

Effects of low-dose oral L-arginine supplementation on anaerobic physical performance metrics of tennis: a pilot study

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Abstract

Introduction. The potential ergogenic effects of L-arginine, a conditionally essential amino acid involved in nitric oxide (NO) synthesis, on anaerobic exercise performance remain inconclusive. **Aim of Study.** This study investigated the potential for L-arginine supplementation to improve anaerobic exercise performance in healthy young adults. **Material and Methods.** A randomized, double-blind, placebo-controlled, cross-over design was employed, with nine participants (7 males, 2 females; mean age 23.67 ± 4.09 years) completing two laboratory visits. Participants consumed either 2 grams of L-arginine or a placebo (dextrose) in cranberry juice, followed by a 30-minute rest period before performance testing. Tennis-specific exercise tests were selected, including grip strength, vertical jump height, and anaerobic cycling performance (Wingate test). **Results.** Results indicated no significant differences between L-arginine and placebo conditions in peak power output ($p = 0.57$), relative peak power output ($p = 0.65$), average power output ($p = 0.69$), or fatigue index ($p = 0.70$) during the Wingate test. Similarly, no significant differences were observed in vertical jump height ($p = 0.73$) or power output ($p = 0.73$). However, grip strength was significantly lower in the L-arginine condition compared to placebo ($p = 0.03$). **Conclusions.** These findings do not support the hypothesis that acute L-arginine supplementation enhances anaerobic exercise performance.

KEYWORDS: L-arginine, anaerobic exercise, power output, tennis, anaerobic performance, fatigue onset.

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Introduction

Investigating the impact of nutritional supplements on exercise performance has garnered a great deal of attention within the research performed today in sports science. Amidst the abundance of supplements analyzed for their possible ergogenic benefits, L-arginine, a conditionally essential amino acid that aids the body in building protein [1], has accumulated some interest. L-arginine plays a crucial role in the synthesis and amalgamation of nitrogen monoxide (NO). NO is essential for numerous physiological processes, including vasodilation [2]. Considering the role L-arginine plays in vasodilation, it has been proposed that this supplement could enhance anaerobic exercise performance [3].

Anaerobic exercise depends extensively on the athlete's ability to metabolize substrates through the phosphagen and glycolytic energy systems for immediate energy production, which leads to the rapid build-up of lactate and ammonia, followed by muscle fatigue [4, 5]. As a contributor to vasodilation [2], the potential capabilities of L-arginine to alleviate these outcomes [5] may be of interest to individuals attempting to maximize their

anaerobic exercise performance. Acute L-arginine supplementation may also reduce fatigue during anaerobic exercise, as discussed in Yavuz et al. [6], who found that acute L-arginine supplementation increased time to exhaustion among young, healthy male athletes performing anaerobic exercise. Despite the theoretical support for supplementation of L-arginine, evidence that supports the effectiveness of the supplement to improve anaerobic exercise performance continues to be mixed, with studies reporting varying results and outcomes [7]. Research using L-arginine to study the ability of NO precursors to improve exercise performance has shown promising results [8].

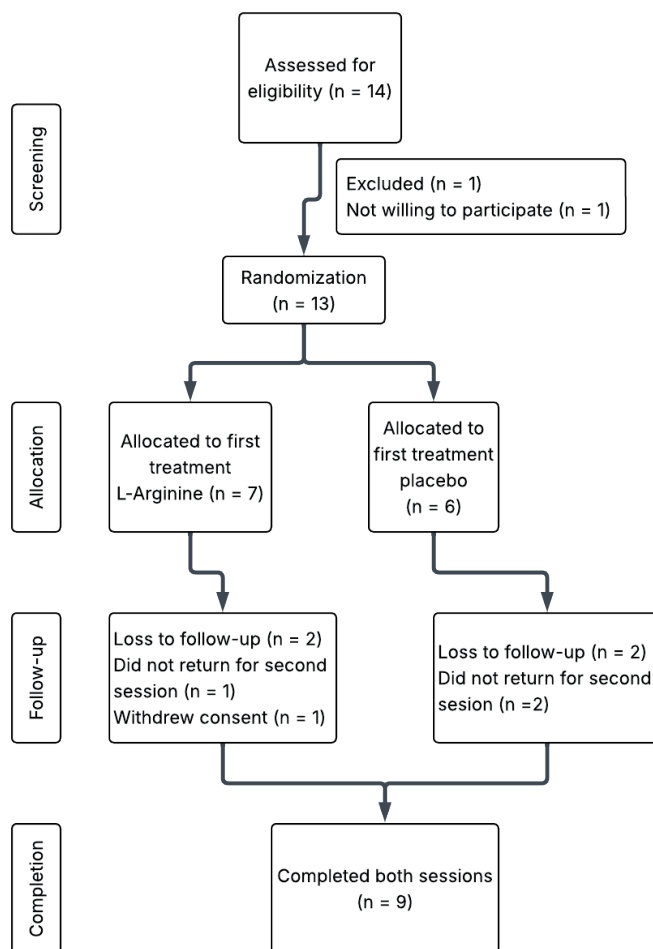
The purpose of this study is to investigate the effects of L-arginine on anaerobic exercise performance in healthy young adults. More specifically, it aims to evaluate whether acute consumption of L-arginine at a low dosage can significantly enhance outcomes in common anaerobic performance parameters, including grip strength, jump height, and peak and average power output during a Wingate anaerobic cycle ergometer test. These tests were chosen for their relation to tennis performance [9]. Greater handgrip strength has been shown to correlate with increased serve velocity in tennis players [10, 11]. Additionally, tennis serve velocity has been shown to be influenced by countermovement jump performance [11]. Based on current research findings, oral supplementations of L-arginine may be associated with improvements and enhancements in anaerobic performance, demonstrated by enhanced peak power output and the attenuated onset of fatigue in individuals participating in high-intensity interval workouts, when compared to a control group consuming a placebo. We hypothesized that acute supplementation with L-arginine would result in better anaerobic exercise performance when compared to a placebo condition.

Material and Methods

Participants

A total of 9 participants (7 males and 2 females) were included in this pilot study (Figure 1). Participants were recruited locally through the University of Manitoba. Six participants were university students, two were working professionals, and one was a professional volleyball player. 14 participants were assessed for eligibility. 13 participants proceeded to randomization. 4 participants were lost to follow-up. All participants were healthy adults between the ages of 18 and 39 years of age (mean age of 23.7 ± 4.1 years). Exclusion criteria for the study included any of the following: cardiovascular disease;

metabolic disease; neurological disease; psychological disease; prescription or non-prescription medication use; and allergy to any ingredients in the supplements.

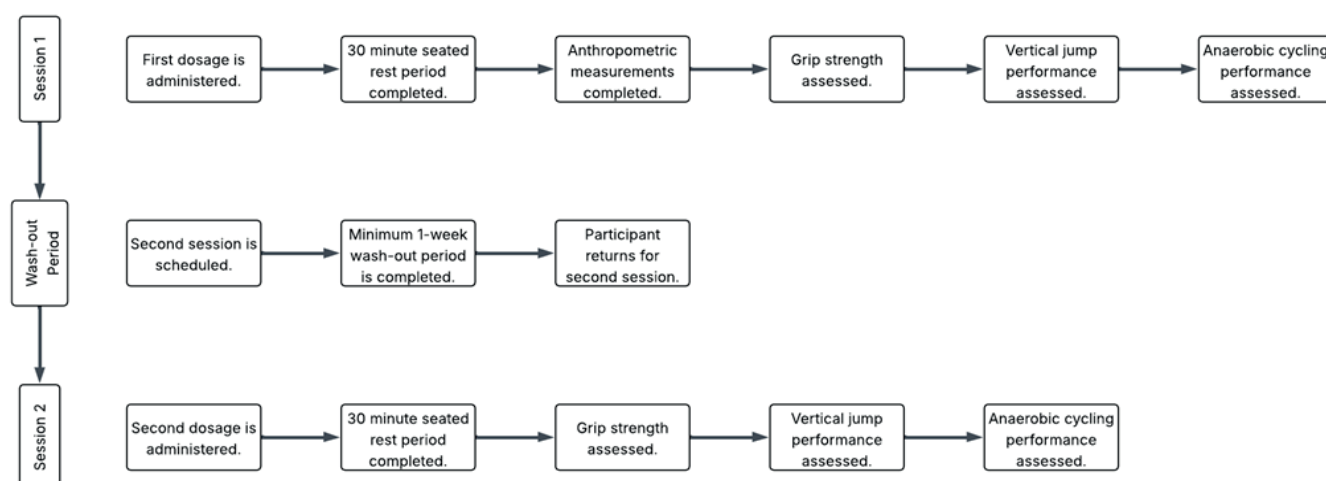


A total of 14 ($n = 14$) individuals were screened for eligibility. Five ($n = 5$) individuals withdrew from participation, and nine ($n = 9$) participants completed the pilot study.

Figure 1. CONSORT flow diagram

Research design

This pilot study utilized a randomized, double-blind, placebo-controlled, cross-over design in which participants were placed into one of two supplement groups at each visit: L-arginine or placebo (dextrose; see Figure 2). The participants were required to complete two laboratory visits where measurements and testing were completed. On the first visit, anthropometric measurements – including height, weight, waist circumference, BMI, and bioelectrical impedance analysis (BIA) – were taken, in addition to completion of the first testing protocol, if eligible. To ensure full supplement washout, participants returned



All participants followed this protocol exactly. Ethical approval was sought and obtained from the host university's research ethics board (protocol number: HE2024-0063). Clinical trial registration was sought and obtained from the www.clinicaltrials.gov (registration number: NCT06475391). Informed consent was obtained from each participant prior to administration of the supplement and testing.

Figure 2. Visualization of the pilot study protocol

for completion of the remaining testing protocol after a minimum of one week. The dependent variables measured 30 minutes after consumption of the supplement were grip strength, vertical jump performance, and anaerobic Wingate cycling performance.

Randomization protocol

Randomization and administration of supplement and placebo dosages were managed by an external research assistant uninvolved in data collection to maintain the double-blind, placebo-controlled nature of this pilot study. Randomization was performed for a total of 20 ($n = 10$ male, $n = 10$ female) participants prior to screening and recruitment. Randomization was completed using the website sealedenvelope.com with the following settings: Treatment Groups: Supplement, Placebo; Block Sizes: 10, 10; List Length: 20; Strata: Male; Female. To facilitate data management and administration of supplement and placebo dosages, participants were assigned a letter identifier based on sex, and a number identifier based on order of recruitment at the time of enrollment.

Supplementation protocol

Participants were administered either two grams of L-arginine (NOW Sports, NOW Foods, Guelph, ON, Canada) or two grams of placebo dextrose (NOW Real Food, NOW Foods, Bloomington, IL, USA), mixed with 250 mL of cranberry juice. This is the absolute maximum allowable dose under Health Canada regulations. Dosage consumption was followed by a 30-minute seated rest period prior to testing to allow for

uptake [12]. An external research assistant uninvolved in testing administered each dosage to maintain the double-blinded nature of the study.

Anthropometric measurements

Height, body mass, BMI, body fat percentage, fat mass, and fat-free mass were collected for each participant. Fat mass, fat-free mass, body fat percentage and total body mass were measured using a BIA device (InBody 270, Cerritos, CA, USA) with hand and foot electrodes. Height was measured using a stadiometer (Seca 213, Hamburg, Germany).

Tennis performance metrics testing

Grip strength

Isometric strength was measured using a handgrip dynamometer (Baseline Smedley Electric Hand Dynamometer, model 12-0286, White Plains, NY, USA). Participants stood with the dynamometer held at their side in the dominant hand, maintaining a straight arm and a neutral wrist position. Participants were instructed to squeeze the dynamometer as hard as possible with a smooth application of force for 5 seconds. Three trials were completed with 60 seconds of rest between trials. Isometric grip strength was calculated as the mean score across the three trials.

Vertical jump performance

The Vertec Vertical Jump Trainer (Sports Imports, Columbus, OH, USA) was used to assess vertical jump performance. Standing reach height was determined by having participants stand directly beneath the target

vanes with their feet flat on the floor, reaching upwards to push the highest vane possible with their dominant hand. Participants then performed countermovement jumps, with a 60-second rest interval, until two consecutive jumps failed to reach a higher target vane. Maximum jump height was calculated as the difference between the highest jump height achieved and the recorded standing reach [Vertical Jump Height (cm) – Standing Reach Height (cm)]. Average and peak vertical power were determined using the following equations described by Johnson and Bahamonde [13]: (i) Average Vertical Power (W) = $[43.8 \times \text{Vertical Jump (cm)}] + [32.7 \times \text{Mass (kg)}] - [16.8 \times \text{Height (cm)}] + 431$; (ii) Peak Vertical Power (W) = $[78.6 \times \text{Vertical Jump (cm)}] + [60.3 \times \text{Mass (kg)}] - [15.3 \times \text{Height (cm)}] - 1308$.

Anaerobic cycling performance

A 30-second Wingate test with a resistance equal to 7.5% of body mass was administered to measure anaerobic capacity and anaerobic power outputs [14]. The test was completed using a Monark Ergonomic 894E cycle ergometer (Vansbro, Dalarna, Sweden). Participants were familiarized with the Monark 894E cycle ergometer and instructed on how to perform the 30-second Wingate test prior to testing. They were instructed to pedal at their maximum speed before the 7.5% body-mass resistance was activated and then to maintain their highest possible pedaling speed for the duration of the test. Before testing, participants completed a five-minute warm-up at a resistance of 50 W at a self-selected pedaling cadence. Peak power (PP) and average power (AP) were recorded during the 30-second maximal anaerobic cycle ergometer test. Relative PP and relative AP were determined through: (i) Relative PP (W/kg) = $[\text{PP (W)}] / [\text{Body Mass (kg)}]$; (ii) Relative AP (W/kg) = $[\text{AP (W)}] / [\text{Body Mass (kg)}]$. The Fatigue Index (FI) was used to quantify the decline in power output over the course of the maximal exercise bout. The following equation for FI was used to determine the percent change in power output: $(\text{Peak Power} - \text{Minimum Power} / \text{PP}) \times 100$ [14].

Statistical Analysis

Data are presented as mean $\pm$ standard deviations. A Shapiro-Wilk test was used to determine whether the data were normally distributed. A dependent samples t-test was performed to compare the L-arginine and placebo conditions for all measured variables. All statistical analyses were conducted using Statistica version 13.3 (TIBCO, Santa Clara, CA, USA) with $p \leq 0.05$ considered statistically significant.

Results

Anthropometric measurements

Participants had a mean height of 176.8 ± 10.8 cm, a mean body mass of 79.3 ± 11.0 kg, a mean BMI of 25.4 ± 2.5 , a mean body-fat percentage of 17.4 ± 12.2 , a mean fat mass of 13.7 ± 9.7 kg, and a mean fat-free mass of 65.6 ± 14.3 kg.

Wingate anaerobic cycle ergometer test

PP in watts during the Wingate maximal cycle ergometer test did not differ significantly between supplementation conditions, $t(8) = 0.59$, $p = 0.57$ (Table 1). Similarly, relative peak power (RPP) in watts per kilogram of body mass did not differ significantly between the conditions, $t(8) = 0.47$, $p = 0.65$ (Table 1). Furthermore, AP output, $t(8) = 0.41$, $p = 0.69$, relative average power output, $t(8) = 0.36$, $p = 0.73$, and FI, $t(8) = 0.39$, $p = 0.70$, were not significantly different between L-arginine and placebo conditions in this cohort (Table 1).

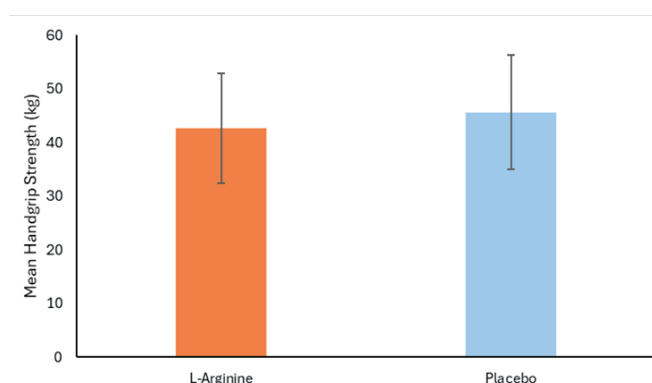
Table 1. Wingate cycle ergometer performance outcomes for L-arginine and placebo conditions

Variable - Condition	Mean $\pm$ SD	<i>p</i> -value
PP-A (W)	771.37 $\pm$ 206.42	0.57
PP-P (W)	760.43 $\pm$ 201.78	
RPP-A (W/kg)	9.64 $\pm$ 1.67	0.65
RPP-P (W/kg)	9.53 $\pm$ 1.88	
AP-A (W)	589.37 $\pm$ 152.67	0.69
AP-P (W)	583.29 $\pm$ 155.99	
RAP-A (W/kg)	7.36 $\pm$ 1.14	0.73
RAP-P (W/kg)	7.29 $\pm$ 1.34	
FI-A (%)	58.90 $\pm$ 12.30	0.70
FI-P (%)	56.47 $\pm$ 12.84	

Note: PP-A – peak power-L-arginine, PP-P – peak power-placebo, RPP-A – relative peak power-L-arginine, RPP-P – relative peak power-placebo, AP-A – average power-L-arginine, AP-P – average power-placebo, RAP-A – relative average power-L-arginine, RAP-P – relative average power-placebo, FI-A – fatigue index-L-arginine, FI-P – fatigue index-placebo

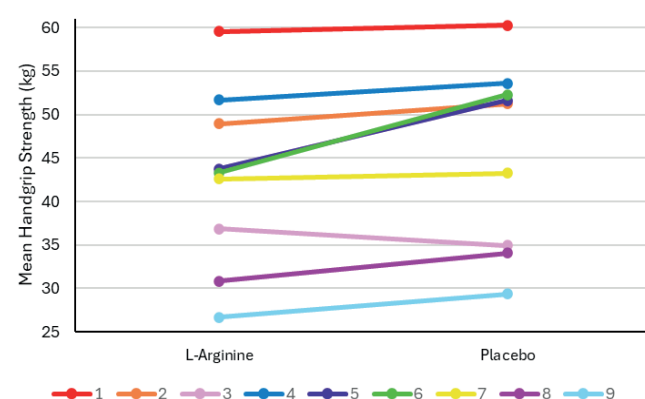
Handgrip strength test

The results for handgrip strength indicate that performance in the placebo condition ($M_{\text{Pla}} = 45.6 \pm 10.6$ kg) was significantly greater than in the L-arginine condition ($M_{\text{Arg}} = 42.7 \pm 10.2$ kg), $t(8) = -2.5$, $p = 0.03$ (Figures 3 and 4).



Mean handgrip strength (in kilograms) was averaged from three trials per participant ($n = 9$). Results indicate significantly improved performance under the placebo condition ($MPl_a = 45.63 \pm 10.64$ kg), $t(8) = -2.54$, $p = 0.03$.

Figure 3. Change in handgrip strength (kg) by treatment condition



Mean handgrip strength (in kilograms) was averaged from three trials per participant ($n = 9$). Results indicate significantly improved performance under the placebo condition ($MPl_a = 45.63 \pm 10.64$ kg), $t(8) = -2.54$, $p = 0.03$.

Figure 4. Change in handgrip strength (kg) by participant and treatment condition

Vertical jump test performance

All three vertical jump performance metrics compared between L-arginine supplementation and placebo demonstrated no significant differences between conditions, $t(8) = -0.35$, $p = 0.73$ (Table 2).

Table 2. Vertical jump performance measures for L-arginine and placebo conditions

Variable - Condition	Mean $\pm$ SD	p-value
VJ-A (cm)	59.69 $\pm$ 17.39	0.73
VJ-P (cm)	60.95 $\pm$ 16.04	

PVP-A (W)	5522 $\pm$ 1655.10	0.73
PVP-P (W)	5621.65 $\pm$ 1299.79	
AVP-A (W)	2957.81 $\pm$ 831.30	0.73
AVP-P (W)	3012.81 $\pm$ 645.87	

Note: VJ-A – vertical jump height-L-arginine, VJ-P – vertical jump height-placebo, PVP-A – peak vertical power-L-arginine, PVP-P – peak vertical power-placebo, AVP-A – average vertical power-L-arginine, AVP-P – average vertical power-placebo

Discussion

The purpose of this pilot study was to investigate the effects of acute L-arginine supplementation on the anaerobic exercise performance parameters – grip strength, jump height, and Wingate power output – in healthy young adults. We hypothesized that acute supplementation of L-arginine would result in better anaerobic exercise performance compared to performance in a placebo condition. Contrary to the hypothesis, results indicated that acute low-dosage oral supplementation of L-arginine did not result in significant performance improvements among anaerobic exercise parameters. This pilot study found that performance outcomes in the Wingate anaerobic cycling test, vertical jump test, and handgrip strength test did not show improvements following L-arginine consumption compared to the placebo condition. PP output, RPP output, AP output, and FI during the Wingate test demonstrated no statistically significant differences between the two conditions ($p > 0.05$). Likewise, vertical jump height and associated power metrics showed no performance enhancements from L-arginine supplementation ($p = 0.73$). Interestingly, grip strength was significantly lower in the L-arginine condition compared to placebo ($p = 0.03$). The anaerobic exercise test results do not support the theory that L-Arginine supplementation can improve tennis performance.

The results of prior research examining the effects of L-arginine supplementation on acute anaerobic exercise performance are varied. Olek et al. [15] examined acute L-arginine supplementation in healthy adults. Similarly to this pilot study, two grams of L-arginine were administered orally 60 minutes prior to the performance of a Wingate Anaerobic Test. Their findings demonstrated no performance differences between the supplemented and placebo trials, further supporting the inefficacy of L-arginine supplementation for enhancing exercise performance. Similarly, the results of this pilot study showed no significant improvements in anaerobic performance, including Wingate test outcomes.

Additionally, Greer and Jones [16] found that acute oral L-arginine supplementation provided no performance-enhancing benefits in resistance-exercise tasks and suggested that the L-arginine-based nitric oxide production, which stimulates vasodilation, may actually reduce both range of motion and total force generation in skeletal muscles. This aligns with the results of the present pilot study, which identified a decrease in handgrip strength performance following L-arginine supplementation. Finally, Meirelles and Matsuura [17] and Álvares et al. [12] both concluded that acute supplementation of L-arginine provides no significant enhancement to anaerobic exercise performance. The results of this pilot study are consistent with these findings.

In line with the results of this study, a review by Gonzalez et al. [18] likewise reported minimal evidence supporting any short-term benefits from oral supplementation of L-arginine or other nitric-oxide-stimulating supplements. It is possible that oral L-arginine supplementation acted as a confounding factor when examining its efficacy for improving anaerobic exercise performance in this study, as research suggests that shortly after ingestion L-arginine undergoes extensive catabolism, resulting in very low bioavailability [18]. Our research did not assess any direct measures of nitric oxide metabolism, blood flow, or lactate and ammonia production; therefore, it is speculative to conclude that catabolism of L-arginine occurred. Future research may wish to examine other methods of supplementation.

Although support for acute, independent L-arginine supplementation to enhance anaerobic exercise performance is limited – as reflected in this pilot study, which found no significant improvement in anaerobic performance – there is some evidence that another form of arginine, arginine α -ketoglutarate, can enhance anaerobic exercise performance when combined with creatine. Little et al. [19] found that a combination of arginine α -ketoglutarate and creatine enhanced bench-press repetitions and increased peak power during anaerobic cycling (Wingate) tests.

Ultimately, there remains inconsistency among studies examining L-arginine supplementation, even with the inclusion of alternative forms of arginine that have been investigated. Further research is required to elucidate the effects of this supplement on anaerobic performance. Supplementation of arginine α -ketoglutarate may prove to be an alternative to L-arginine supplementation. Future research should examine the effects of higher acute dosage of L-arginine, the timing of consumption,

the training status of the subject, and the nature of the tasks that are being evaluated.

Strengths of this pilot study include its easily replicable methods and the consistency of results across participants, regardless of occupation, suggesting that these outcomes are generalizable to healthy adults aged 18 to 39. Some novelty lies in the examination of these three performance tests together, across one group of participants. The maximum allowable dose of L-arginine according to Health Canada regulations (2 grams) was used. Quantifiable data and researchers' subjective observations suggest that participant motivation was high during both testing sessions.

The limitations of this pilot study include the relatively low dosage of L-arginine administered (2 g per participant). A higher dosage might have yielded statistically significant results but would have required approval from the Health Canada regulatory body. The low dose used in this study may not have been enough of a physiological stimulus to improve anaerobic exercise performance with the various parameters assessed in this research. It is suggested that a much higher dose be used in future research to better determine the potential anaerobic performance-enhancing effects that L-arginine may have. Additionally, the total participant sample was low ($n = 9$), which may have limited our ability to detect significant differences between conditions. The low sample size could have increased the likelihood of a type II statistical error, reduced statistical power, and decreased the generalizability of the results. Furthermore, our participants were quite heterogenous in their physical fitness training status, which likely introduced additional variability into the outcomes; this variability may have been reduced by increasing participant homogeneity. Future research examining L-arginine supplementation should consider using higher dosages in larger participant samples.

Conclusions

In summary, acute low dose L-arginine supplementation does not provide any significant enhancement to anaerobic exercise performance and may hinder anaerobic strength performance (i.e., grip strength). This study found no statistically significant results that would suggest that acute L-arginine supplementation enhances anaerobic exercise performance in healthy young adults. Despite theoretical support for its role in NO production, vasodilation, and improved time to fatigue, performance outcomes in grip strength, vertical jump, and the Wingate anaerobic cycling test did not change following L-arginine supplementation. Instead,

grip strength was significantly lower with L-arginine supplementation compared to the placebo. However, a small sample size and relatively low dosage (2 grams) make it difficult to draw concrete conclusions about the efficacy of L-arginine for anaerobic exercise performance. Future research should explore higher dosages, a wider variety of timings, tasks, and types of exercise, participant training status, alternative NO precursors, and larger, more diverse participant samples to better understand the role of L-arginine in anaerobic performance. Although L-arginine may remain a promising supplement in other physiological contexts, its efficacy for enhancing tennis-related exercise performance may be limited.

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Conflict of Interest

The authors declare no conflict of interest.

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