

The Role of Footwear in Improving Running Economy: A Systematic Review with Meta-analysis of Controlled Trials

INPLASY2024120032

doi: 10.37766/inplasy2024.12.0032

Received: 9 December 2024

Published: 9 December 2024

Xu, LY; Wang, YF; Wen, X.

Corresponding author:

Xu Wen

wenxu@zju.edu.cn

Author Affiliation:

Zhejiang University.

ADMINISTRATIVE INFORMATION**Support -** No.**Review Stage at time of this submission -** Data analysis.**Conflicts of interest -** None declared.**INPLASY registration number:** INPLASY2024120032**Amendments -** This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 9 December 2024 and was last updated on 9 December 2024.**INTRODUCTION**

Review question / Objective This systematic review aimed to explore the impact of different types of footwear and footwear characteristics on the running economy (RE) of long-distance runners and providing guidance for running enthusiasts and clinical practice.

Condition being studied In recent years, the impact of different footwears on RE has become a topic of great interest. For runners, choosing suitable footwear is considered a basic requirement of running and a mean of improving RE. The advancement of footwear technology aims to maximize RE and minimize energy loss. Different footwear characteristics, such as mass, cushioning performance, motion control performance, and comfort, can affect RE. Among them, the mass of footwear has been proven to be one of the important factors affecting RE. Some scholars have studied the impact of footwear mass on RE and showed that for every 100 g increase in

footwear mass, the VO₂ required for exercise increases by about 1%.

Barefoot running or minimalist running (running in minimalist shoes and imitating barefoot running) without cushioning may be more economical than some shod running. Scholars have found that over 50% of marathon runners choose minimalist running or barefoot running. Reducing the footwear mass during minimalist running or barefoot running is suggested to help improve RE compared with shod running. Some scholars believe that minimalist running or barefoot running can cause runners to transition from landing on their rearfoot to forefeet, thus increasing rhythm and reducing energy consumption, which may help improve RE. However, at present, no consensus exists on the impact of footwear in RE among papers published in this field. Some scholars have proposed that barefoot running can improve RE more than shod running, but the effect of the research results was very small. In addition, improvement in footwear comfort can improve RE. Protruding patterns can more effectively improve RE than no protruding patterns on the front half of

the sole. However, no systematic review has fully determined the impact of footwear cushioning performance on RE.

Hall and Cheung et al. investigated the effects of footwear on RE in distance runners and systematically reviewed the impact of different footwears on RE. The results indicated that barefoot running or minimalist running may require lower utilization of oxygen than shod running. However, the types and characteristics of varying footwears and sports injuries were not discussed. Moreover, no meta-analysis was conducted in the past 5 years. Due to the high incidence of sports injuries and the increasingly rapid development of footwear technology, organizing and analyzing existing literature on the impact of footwear on the RE and provide scientific support through comprehensive research information are necessary. In addition, a systematic review can provide valuable information for long-distance runners to help them choose suitable footwear and minimize the risk of sports injuries.

METHODS

Participant or population Healthy adult long-distance runners (aged > 18 years).

Intervention Exercise data on barefoot running or minimalist running for the intervention group.

Comparator Exercise data on shod running for the control group.

Study designs to be included The research design was strictly limited to randomized controlled trials (RCTs) published in peer-reviewed journals.

Eligibility criteria Reported RE value and measured steady-state oxygen consumption or calculate energy consumption using indirect calorimetry.

Information sources The search was conducted on 1 April 2024. The search databases include Web of Science, Embase SCOPUS, SPORTDiscus, and Cochrane Library databases. This study searched for literature from establishment of the database to April 2024. It supplemented the search by citation search and manual selection of relevant references that met the selection criteria. The search strategy was to refine the inclusion and exclusion of pertinent literature, and all terms were searched in the form of free text and keywords. In each database, the following types of keywords were searched through "title, summary": Keywords 1, Running

economy (running economy OR VO2 OR oxygen consumption* OR metabolic cost) AND Keywords 2, Footwear (footwear OR shoe* OR shod OR barefoot* OR minimalist*) AND Keywords 3, Running (run* OR jog* OR treadmill OR overground OR marathon).

Main outcome(s) A total of 1338 articles were obtained through a preliminary search. After 587 duplicate reports were deleted, the titles and abstracts of 751 articles were evaluated, further excluding 717 records. After the entire article was read, 26 articles were finally included in the meta-analysis.

Quality assessment / Risk of bias analysis

According to the PEDro scores obtained in Table 2, the selected studies have good quality (PEDro score ≥ 6). All studies have a high risk of bias in condition concealment, because the subjects and investigators cannot be blinded to footwear conditions.

Strategy of data synthesis Statistical analyses were conducted using Review Manager 5.4 (Cochrane Collaboration). The standardized mean difference (SMD) for the results of RE studies in each study were calculated while calculating the standardized mean and standard error. Effects were quantified as trivial (≤ 0.2). This study analyzed the RE levels on barefoot running, minimalist running, or shod running and compared the RE under different footwear longitudinal bending stiffness, cushioning degrees, and comfort levels. However, compared with barefoot running, minimalist running, or shod running, other characteristics, such as shoe cushioning and longitudinal bending stiffness, cannot be controlled, so statistical analysis included the average impact of shoe mass only. The heterogeneity across the studies was evaluated using the I^2 statistic. $I^2 \leq 25\%$ indicated insignificant heterogeneity, $I^2 \leq 50\%$ and $I^2 > 25\%$ indicated moderate heterogeneity, and $I^2 \leq 75\%$ and $I^2 > 50\%$ indicated high heterogeneity. If heterogeneity exists, a subgroup analysis of regulatory variables was performed.

Subgroup analysis Given that the population included in the study is mainly composed of males, and the number of studies involving females is insufficient to form subgroups.

Sensitivity analysis Change the statistical model. For example, when analyzing continuous variables, switch from the fixed-effect model to the random-effect model, or use different effect size metrics (such as changing from the standardized mean

difference to the mean difference), and then compare the differences in the results under different models. A leave-one-out sensitivity analysis was carried out to examine potential sources of single-study heterogeneity in the analysis of diabetic retinopathy.

Country(ies) involved China.

Keywords running economy; footwear; meta-analysis.

Contributions of each author

Author 1 - Liya Xu - Author 1 designed the study and wrote the protocol, independently conducted screening and data extraction, performed quality scoring, carried out statistical analysis and wrote the first draft.

Email: 15207149098@163.com

Author 2 - Yifan Wang - Author 2 independently conducted screening and data extraction, performed quality scoring, carried out statistical analysis.

Email: zjuwangyifan@zju.edu.cn

Author 3 - Xu Wen - Author 3 revised the manuscript.

Email: wenxu@zju.edu.cn