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Effects of Garlic on Aerobic Performance

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Abstract: The effects of the administration of a single dose of garlic on the aerobic performance of college endurance athletes were investigated in this study. Ten trained male athletes participated voluntarily in this study. A 900-mg dose of dried garlic powder or placebo was administered randomly in a double-blind cross-over fashion. Five hours after ingestion of the tablets, the subjects underwent an incremental treadmill running test according to the Bruce protocol until subjective exhaustion. During the test, blood pressure and heart rate were monitored at 3 min intervals. After a one-week wash out period, the subjects were crossed over and

the procedures were repeated for the other substance. A paired t test was used for statistical analyses. There was a significant increase in maximum oxygen consumption (VO₂max) and endurance performance time 5 h after garlic administration as compared to the placebo (p<0.05). The administration of single dose of garlic was thus shown to increase VO₂max and endurance performance time of college endurance athletes during a treadmill running test according to the Bruce protocol.

Key Words: Garlic, *Allium sativum*, aerobic performance

Introduction

Performance in endurance-type events is dependent upon the ability to maintain a high energy output per unit of time (1, 2, 3, 4). Therefore, there is an increasing trend among athletes to use various substances and ergogenic aids in order to improve aerobic performance.

It has been shown that there is a positive relationship between blood fluidity and aerobic performance. Letcher et al. (1981) and Lacombe and Lelievre (1986) stated that regular prolonged endurance training induces a decrease in whole blood viscosity, which is determined by haematocrit, plasma viscosity and red cell deformability, in the resting state (5, 6). A lowered plasma viscosity and haematocrit and a higher blood cell deformability are rheological advantages which might contribute to a better oxygen supply to the working muscle tissues (7, 8).

Garlic (*Allium sativum*), a natural plant used as a food item in all parts of the world, has been shown to produce rheological effects similar to those produced by endurance training. It inhibits platelet aggregation and enhances fibrinolytic activity, and thus improves blood fluidity (9-13). In addition, garlic has been shown to affect vessel diameter, and increase blood flow in arterioles (13) and capillaries (14).

A decrease in whole-blood viscosity at rest and during exercise has been shown to have several advantages in sports performance. Regular prolonged endurance training improves rheological parameters at rest; however, there is an increase in whole blood viscosity during prolonged exercise even in well-trained top-level athletes. A further increase in blood fluidity by garlic administration in the resting state may induce rheological advantages beyond those produced by endurance

training, and thus may improve aerobic performance. Therefore, the effects of a single dose of garlic on aerobic performance in college endurance athletes were investigated in this study.

Materials and Methods

Garlic Preparation

The garlic used in this study was prepared as follows: Chinese garlic, cut into slices (3 mm) immediately after harvest, was blow-dried with air (at 40-50°C), ground cold, and coated with sugar. The preparation has a standard 1.3 % alliin content which corresponds to an allicin release of 0.6 % (equivalent to 2.7 g or approximately one clove of fresh garlic), and is manufactured in the form of tablets of 900 mg odour-modified dried garlic by Lichtwer Pharma GmbH (Berlin, Germany) under the commercial name Kwai.

Subjects

Ten trained male college endurance athletes participated in this study on a voluntary basis. Their mean age was 21.6 ± 3.5 years, their mean height was 175.8 ± 5.1 cm and their mean weight was 66.5 ± 8.4 kg. The characteristics of the subjects are given in Table 1. None of the participants was a smoker or alcohol user or took any medication interfering with blood circulation or coagulation. All the subjects were experienced in running on a treadmill with increased workloads, which justified the assumption that the test performance was not limited by skill. Prior to testing, written informed consent was taken from each subject after the procedure and possible side effects of garlic intake had been explained. All the procedures were conducted in accordance with the ethical standards of the World Medical Association Declaration of Helsinki.

Study Design

The subjects took part in a randomized, double-blind, placebo controlled, cross-over study with a washout period of one week. Each subject received either 900 mg dried garlic powder or placebo in a single administration. The subjects were instructed to maintain their normal training program during the study. They were asked to refrain from training 48 h before the test. During each

study session, the subjects were asked to take no meals or drinks, including water, in order to avoid interaction of the test substances with food and/or digestion disturbances. A small drink of water was allowed for the administration of the substances.

In the pre-experimental period each subject came to the laboratory two days before the start of the actual study, and performed an incremental running test on a motor-driven treadmill (Quinton, Model Q65, USA) according to the Bruce protocol until subjective exhaustion in order to determine the baseline endurance performance time and maximum oxygen consumption (VO_{2max}). Blood pressure and heart rate measured by telemetry (PF 3000 Polat Electro, Finland) were monitored during the treadmill tests at 3-min intervals. Endurance performance time was also recorded at the end of the test for each subject. The VO_{2max} value for each subject was calculated from the treadmill running test using the Bruce protocol (15). The mean VO_{2max} and endurance performance time are presented in Table 1.

During the experimental period, the subjects performed two endurance tests over two successive weeks. The day of the week and time of day were kept constant for each individual in order to avoid possible diurnal effects. The tests only differed in terms of the test substance (either garlic or placebo) ingested before exercise. The subjects arrived at 8:00 am at the laboratory after a 12-h overnight fast. They were randomly allocated to receive either one tablet containing 900 mg dried garlic powder or to take a similar-looking placebo tablet containing starch, which they took with water. After tablet ingestion, the subjects were rested for five hours in the laboratory. An incremental treadmill running test using the Bruce protocol was performed until subjective exhaustion 5 h after the ingestion of

Table 1. Physical and physiological characteristics

Subjects	Mean \pm SD
Age (years)	21.6 ± 3.5
Height (cm)	175.8 ± 5.1
Weight (kg)	66.5 ± 8.4
VO_{2max} (ml.kg ⁻¹ .min ⁻¹)	55.3 ± 5.3
Endurance Time (s)	980 ± 107

either garlic or placebo since peak rheological reaction is reached four to five hours after the ingestion of garlic (13).

After the completion of the test, each subject was asked to fill out a questionnaire regarding side effects and their feelings before, during and after the study. Double-blindness was also checked by this questionnaire. After a washout period of one week, the subjects were crossed over to the other treatment and the test was repeated.

Statistical Analysis

SPSS for Windows 6.0 was used for statistical analysis. The data are presented as mean \pm SD. Statistical analysis was performed by paired t test. The descriptive level of significance was $p < 0.05$.

Results

The heart rate, $VO_2\text{max}$ and endurance time responses of each subject to either garlic or placebo are presented in Table 2. The results showed that the mean $VO_2\text{max}$ value and the mean endurance performance time for the treadmill running test increased significantly 5 h after the ingestion of a single dose of garlic as compared to the placebo test ($p < 0.01$ and $p < 0.001$, respectively, Table 3).

Table 2. Heart rate, maximum oxygen consumption ($VO_2\text{max}$) and endurance time responses of each subject with either garlic or placebo during exercise tests.

Subject number	Heart Rate(bpm)		$VO_2\text{max}(\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1})$		Endurance Time(s)	
	Garlic	Placebo	Garlic	Placebo	Garlic	Placebo
1	204	203	48.8	48.8	872	850
2	179	178	63.5	60.6	1140	1080
3	195	192	60.6	57.6	1080	1010
4	199	198	54.7	51.8	965	900
5	198	196	51.8	51.8	937	900
6	187	185	63.5	60.6	1135	1085
7	205	206	63.5	63.5	1164	1185
8	190	189	57.6	54.7	1050	990
9	187	184	57.6	54.7	1052	980
10	194	195	51.8	51.8	941	920

After the completion of each test, the subjects completed a standard questionnaire regarding the side effects of the ingested substances, and their feelings. One of the subjects reported a headache in both the garlic and

Table 3. Oxygen consumption and endurance time 5 hours after garlic and placebo consumption. Values are mean \pm SD.

Parameter	Garlic	Placebo	p
$VO_2\text{max}(\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1})$	57.3 \pm 5.4	55.6 \pm 4.8	0.019*
Endurance Time (s)	1033.6 \pm 100.1	990 \pm 103.5	0.001*

*Significantly different from placebo ($p < 0.05$)

placebo treatments. No allergic reactions or other possible side effects of garlic intake were observed. None of the subjects experienced eructations tasting of garlic. Nine of the subjects reported a feeling of fullness in their stomach with the garlic treatment.

Discussion

Several studies have investigated the relationship between haemorheological parameters and $VO_2\text{max}$ and endurance performance. Ernst et al. (1985) tested athletes for maximal work output, and found that blood fluidity (quantified by a score taking into account four major determinants of blood viscosity - haematocrit, plasma viscosity, red cell deformability and red cell aggregation) correlates significantly with fitness: the fitter the athlete the more fluid his blood (7). It was stated that total peripheral resistance is composed of both vascular and viscous resistance, and a "rheological advantage" in athletes might contribute to better oxygen supply to the working musculature (7, 8).

An increase in whole blood viscosity and plasma viscosity as an acute response to exercise has been shown by several studies (5, 16-19). Increased whole-blood viscosity may decrease oxygen and nutrient supply to working muscle tissues, and thus may reduce exercise performance (8, 17).

Chien (1982) and Usami (1982) suggested that fibrinogen concentration has the greatest relative influence on plasma viscosity (20, 21). Martin et al. (1985) found a slight increase (3.7%) in fibrinogen levels after maximal exercise. They suggested that this smaller than expected rise in fibrinogen concentration has several rheological consequences that are advantageous for the exercising subject (16). However, increases in plasma viscosity (because of an increase in fibrinogen

concentration) elevate whole-blood viscosity and decrease the flow, without enhancing oxygen transport (21).

Letcher et al. (1981) proposed that a decrease in plasma viscosity in endurance-trained individuals at rest and during exercise will increase the efficiency of oxygen delivery (5). They found significantly lower plasma viscosity in a group of 13 subjects who ran 20-70 miles/week when compared with 12 sedentary subjects. The difference was primarily due to a lower fibrinogen concentration in the runners.

Increased fibrinolytic activity has been suggested as the mechanism of decreasing fibrinogen concentration at near pre-exercise levels during exercise-induced haemoconcentration (5, 6). It is well documented that fibrinolytic activity is markedly accelerated with exercise (22, 23, 24) and a decrease in fibrinogen subsequently results in lower plasma viscosity (16).

Several studies have reported that garlic significantly enhances fibrinolytic activity in humans within a few hours of administration. Chutani et al. (1981) found that fibrinolytic activity increases about 72 % six hours after ingestion of raw garlic and 63 % six hours after ingestion of fried garlic, and that this increase was maintained up to 12 h (25). Jung et al. (1991) reported that 5h after the ingestion of garlic tablets there was a significant increase (86 %) in tissue plasminogen activator, which

increases fibrinolytic activity. They also found a visible increase in vessel diameter and assumed that it resulted from vessel dilation. It was stated that the observed vasodilatation results in an increase in capillary skin perfusion (13). Their results are in accordance with the findings of Wolf et al. (1990), who detected a significant increase in conjunctival vessel diameters (arterioles and venules) five hours after ingestion of 900 mg garlic (26).

The findings of this study revealed that garlic significantly increased the $VO_2\text{max}$ and endurance performance time of college endurance athletes 5 h after the administration of a single dose. A further increase in fibrinolytic activity in the resting state might have been responsible for the higher oxygen consumption and improved running performance during treadmill running tests of aerobic athletes. In this study, the $VO_2\text{max}$ was measured indirectly using the Bruce protocol, and rheological characteristics in the garlic and placebo subjects were not measured. Therefore, further studies using a direct method to measure $VO_2\text{max}$ and measurement of haemorheological parameters during aerobic exercise are needed to clarify the effects of garlic administration on endurance performance. The effects of long-term garlic administration longer than that examined in this study, on $VO_2\text{max}$ and endurance performance should also be investigated.

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