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Systematic Review

Effects of Caffeine Intake on Endurance Running Performance and Time to Exhaustion: A Systematic Review and Meta-Analysis

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Abstract: Caffeine (1,3,7-trimethylxanthine) is one of the most widely consumed performance-enhancing substances in sport due to its well-established ergogenic effects. The use of caffeine is more common in aerobic-based sports due to the ample evidence endorsing the benefits of caffeine supplementation on endurance exercise. However, most of this evidence was established with cycling trials in the laboratory, while the effects of the acute intake of caffeine on endurance running performance have not been properly reviewed and meta-analyzed. The purpose of this study was to perform a systematic review and meta-analysis of the existing literature on the effects of caffeine intake on endurance running performance. A systematic review of published studies was performed in four different scientific databases (Medline, Scopus, Web of Science, and SportDiscus) up until 5 October 2022 (with no year restriction applied to the search strategy). The selected studies were crossover experimental trials in which the ingestion of caffeine was compared to a placebo situation in a single- or double-blind randomized manner. The effect of caffeine on endurance running was measured by time to exhaustion or time trials. We assessed the methodological quality of each study using Cochrane's risk-of-bias (RoB 2) tool. A subsequent meta-analysis was performed using the random effects model to calculate the standardized mean difference (SMD) estimated by Hedges' g and 95% confidence intervals (CI). Results: A total of 21 randomized controlled trials were included in the analysis, with caffeine doses ranging between 3 and 9 mg/kg. A total of 21 studies were included in the systematic review, with a total sample of 254 participants (220 men, 19 women and 15 participants with no information about gender; 167 were categorized as recreational and 87 were categorized as trained runners.). The overall methodological quality of studies was rated as unclear-to-low risk of bias. The meta-analysis revealed that the time to exhaustion in running tests was improved with caffeine (g = 0.392; 95% CI = 0.214 to 0.571; $p < 0.001$, magnitude = medium). Subgroup analysis revealed that caffeine was ergogenic for time to exhaustion trials in both recreational runners (g = 0.469; 95% CI = 0.185 to 0.754; p = 0.001, magnitude = medium) and trained runners (g = 0.344; 95% CI = 0.122 to 0.566; p = 0.002, magnitude = medium). The meta-analysis also showed that the time to complete endurance running time trials was reduced with caffeine in comparison to placebo (g = −0.101; 95% CI = −0.190 to −0.012, p = 0.026, magnitude = small). In summary, caffeine intake showed a meaningful ergogenic effect in increasing the time to exhaustion in running trials and improving performance in running time trials. Hence, caffeine may have utility as an ergogenic aid for endurance running events. More evidence is needed to establish the ergogenic effect of caffeine on endurance running in women or the best dose to maximize the ergogenic benefits of caffeine supplementation.

Keywords: caffeine; ergogenic aid; runners; dietary supplement; exercise

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