременно – как фактор риска острых сосудистых расстройств.

Материалы и методы. В исследовании участвовали 27 мужчин в возрасте 18–25 лет, условно здоровые, без нарушений со стороны сердечно-сосудистой системы. Было сформировано три группы: высококвалифицированные спортсмены циклических видов спорта – легкая атлетика, $n = 10$ (группа 1); высококвалифицированные спортсмены силовых видов спорта – тяжелая атлетика, $n = 7$ (группа 2); нетренированные мужчины, $n = 10$ (группа 3). Выполнялись допплерографическое исследование на аппарате «Ангиодин-ПК», фоновое измерение показателей кровотока на плечевой артерии при физической нагрузке, окклюзионная проба.

Результаты. У спортсменов высокой квалификации имеет место угнетение функциональной активности эндотелия, причем эти изменения не связаны с характером и направленностью физических нагрузок. При этом однократная физическая нагрузка динамического характера потенцирует вазодилатационную функцию эндотелия во всех обследованных группах.

Ключевые слова: высокоинтенсивные физические нагрузки, острые сосудистые расстройства, приспособительные реакции.

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