Effect of Short-term Arginine Supplementation on Vasodilation and Performance in Intermittent Exercise in Judo Athletes

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Abstract

Arginine supplementation has been shown to induce endothelium-dependent vasodilation and enhance exercise performance via increasing nitric oxide (NO) production in patients with various cardiovascular diseases. The purpose of this study was to determine the effect of short-term arginine supplementation on vasodilation and performance in intermittent anaerobic exercise in well-trained male athletes. Ten elite male college judo athletes completed 2 trials in a randomized crossover and placebo-controlled design. All subjects received 6 g/day arginine (ARG trial) or placebo (CON trial) for 3 days before undertaking an intermittent anaerobic cycling test. In each exercise test, the subjects alternated 20-sec all-out exercise and 15-sec rest periods for 13 sets on a cycle ergometer. Vasodilation was measured using photoplethysmography in pre-supplementation, pre-exercise, and 0, 3, 6, 10, 30, and 60 min of post-exercise. The 2 trials had similar vascular reflection index and heart rate before the exercise test. Immediately after exercise reflection index of both trials was significantly reduced, then it showed a trend of decrease at 6 and 10 min after exercise ($p<0.1$). However, no significant difference in refection index and heart rate was found at any the same time point between the trials. There was no significant difference in power drop of each set and the decrements of peak and average power between the trials. This study suggested that the short-term arginine supplementation had no effect on exercise-induced vasodilation and performance in intermittent anaerobic tests in well-trained male judo athletes.

Keywords: Nitric oxide, NO, Endothelium-dependent vasodilation, Photoplethysmography, Anaerobic exercise

Introduction

Arginine has the potential effect on increasing endothelium-dependent vasodilation and improving exercise performance by serving as a precursor for nitric oxide (NO) synthesis [1]. Oral arginine supplementation has been reported to increase endothelium-dependent vasodilation in the forearm in patients with hypercholesterolemia [2], coronary artery atherosclerosis [3,4], essential hypertension [5] and chronic heart failure [6,7]. Arginine administration intravenously could also improve exercise-induced blood flow in the calf in subjects with chronic heart failure [8]. Arginine administration also improved endothelium-dependent vasodilation in healthy elderly and young subjects [9,10]. In addition, NO could increase exercise-induced vasodilation in healthy sedentary adults [11].

Arginine could also improve exercise capacity in patients with various cardiopulmonary diseases. It has been shown that oral arginine supplementation improved time to exhaustion and maximal oxygen consumption in patients with coronary artery diseases [4,12] and angina pectoris [13,14]. A 4-week oral arginine in combination with handgrip training has been shown to enhance maximal handgrip work in patients with chronic heart failure, by increasing endothelium-dependent vasodilation and blood flow in the forearm [6]. The evidences suggested that arginine administration orally or intravenously could also significantly reduce the accumulation of plasma lactate and ammonia, the metabolites may result in muscular fatigue, after endurance exercise or maximal graded exercise in healthy subjects [15-17]. Therefore, arginine supplementation could improve exercise capacity via attenuating exercise-induced accumulation [18].

The ergogenic effect of arginine supplementation in healthy subjects and well-trained athletes is still inconclusive. It has

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been suggested that oral supplementation of arginine combined with glycine and alpha-ketoisocaproic acid (GAKIC) prior to exercise may increase total and average power output in exhaustive anaerobic exercise in healthy young males [19,20]. Nevertheless, the role of arginine in these studies was difficult to identify due to the synergistic effect of the two other compounds on delaying muscular fatigue.

Since arginine could increase exercise-induced vasodilation and reduce the accumulation of the exercise-induced metabolites that may induce muscular fatigue, we hypothesized that oral supplementation of arginine may improve exercise performance in well-trained athletes. The purpose of this study was to determine whether short-term arginine supplementation could enhance vasodilation and prevent performance decline in intermittent anaerobic exercise in well-trained male athletes.

Methods

Subjects

Ten elite male judo athletes were recruited from National Taiwan College of Physical Education. The subjects were matched by similar body weight to avoid the potential difference in exercise performance and supplementation dosage. Exclusive criterion was consisted of known cardiovascular disease risks, musculoskeletal injuries and abnormally plasma arginine concentrations in the preliminary study. All subjects were asked to abstain from any supplements at least 3 months prior to the present study. Each athlete has received regular judo training for at least 3 years and participated in the national or international contests.

During the study period, all subjects were asked to maintain their regular training programs and diets. Each subject consumed the identical food on the day prior to the 2 trials. After the experimental procedures and possible risk were explained by the researchers, the subjects gave their written informed consent. The study protocol was approved by the Human Subject Committee of National Taiwan College of Physical Education.

Experimental design

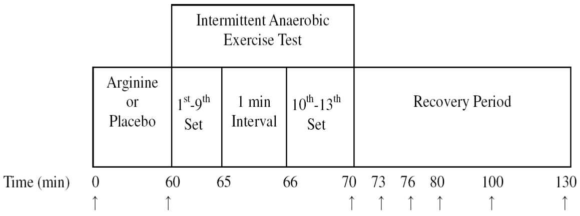

Figure. 1. The experimental protocol of intermittent anaerobic exercise test and cardiovascular function measurement. ↑ : photoplethysmography.

This study used a randomized crossover and placebo-controlled design. All subjects completed two trials, ARG and CON. The 2 trials were separated by a 4-day washout period. In the ARG trial, the subjects consumed 6 g/day arginine tablets (General Nutrition Corp., Pittsburgh, PA, USA) for 2 days. After an overnight fasting, each subject received the third dose of 6 g arginine in the morning, undertook the intermittent anaerobic exercise test 60 min after supplementation. In the CON trial, the subjects consumed the equal number of tablets containing starch. The experimental protocol is shown in Fig. 1.

Intermittent anaerobic exercise test

The test was designed to mimic the actual judo competition. Each subject practiced the same test at least once prior to the study. The subjects alternated 20-sec all-out exercise and 15-sec rest periods for 13 sets on a Monark cycle ergometer (894E, Monark, Varberg, Sweden). There was a 1-min rest after the 9th set to simulate the rest in the actual competition. The ergometer resistance was set at 0.05 kp/kg BW. The subjects were vocally encouraged to pedal as fast as possible by the researchers. In the 15-sec rest periods, the resistance was removed and the subject sustained pedaling at 60 rpm. The peak power, average power, and power drop of each set was collected through all sprints. The following equation was used to calculate power drop in each sprint set [21].

Power drop (%) = (peak power – lowest power) / peak power × 100

The decrements of peak and average power were used to represent the decline between total and maximal work of the test. The following equations were used to calculate the decrements of peak and average power, respectively [22].

Peak power decrement (%) = 100 – [total peak power / (maximal peak power × 13 sets)] × 100
Average power decrement (%) = 100 – [total average power / (maximal average power × 13 sets)] × 100

Measurement of cardiovascular function

It has been shown that transmission of infrared light through the finger is proportional to blood volume. The transmission measured by photoplethysmography gives a digital volume pulse (DVP). The DVP exhibits a characteristic notch or inflection point that can be expressed as percent maximal DVP amplitude (reflection index). Reflection index of pressure wave reflection was derived form the DVP and used to examine endothelium-dependent vasodilation. It has been reported that vasodilators such as glyceryl trinitrate produced marked changes in pulse waveform with a decrease in reflection index [23]. In this study reflection index and heart rate was determined from the right index finger by photoplethysmography (Pulse Trace PT1000, Micro Medical, Rochester, England). The data was collected before supplementation and exercise, and 0, 3, 6, 10, 30, and 60 min after exercise before blood samplings.

Statistical analysis

All data was expressed as means ± SEM. Changes in reflection index and heart rate were analyzed by a two-way analysis of variance (ANOVA) with repeated measures. The differences in cardiovascular function parameters among different time points were analyzed by post hoc Tukey's test. The cardiovascular parameters at the same time point, power drops in each set and power decrements between trials were analyzed by Student's paired t-test. The analysis was performed with SPSS for Windows 10.0 (SPSS Inc., Chicago, IL, USA). A p-value less than .05 was considered statistically significant.

Results

The subjects were 20.2 ± 0.6 years old. The height was 1.72 ± 0.02 m. The body weight in the ARG and CON trials was 73.3 ± 2.1 kg and 73.6 ± 2.0 kg, respectively. The body weight was not significantly different between the 2 trials.

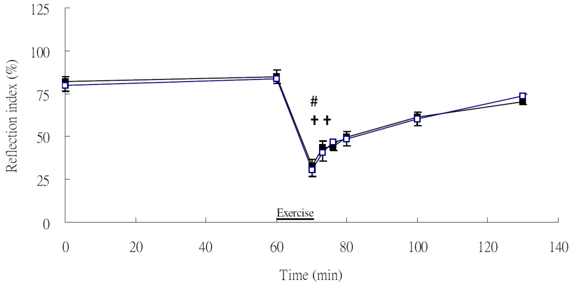

Figure 2. Vascular reflection index at each time point in ARG (■) and CON (□) trials. #p<.05 vs. 60 min in ARG trial; †p<.05 vs. 60 min in CON trial.

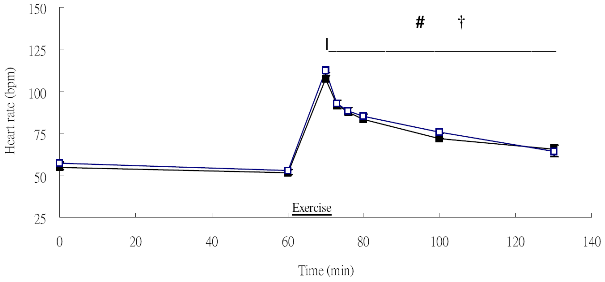

Figure 3. Heart rate at each time point in ARG (■) and CON (□) trials. #p<.05 vs. 60 min in ARG trial; †p<.05 vs. 60 min in CON trial.

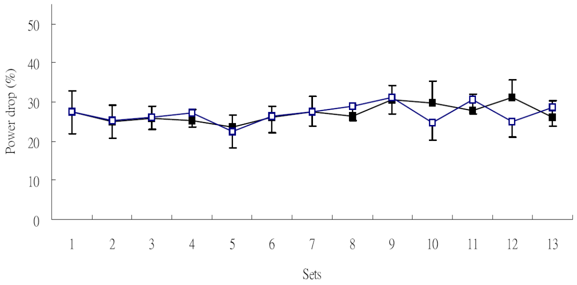

Figure 4. Power drop in each set of intermittent anaerobic exercise in ARG (■) and CON (□) trials.

Vascular reflection index, an indicator of endothelium-dependent vasodilation, at each time point in ARG and CON trials is shown in Fig. 2. Reflection index showed a significant time effect (p<.001). Before exercise, no significant difference was found between the ARG (85.0 ± 3.6 %) and CON (83.6 ± 2.9 %) trials. Immediately after exercise, the reflection index of ARG and CON significantly declined to 32.8 ± 4.3 and 30.8 ± 4.0 %, respectively. In ARG trial, there was a trend of decrease from 3 min to 30 min after exercise compared to pre-exercise (p= .058-.077). In CON trial, reflection index at 3 min after exercise (40.6 ± 4.7 %) was significantly lower than pre-exercise, and showed a trend of decease at 6 and 10 min after exercise (p= .052-.078).

Heart rate at each time point in the ARG and CON trials is displayed in Fig. 3. Heart rate showed a significant time effect (p<.001). Both trials had similar heart rate before exercise (ARG: 51.6 ± 2.2; 53.1 ± 2.4 bpm). Heart rates remained significantly higher throughout the post-exercise period compared to the pre-exercise level. Nevertheless, no significant difference was found between the 2 trials at any time point.

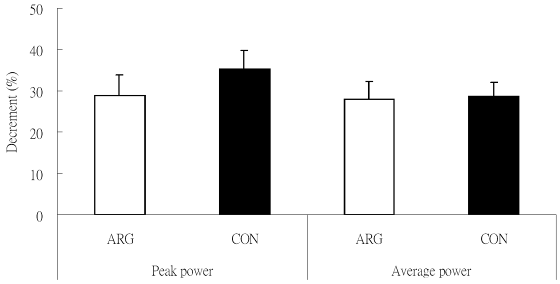

Figure 5. Power decrement of intermittent anaerobic exercise in ARG (■) and CON (□) trials.

The peak and average power of the intermittent anaerobic exercise has been published elsewhere [24]. The 2 trials had similar peak power and average power in each set. The power drop of each sprint set in ARG and CON trials is shown in Fig. 4. Power drops in both trials were 22.4-31.2% in all sets. There was no significant difference in power drops between the 2 trials in any set. Figure 5 shows the decrements of peak and average power in both trials. No significant difference in the decrements of peak power (ARG: 29.0 ± 4.9%; CON: 35.1 ± 4.5%) and average power (ARG: 28.0 ± 4.3%; CON: 28.6 ± 3.4%).

Discussion

The results of this study suggested that short-term arginine supplementation had no effect on exercise-induced vasodilation and performance in intermittent anaerobic exercise in well-trained male judo athletes.

Our results showed that power drop in each set and power decrement of the intermittent anaerobic exercise test was similar in ARG and CON trials. The exercise protocol was used to simulate the judo training and competition pattern of these elite athletes. Similarly, it has been shown that supplementation of arginine aspartate for 4 weeks did not affect the performance of a graded maximal cycling test in endurance athletes [25]. On the other hand, it has been reported that GAKIC, a combination of supplementations including arginine, could delay muscle fatigue and sustain work for at least 15 min during intensive anaerobic exercise in healthy subjects [20]. Furthermore, GAKIC attenuated the decline in mean power during repeated bouts of supramaximal exercise in healthy male college students [19]. Nevertheless, this effect may result from the combination of the compounds, rather than arginine alone.

Both ARG and CON trials showed exercise-induced vasodilation measured by reflection index. However, arginine supplementation had no additional effect on exercise-induced vasodilation in these well-trained subjects. This result was in contrast to previous studies that suggested arginine supplementation could improve exercise-induced vasodilation in subjects with various cardiovascular diseases [4,8,26]. In agreement to our results, supplementation of arginine 20 g/d for 4 weeks had no effect on forearm blood flow in healthy male [27]. Although arginine administration and regular exercise training may have additive effects on improving endothelium-dependent vasodilation in chronic heart failure subjects [6], it did not provide any additional effect on vasodilation in our well-trained subjects.

Our previous publication has shown that the short-term arginine supplementation did not alleviate exercise-induced accumulation of plasma lactate and ammonia [24]. This may partially result from the lack of additive effect of arginine on exercise-induced vasodilation. Further investigations with higher dosages or extended supplementation periods are warranted in well-trained athletes.

Conclusions

This study suggested that the short-term arginine supplementation had no additive effect on exercise-induced vasodilation and performance decline in intermittent anaerobic tests in well-trained male athletes. Further research should be critically considered with higher dosages, longer supplementing durations, or combined with other supplements.

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