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# High-Intensity Interval Training and Moderate-Intensity Continuous Training Affect Running Economy in Endurance Runners: A Systematic Review and Meta-Analysis of Randomized Controlled Trials

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**ADMINISTRATIVE INFORMATION**

**Support -** None.

**Review Stage at time of this submission -** Preliminary searches.

**Conflicts of interest -** None declared.

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**Amendments -** This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 29 November 2024 and was last updated on 29 November 2024.

## INTRODUCTION

**Review question / Objective** This systematic review aimed to evaluate the effects of moderate-intensity continuous training (MICT) and high-intensity interval training (HIIT) on running economy (RE) in endurance runners.

**Rationale** At present, there are inconsistent studies on the improvement of running economy between a moderate-intensity and high-intensity interval training. Some researchers pointed out that high-intensity interval training can improve running economy, while most endurance runners believe that "more is better," they tend to train at low to moderate levels and log large numbers of kilometers. Therefore, the effects of moderate-intensity continuous training and high-intensity interval training on running economy are comprehensively evaluated in this paper. The effects of the present high intensity interval training and moderate-intensity continuous training was researched, and the changes of physiological indexes such as maximal oxygen uptake, running economy and lactate threshold were summarized to provide scientific training and heretical basis for endurance runners.

**Condition being studied** In endurance running, the efficiency and economy of energy utilization in human movement are among the principal factors influencing performance. This efficiency can be quantified through running economy (RE), which refers to the body's energy consumption at a given speed. RE is typically measured by oxygen uptake per unit of body weight over time during exercise (O2 $ml \cdot kg^{-1} \cdot min^{-1}$) (Williams KR, 1987) or by oxygen uptake per unit of body weight per distance (O2 $ml \cdot kg^{-1} \cdot km^{-1}$) (Folland JP, 2017). At a steady state pace, runners with superior RE consume less oxygen than those with lower RE (Thomas DQ, 1999). For intermediate and long-distance runners, energy availability is often limited; therefore, higher energy consumption can negatively impact both running performance and endurance. In marathon running, efficient energy utilization and conservation enable runners to perform at their

best, delay fatigue, and cover longer distances more effectively.

## METHODS

**Search strategy** The processes outlined here was based on the PRISMA Statement (Page MJ, 2021). We searched electronic databases in PubMed, Embase, Scopus, and Web of Science by utilizing the following search phrases along with Boolean operators: (running OR jogging OR "marathon running" OR " distance running" OR “endurance running” OR “distance runners” OR “endurance runners” OR “middle distance runners”) AND (“running economy” OR "energy metabolism" OR "metabolism energy" OR "energy expenditure" OR "energy expenditures” OR "expenditure energy" OR energy OR "energy cost" OR "metabolic cost") And (“intermittent training” or “interval exercise” OR “interval running” OR “sprint interval training” OR "intensity training"). The search was updated in March 2024 based on reports of additional research discovered through the search approach across the several databases.

**Participant or population** Participants are endurance runners.

**Intervention** High-intensity interval training (HIIT).

**Comparator** Moderate-intensity continuous training (MICT).

**Study designs to be included** Randomized control study (RCT).

**Eligibility criteria** Studies that satisfied the following criteria were included in the review: (1) published in journals with peer review; (2) interval training and continuous training were the main types of endurance training; (3) participants are endurance runners; (4) using a run-based test course, a run-based training program in the intervention study; (5) the test results included running economy as the primary outcome, which was calculated using energy cost or steady-state oxygen consumption; Secondary outcome measures included at least one of the following: VO2max and blood lactic acid levels. Studies were excluded if they (1) studies without intervention type, (2) did not conform to the guidelines for training design, (3) studies with training interventions less than 4 weeks in duration, or non-interval training interventions. Additionally, this systematic review did not include any review articles.

**Information sources** We searched electronic databases in PubMed, Embase, Scopus, and Web of Science. References included in the literature will also be searched.

**Main outcome(s)** The primary outcome, which was calculated using energy cost or steady-state oxygen consumption.

**Additional outcome(s)** Secondary outcome measures included at least one of the following: VO2max and blood lactic acid levels.

**Quality assessment / Risk of bias analysis** The risk of bias was assessed using the Cochrane Collaboration's tool (Higgins J.P.T,2023). The performance bias item was eliminated because it was not practicable to blind the participants. A technique was established to assess the potential for bias in selection (random sequence generation and allocation concealment), detection, attrition, and reporting biases. The study was classified as "high risk" or "low risk," and where omitted information, it was graded as "unclear".

**Strategy of data synthesis** We conducted a meta-analysis utilizing RevMan5.3.5 to determine whether HIIT training could have an impact on running economy performance. Using the sample size, mean, and standard deviation (SD) values from both the experimental and control groups, Hedges' g and 95% confidence intervals (CIs) were calculated to assess the magnitude of changes in outcomes between the pre-training and post-training periods. (Nakagawa S, 2007). A fixed effect model was used in the forest plot to synthesize the effect sizes for each group. We summed these effect sizes using the Cochrane handbook's criteria when the included publications evaluated running economy at several different velocities or included multiple training groups (Higgins JP, 2022). We discussed statistical heterogeneity using the $I^2$ statistic, where values of 25%, 50%, and 75% indicate low, moderate, and high heterogeneity, respectively. (Higgins JP, 2003).

**Subgroup analysis** Subgroup analysis was performed according to lactate threshold.

**Sensitivity analysis** Sensitivity analysis was performed by excluding studies one by one.

**Language restriction** English.

**Country(ies) involved** China.

**Keywords** HIIT, MICT, running economy.

## Contributions of each author

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