

Brief Report

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Brief Report

Nitrate is Ineffective in Improving Exercise Performance when Ingested long-Term with Higher Doses – Is Less More?

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Abstract: This brief report presents a comparative analysis to examine differences in the mean dose of nitrate supplementation between studies with positive and negative results on exercise performance. Protocols of at least six days that had positive results used lower nitrate doses (~7.7 mmol), whereas those with negative results used higher doses (~10.2 mmol), showing a statistically significant difference ($p < 0.05$). These findings suggest long-term supplementation with higher doses (~10.2 mmol) may not improve exercise performance. Further research is essential to understand the underlying mechanisms.

Keywords: nitric oxide; nitrate; optimal dose; supplementation

Introduction

Exercise performance is influenced by various factors, including the utilization of ergogenic aids, such as nutritional compounds. Within the realm of sports nutrition, determining optimal dosages for these compounds remains an essential area of interest [1]. Consequently, much research has been conducted to explore the effects of different compounds and their dosages on exercise performance [2]. Nitrate, for instance, has garnered significant attention [3] due to its potential to enhance performance in exercise [4].

Nitrate can be found in vegetables like radishes, beetroot, and dark leafy greens. It is widely known that nitrate ingestion can stimulate endogenous nitric oxide synthesis [5]. As a result, nitrate intake not only aids in reducing blood pressure [6,7] but also holds promise for individuals striving to improve their athletic performance. Previous studies have demonstrated the effectiveness of nitrate in increasing power output [8] and extending time to exhaustion [9]. These findings have been further substantiated by a recent study published in *Advances in Nutrition* [10]. While this meta-regression showed a diminishing effect of nitrate at higher doses after a two-day ingestion period [10], exploring the data from an alternative perspective can offer valuable insights and contribute to a broader understanding of nitrate consumption's impact on exercise performance [11].

Accordingly, it would be relevant to group the data points from primary studies based on the observed outcomes (i.e., significant improvement *versus* no significant improvement) and conduct a comparative analysis of the mean doses. This approach would enhance the certainty of the previous systematic review findings, particularly concerning the effectiveness of nitrate supplementation above 9.9 mmol for long-term use [10]. Additionally, investigating the possible disparity in the optimal dosage between shorter-term and long-term nitrate ingestion will contribute to a broader scientific understanding of the optimal nitrate dose, potentially guiding dosing strategies in the sports nutrition field.

Therefore, here I aimed to evaluate the mean supplemented doses of studies that showed significant improvement with those that did not have statistically significant improvements.

Methods

The data points were obtained from the result table of a previous systematic review [10]. Only exercise performance outcomes were included in the analysis, such as exercise tolerance, time-to-completion, and power output. As a result, physiological variables, including blood pressure, heart rate, oxygen saturation, and oxygen consumption, were excluded [10]. The data points were then categorized into three different ranges of supplementation duration in days (1 day; 2 to 5 days; ≥ 6 days). I tested all continuous variables for normality using the Shapiro-Wilk test, recognized for its robustness [12]. Subsequently, data points from the primary studies were categorized by outcome, and mean doses were subjected to comparison using a t-test for independent samples. Specifically, I examined whether there was a significant difference in the mean dose between data points with favorable outcomes (i.e., statistically significant improvement in exercise performance with $p \leq 0.05$) and those manifesting unfavorable outcomes (i.e., no statistically significant improvement in exercise performance with $p > 0.05$). In the event of non-parametric variables (i.e., those not following a normal distribution), appropriate non-parametric tests, such as the Mann-Whitney U test, would be employed for their analysis [13]. Data points with unavailable doses and those analyzed using the magnitude-based inference method were excluded due to concerns about the potential for increased type I error [14–17]. All analyses were performed using SPSS software (version 25).

Results

A total of 231 data points were used to perform comparisons. There were no significant differences between the means of supplemented doses in the categories of 1 day (Mean \pm SD, Favorable result: 10.4 ± 3.9 mmol; Unfavorable results: 9.2 ± 4.4 mmol; [$t(116) = -1.211$; p -value = 0.228]; Figure 1A) or 2 to 5 days of supplementation (Mean \pm SD, Favorable result: 8.4 ± 3.0 mmol; Unfavorable results: 8.5 ± 2.3 mmol; [$t(38) = 0.101$; p -value = 0.357]; Figure 1B). On the other hand, there was a significant difference in mean doses when comparing studies with a duration of ≥ 6 days (Mean \pm SD, Favorable result: 7.7 ± 2.5 mmol; Unfavorable results: 10.2 ± 3.6 mmol; [$t(71) = 2.913$; p -value = 0.005]; Figure 1C).

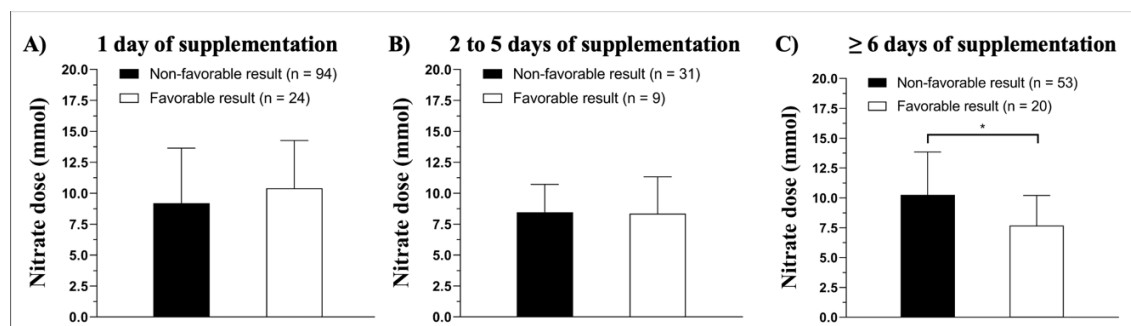


Figure 1. Comparison of the mean nitrate dose between studies with favorable outcomes (represented by white bars) and unfavorable outcomes (represented by black bars) categorized by duration (A = 1 day; B = 2 to 5 days; C = ≥ 6 days). * ($p < 0.05$) denotes a significant difference.

This means that among studies with an ingestion protocol lasting at least six days, those that yielded favorable results employed lower doses (~ 7.7 mmol). Conversely, studies with unfavorable outcomes utilized higher doses (~ 10.2 mmol).

Discussion

This comparative analysis suggests that the optimal dosage of nitrate supplementation for exercise performance may vary depending on the duration of supplementation. The analysis revealed an inverse relationship between nitrate dose and exercise performance outcomes. Among trials lasting ≥ 6 days, those exhibiting favorable results utilized a lower mean nitrate dose (~ 7.7 mmol), in contrast to studies reporting unfavorable outcomes, which employed a higher mean dose (~ 10.2

mmol). This indicates that a lower nitrate dose may more effectively elicit performance improvements over longer-term ingestion. Furthermore, these results can inform evidence-based clinical recommendations and guide future research in sports nutrition.

The subgroup meta-analysis in the previous systematic review demonstrated that nitrate supplementation with a dose above 9.9 mmol appears ineffective when used long-term [10]. Therefore, these current findings further underscore the significance and impact of this previous systematic review, suggesting that nitrate supplementation seems to be ineffective in improving exercise performance when used long-term with higher doses.

Considering the outcomes outlined in the earlier systematic review [10] as well as those disclosed here, a thorough consideration of the supplemented dosage becomes paramount, especially during extended supplementation periods (≥ 6 days). These findings contribute to the ongoing scientific discourse and provide valuable insights that can inform future studies and recommendations regarding doses of nitrate intake.

Practical Implications

These findings have significant practical implications for athletes and individuals seeking to enhance exercise performance through nitrate supplementation. Understanding the optimal nitrate dose for longer-term use can guide evidence-based clinical recommendations and aid in the development of personalized supplementation regimens. Coaches, sports dietitians, and athletes can implement this knowledge to adapt nitrate intake and improve training outcomes.

Limitations and Future Directions

While this comparative analysis provides valuable insights, I acknowledge some limitations. The included studies may vary in their methodologies, subject populations, and dosages, which could influence the observed relationship. Future research should explore the mechanisms underlying the nitrate-dose-performance relationship further and investigate potential individual variability in responses to nitrate supplementation.

Conclusion

The current evidence suggests that long-term nitrate supplementation performed with higher concentrations may exhibit reduced effectiveness in improving exercise performance. Further investigations are warranted to elucidate the mechanisms underlying this observation.

Author Contributions: KVCS conceived the research focus, goals, and methodology, managing and organizing all data for analysis. KVCS conducted analyses statistically and created all visual elements - figures. As the sole contributor, KVCS drafted the initial version of the manuscript and substantively edited and critically reviewed it.

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Conflicts of Interest: The author declares he has no conflict of interest.

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