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A SINGLE DOSE OF VITAMIN C MAY NEGATIVELY AFFECT AEROBIC POWER IN SOME INDIVIDUALS

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ABSTRACT

Traditionally, the research effects of vitamin supplementation upon health and exercise performance have been a favorite topic. Recent investigations have shown that large doses of vitamin C may enhance endothelial responses. Therefore, vitamin C (as a vasodilator) may provide a possible ergogenic benefit by maintaining high blood flows to the heart and skeletal muscles. Unfortunately, previous investigations into the effect of vitamin C on exercise parameters have produced inconclusive results. In agreement with several previously published reports, this study demonstrated that vitamin C had no impact on maximal aerobic power ($\dot{V}O_2$max), and therefore, will not enhance aerobic performance. In fact, further analysis of the data revealed that such an ingestion prior to exercise might negatively impact some individuals.

Keywords: vitamins, supplementation, athletic performance, and ergogenic aid

Introduction

Traditionally, the research effects of vitamin supplementation upon health and exercise performance have been a favorite topic. Vitamin C has been one of the most popular vitamins to be investigated and recent investigations have shown that large doses of vitamin C (1000 and 2000 mg) may enhance endothelial responses (11, 14). The ability of vitamin C to support vasodilatation suggests that this vitamin may provide a possible erogogenic benefit by maintaining high blood flows to the heart and skeletal muscles. While ingestion of vitamin C has been demonstrated to improve some aspects of clinical pathology, such large doses taken chronically may actually impair vascular function. Even though vitamin C is a proficient scavenger of superoxide ions and other reactive oxygen species, it can also act as a pro-oxidant to generate free radicals in the presence of ferric ions (13). Unfortunately, previous investigations into the effect of vitamin C on exercise parameters have produced inconclusive results. Some researchers have reported a positive impact on physical performance (2, 5, 6, 7), others have noted a negative impact (8) and still others have seen zero influences (4, 9, 12). The inconsistencies of vitamin C effect between these studies are probably related to the diversity of the experimental designs. These studies have varied with respect to physical performance measures (e.g. muscular strength, endurance and aerobic capacity), vitamin C dosage (500 - 2000 mg), dose frequency (acute vs. chronic) and subject's training status. Most importantly, none of these studies implemented a cross-

over design so that subjects could serve as their own controls. Therefore, the multitude of experimental designs has made it difficult to elucidate the true effects, adverse or beneficial, that large doses of vitamin C have on physical performance. Hence, the purpose of this study was to use a cross-over design and investigate the effects of a single dose of vitamin C (1000 mg) on cardiovascular endurance in young, healthy, physically active adult subjects.

Methods

Fourteen female and eight male subjects were recruited for the study. Subject characteristics are presented in Table 1. The Louisiana State University Institutional Review Board approved the protocol. After a detailed explanation of the procedures involved and consent obtained from the subjects, anthropometric measurements (height & weight) were taken. The study was a randomized double blind cross-over design. The trials were balanced to ensure that the initial treatment was equally represented.

Experimental Trials

Subjects reported to the laboratory following a 4-hour fast. Four hours prior to the exercise protocol, the subjects consumed either the placebo (sugar pill) or the vitamin C (1000 mg) pill. Oxygen consumption ($\dot{V}O_2$) was obtained using a Quinton Q-plex I respiratory metabolic system. The gas analyzers were calibrated immediately prior to the experimental trial using standard reference gases. The tests were conducted on a Monark bicycle ergometer using the Åstrand protocol (1). This protocol was chosen to ensure that the subject reached a steady-state level of exercise before progressing to a more difficult stage. The subject was allowed a 2-minute warm-up period consisting of unloaded pedaling at a self-selected pace. Following the warm-up period, the subject was instructed to maintain a pedal rate of 100 rpm with a set resistance of 1 kilopond. At the end of the six minutes, the resistance increased by 0.5 kilopond and increased another 0.5 kilopond every 6 minutes thereafter. The test continued until the subject could no longer maintain 100 rpm for 20 seconds, or reached volitional fatigue. When either of the two criteria was met, the test was terminated. During the test, O_2 consumption, heart rate, blood pressure, and ratings of perceived exertion (RPE) were recorded. The two experimental trials took place at the same time of day and were separated by at least three days. The ambient temperature in the laboratory was maintained at approximately 21˚C throughout the duration of the study.

Statistics

The two experimental trials were analyzed using a paired t-test. A significance level of $p < 0.05$ was chosen *a priori*.

Results

There was a non-significant difference between trial 1 and trial 2, indicating an absence of a carry-over effect. Table 2 presents the maximal oxygen consumption of each trial (vitamin C vs. placebo). The paired t-test revealed a non-significant ($p >$

Table 1. *Anthropometric data (Means, ±SD & ranges of the participants)*

Subjects	Age (yr)	Ht (cm)	Wt (kg)
n = 22	22 ± 2 (20-30)	170.7 ± 11.7 (160.0 -195.6)	69.9 ± 18.0 (47.7-107.7)

Table 2. *Means and standard deviations for treatments*

	Vitamin C	Placebo	p	Trial 1	Trial 2	p
$\dot{V}O_2max$ ($ml \cdot kg^{-1} \cdot min^{-1}$)	49.1 + 8.9	48.6 + 7.8	.670	48.6 + 8.	49.0 + 8.4	.727

Table 3. *Means and standard deviations for responders and non-responders with 1000 mg vitamin C ingestion*

		Vitamin C	Placebo	p	Trial 1	Trial 2	p
Responders	$\dot{V}O_2max$ ($ml \cdot kg^{-1} \cdot min^{-1}$)	52.1 + 10.2	47.1 + 9.9	*.0003	49.2 + 10.2	49.9 + 10.5	.688
Non-Responders	$\dot{V}O_2max$ ($ml \cdot kg^{-1} \cdot min^{-1}$)	46.0 + 6.4	50.0 + 5.0	*.002	47.9 + 6.4	48.1 + 5.9	.962

* Significant difference

0.05) difference between the placebo and vitamin C treatments.

It should be noted however, that 11 of the 22 subjects did increase their $\dot{V}O_2max$ significantly. When this data was analyzed separately using a pair t-test, significant ($p < 0.05$) results were obtained, as shown in Table 3. Interestingly, the remaining 11 subjects demonstrated a significant ($p < 0.05$) decrease in $\dot{V}O_2max$ with vitamin C supplementation (Table 3). Again, there were no significant differences between trial 1 and trial 2, eliminating a carry-over effect. The significant differences observed between the placebo and vitamin C treatment is unexplained for these two groups of subjects (responders and non-responders to vitamin C).

Discussion

To date, research on the effects of vitamin C upon exercise performance has been inconclusive. This study, in an effort to provide a clearer picture in the relationship between vitamin C and aerobic power, utilized a cross-over design. Supporting the works of Margaria et al. (12), Gey & Cooper (4) and Keren & Epstein (9), this study demonstrated that vitamin C has no impact on maximal aerobic capacity ($\dot{V}O_2max$). Further analysis of the data revealed that exactly 50% of the subjects had a significant increase and 50% had a significant decrease in $\dot{V}O_2max$, suggesting that the interaction between vitamin C and exercise may be complex. The cross-over design utilized in this investigation might have been instrumental in revealing the differing responses to vitamin C supplementation. The existence of two differing respondent populations may help explain why various studies demonstrated such diverse results. Unfortunately, the nature of this study does not provide any information to determine if the existence of responders and non-responders is a true phenomenon and not just serendipitous selection of subjects. However, the negative and positive benefits of vitamin C supplementation during the present investigation may be related to the redox state of the muscles.

During resting conditions and especially during strenuous exercise, reactive oxidant intermediates (e.g. hydroxyl radicals, superoxide ions, and hydrogen peroxide) are continually produced within the muscle (3, 10, 16). Myocytes are able to maintain re-

dox homeostasis through a variety of antioxidant mechanisms so that cytosolic oxidants are maintained at low levels (15). Therefore, reactive oxidant intermediates (ROI's) are intricately regulated by endogenous antioxidants for optimal muscle contraction. Any perturbations of the redox state (i.e. an accumulation of excess oxidants or excess oxidant depletion) will compromise contractile function (15). Reid suggests that exposing passive muscles to exogenous antioxidants (e.g. vitamin C supplementation) can deplete intracellular ROI's. This would markedly alter redox state by reducing cytosolic oxidant levels and subsequently lead to a loss of contractile function. Consuming large doses of exogenous antioxidants during resting conditions (i.e. prior to exercise) in this investigation may have altered the redox homeostasis severely enough to effect the outcome of the exercise protocol. The variation observed between the two differing respondent populations may have been dependent upon their initial redox state at the time of vitamin C ingestion. However, there is no data to support this contention.

Consistent with the current investigation, Bramich and McNaughton (2) demonstrated a non-significant increase in $\dot{V}O_2$max following a single ingestion of vitamin C. Similarly, the ingestion was given prior to exercise and at a much higher dose (2000 mg) than utilized in this study. Margaria and Rovelli (12) suggest that larger doses of vitamin C may actually decrease aerobic performance by serving as a pro-oxidant. Even though recent investigations have demonstrated beneficial health effects from the ingestion of large doses of vitamin C in clinical populations (11, 14), the true effects of vitamin C supplementation remains unclear for the healthy population. Therefore, further research needs to be conducted before recommending such large doses to the general population.

Conclusion

The overall results of this investigation indicate that a single dose supplementation of vitamin C prior to exercise has no beneficial effect. However, further analysis of the data revealed two divergent responses to supplementation. While half the subjects increased $\dot{V}O_2$max significantly with ingestion, more interestingly the remaining half of subjects suffered a significant decline in $\dot{V}O_2$max. The respondent population may actually benefit from such ingestion, while the non-respondent population may be aerobically impaired. Unfortunately, the nature of this study does not provide any information to determine if the existence of responders and non-responders is a true phenomenon. Further, this investigation only utilized a single ingestion of vitamin C and therefore cannot account for any alterations in aerobic power that may occur with chronic ingestion. The literature has suggested that vitamin C may be beneficial to certain clinical populations; however given the results presented herein, such large doses recommended to the general population may not be prudent.

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