Journal of Medical Science and Sports Health

JoMaSSH, 1 (2), 2025, p. 59-70

available online at https://journal.uny.ac.id/publications/jomassh
doi: 10.21831/jomassh.v1i2.1200

Type of Paper: Systematic Review with Meta-Analysis

Effects of Plyometric-Based Training on Cardiorespiratory Fitness, Running Economy, and Functional Performance in Recreational Runners: A Systematic Review and Meta-Analysis

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Article history:
Received: April 15, 2025
Revised: May 19, 2025
Accepted: May 31, 2025

How to Cite: Deviatika, FE.; Rayhan, A. (2025). Effects of Plyometric-Based Training on Cardiorespiratory Fitness, Running Economy, and Functional Performance in Recreational Runners: A Systematic Review and Meta-Analysis. JoMaSSH, 1(2), 59-70. doi: 10.21831/jomassh.v1i2.1200

E-ISSN 3109-5666

Abstrak

Pendahuluan: Latihan pliometrik melibatkan gerakan eksplosif dan cepat yang bertujuan meningkatkan kekuatan otot, koordinasi, dan efisiensi gerak. Selain meningkatkan performa, latihan ini juga berpotensi mendukung kesehatan jantung dan kapasitas fisik secara keseluruhan. Meta-analisis ini menilai dampak latihan pliometrik terhadap), kapasitas kardiorespirasi (VO_2max), efisiensi lari dan performa lari (time trial) pada pelari rekreasional. **Metode:** Studi ini mengikuti pedoman PRISMA dan seleksi studi digambarkan dengan diagram PRISMA. Basis data PubMed, Scopus, dan EBSCO digunakan untuk mencari *Randomized Controlled Trials* (RCTs) yang memenuhi syarat yang membandingkan pelatihan berbasis pliometrik (sendiri atau dikombinasikan) dengan metode pelatihan lain untuk pelari rekreasional. Luaran yang dinilai adalah RE, VO_2max, dan TT. **Hasil:** Sepuluh studi memenuhi syarat dengan melibatkan total 331 peserta. Studi ini menunjukkan pelatihan berbasis pliometrik secara signifikan meningkatkan RE, terutama pada kecepatan 14 km/jam (SMD = -0,42, 95% CI = -0,83 hingga -0,01, p=0,05). Namun, efek pada VO_2max dan TT kurang konsisten. Ditemukan efek keseluruhan kecil pada VO_2max (SMD = -0,11, 95% CI = -0,43 hingga 0,21), efek kecil pada TT pada >3 km (SMD = -0,20, 95% CI = -0,20 hingga 0,51), dan efek besar pada ≤3 km (SMD = -1,83, 95% CI = -4,68 hingga 1,02), meskipun tidak signifikan (p>0,05). **Kesimpulan:** Latihan berbasis pliometrik dapat meningkatkan efisiensi lari tanpa mengorbankan kapasitas kardiorespirasi, meskipun protokol jangka pendek belum secara signifikan meningkatkan kecepatan lari. Program progresif minimal selama 6–12 minggu dengan frekuensi 2–3 sesi per minggu, yang dikombinasikan dengan latihan kardiorespirasi, direkomendasikan. Penelitian lanjutan perlu mengevaluasi hasil jangka panjang dan respons yang terpersonalisasi berdasarkan profil individu pelari.

Kata kunci: Ekonomi Lari; Kebugaran Kardiorespirasi; Latihan Plyometric; Pelari; Waktu coba; VO_2max

Abstract

Introduction: Plyometric-based training involves rapid, explosive movements that enhance muscle strength, coordination, and efficiency. These benefits may extend beyond performance to support cardiovascular health and functional capacity. This meta-analysis evaluates its effects on economy (RE), VO_2max, and time trial (TT) performance in recreational runners. **Methods:** This study adhered to the PRISMA guidelines and study selection illustrated in a PRISMA flowchart. PubMed, Scopus, and EBSCO databases were searched for potentially eligible Randomized controlled trials (RCTs) comparing plyometric-based training (alone or combined) with other training methods for recreational runners. The outcomes assessed were economy, VO_2max, and TT. **Results:** ten eligible studies with a total of 331 participants were included. This study showed that plyometric-based training improved RE significantly, especially at a speed of 14 km/h (SMD = -0.42, 95% CI = -0.83 to -0.01, p=0.05). However, effects on VO_2max and TT were less consistent. A small overall effect on VO_2max (SMD = -0.11, 95% CI = -0.43 to 0.21), small effect of TT at >3 km (SMD = -0.20, 95% CI = -0.20 to 0.51), and a large effect at ≤3 km (SMD = -1.83, 95% CI = -4.68 to 1.02) was found, though not significant (p>0.05). **Conclusions:** Plyometric-based training may enhance RE without compromising cardiorespiratory fitness, although short-duration protocols do not significantly enhance running speed. A minimum of 6–12 weeks of a progressive program with 2–3 sessions per week, alongside aerobic training, is recommended. Further research should examine long-term outcomes and personalized responses based on individual runner profiles.

Keywords: *Cardiorespiratory fitness; Plyometric training; Recreational runners; Running economy; Time trial; VO_2max*

1. Introduction

Endurance running is increasingly recommended as a preventive health strategy due to its accessibility and its role in enhancing cardiovascular fitness, metabolic function, and overall physical health. Among adults engaging in recreational physical activity, improving exercise tolerance, economy, and aerobic capacity can be challenging without structured intervention. To support these health-related adaptations, various training modalities have been implemented, including continuous endurance training, high-intensity interval training (HIIT), resistance exercise, and plyometric-based protocols. Each method offers distinct physiological benefits that can contribute to improved functional capacity and reduced risk of non-communicable diseases (1-4). Among these, plyometric training has gained attention for its potential to enhance running performance.

Plyometric-based training involves jump movements that create a stretch-shortening cycle (SSC), combining eccentric and concentric phases to boost explosive power and neuromuscular coordination (5). The high force produced quickly contributes to running acceleration (6). Studies have shown that plyometric training, alone or with strength training, improves athletic performance (7-10). It is believed to improve neuromuscular efficiency and power, indirectly enhancing economy (RE), cardiorespiratory fitness (VO_2max), and time trial (TT) performance by increasing the muscles' ability to generate force efficiently (5).

Economy refers to the amount of oxygen used at a specific pace, where lower VO_2 indicates more efficient energy use (11-13). VO_2max is the maximum oxygen the body can use during intense exercise, with higher values indicating better cardiovascular and respiratory efficiency (11). Time trial performance measures a runner's ability to complete a given distance quickly or cover the most distance within a set time, reflecting aerobic performance in real-world conditions (14).

Although previous studies suggest plyometric-based training can improve economy, cardiorespiratory fitness, and TT performance in elite athletes, its effects on recreational runners are still unclear. Some studies show improvements, while others report minimal or no effects. Differences in study design, participant characteristics, and protocols may explain these inconsistencies. This systematic review aims to evaluate the effects of plyometric-based training on economy (RE), cardiorespiratory fitness, and time trial (TT) performance in recreational runners. Through meta-analysis, the study seeks to quantify the impact of this training method on key physiological and functional outcomes. In addition to informing training practices for recreational athletes and coaches, the findings may have broader clinical relevance by identifying accessible exercise strategies that support cardiovascular health, enhance physical function, and contribute to the prevention of non-communicable diseases. Factors such as training duration, frequency, and intensity will also be examined to better understand their influence on individual responsiveness and health-related benefits.

2. Methods

2.1. Eligibility Criteria

This systematic review and meta-analysis was done systematically according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method (see Supplementary File). Utilizing the PICO (Population, Intervention/exposure, Control/comparison, and Outcome) framework, the studies that met the subsequent criteria were integrated into this study (**Table 1**).

Table 1. PICOS of this Study

Component of PICOS	Population
Population	Recreational runners with inclusion criteria: 1) Not participating in elite competition with no prior plyometric-based training within the past years 2) Age >18 years 3) Distance runners, not sprinters 4) Recreationally trained (2-5 running sessions per week) for the last 2 months Exclusion criteria: 1) Lower limb injury within the last 6 months 2) Any cardiovascular or neurological diseases
Intervention	Plyometric-based training involves structured and repetitive jumping and bounding movements alone or in combination with other types of training (e.g., endurance, speed, strength, etc.).
Control	Strength training or regular running program alone, the combination of training modalities that exclude plyometric components, or a training program with no additional intervention.
Outcome	1) RE (amount of oxygen consumed during running at a specific speed (mL/kg/min)) 2) VO_2max 3) TT performance at 10 km/h, 12km/h, and 14km/h
Study design	Randomized Controlled Trials

2.2. Information Sources and Search Strategy

A comprehensive literature search was implemented across the electronic databases of PubMed, Scopus, and EBSCO between 2015 to 2025. The Boolean search strategy used for literature searching can be found in the Supplementary File.

2.3. Study Selection

The identification, screening, eligibility, and inclusion phases were systematically documented using a PRISMA flowchart (**Figure 1**). Three reviewers screened the titles and abstracts of potentially relevant articles. Duplicates were identified automatically by Rayyan.ai and verified by the authors. The full texts of the selected articles were then retrieved and assessed for eligibility based on predefined criteria. Full-text screening ensured that the studies met the inclusion/exclusion criteria and involved plyometric-based training. The number of included and excluded studies is shown in **Figure 1**.

2.4. Characteristic Studies Included

Information regarding the author, year, population, type of plyometric-based training, training frequency, training duration, and outcome measurement methods of the eligible randomized controlled trials (RCTs) are tabulated.

2.5. Risk of Bias

For the Risk of Bias (RoB) assessment, we used the RevMan tool to examine biases in the included studies. We looked at seven areas: random sequence generation, allocation concealment, blinding of participants and assessors, incomplete data, selective reporting, and other biases. Each study was rated as having low, unclear, or high bias risk based on the methods used. The overall bias risk was determined by evaluating the most critical areas, and studies with high bias risk were either excluded or analyzed cautiously. This ensures the review's findings are based on reliable evidence.

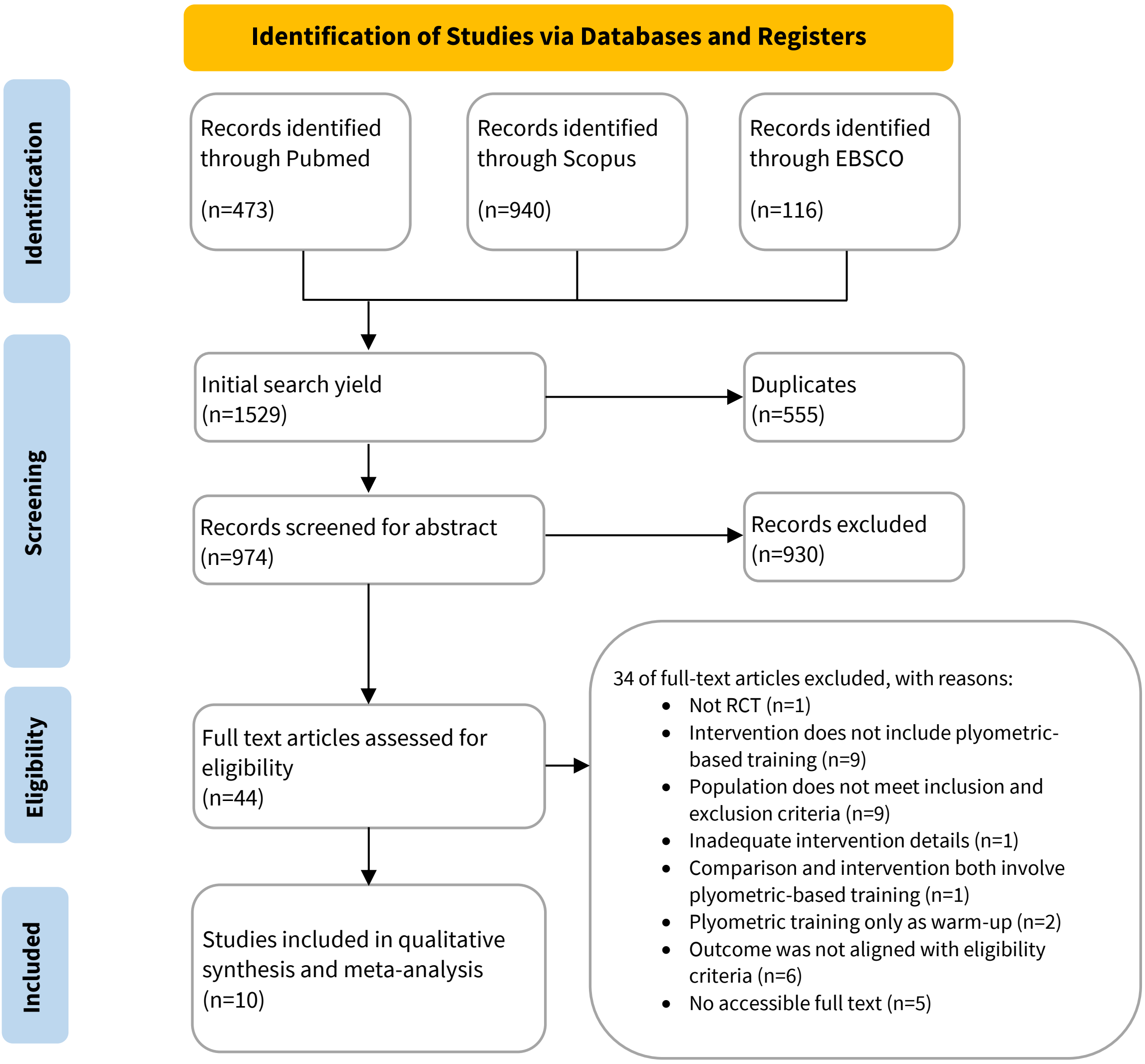


Figure 1. PRISMA Flowchart for Study Selection.

2.6. Summary Measures and Synthesis of Result

RE, cardiorespiratory fitness assessed by VO_2max, and TT performance were the primary outcomes of this systematic review and meta-analysis. In this study, the mean difference (post-intervention mean minus pre-intervention mean) and SD change (adjusted SD for mean difference data) were first calculated for both groups according to the formula: SD change = √(SD baseline² + SD final² - 2 × r × SD baseline × SD final) (15). Data presented only in graphical form were read using the Web Plot Digitizer 5.4 application. All statistical analyses were conducted using a 95% confidence interval (95% CI). Potential clinical heterogeneity was assessed through pooled analysis employing a random effects model, facilitated by the Review Manager software version 5.4. Statistical heterogeneity was quantified using I^2 statistics. I^2 values below 25% were classified as low, those ranging from 25% to 50% were deemed moderate, and values exceeding 50% were categorized as high.

3. Results

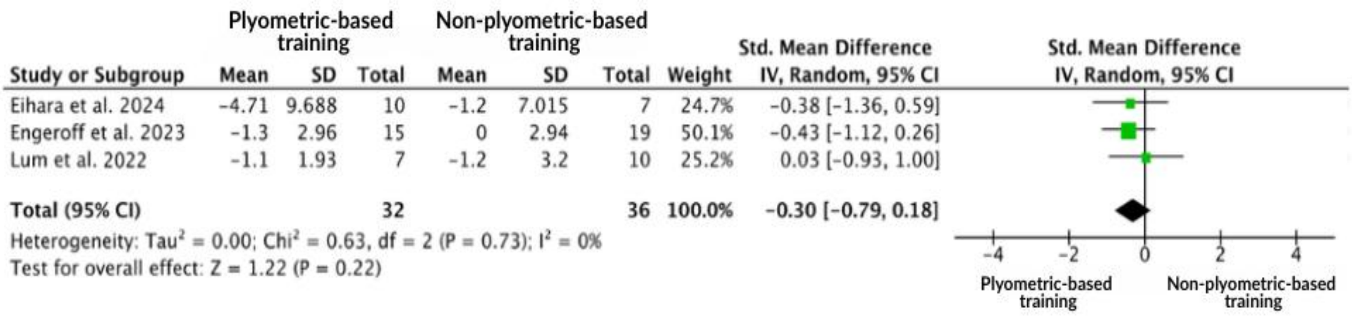
Upon completion of the literature search using the specified keywords, a total of 1,529 studies were identified, including 373 from PubMed, 940 from Scopus, and 116 from EBSCO. After removing duplicate entries, 974 studies remained for further examination. The titles and abstracts of these studies were screened for potential inclusion using Abstrackr (Brown.edu). During the retrieval phase, certain studies were inaccessible, leading to the assessment of the remaining 44 studies for eligibility based on their full text. A total of 10 studies were included in the qualitative review and meta-analysis. Several subgroups were created to facilitate a focused discussion and minimize heterogeneity within the systematic review, considering factors such as the duration of the intervention for assessing VO_2max and the distance group for assessing TT performance. **Table 2** summarizes the characteristics of included studies. Some cells in the table are blank (N/A), indicating that the data is either unavailable, unreported data from the literature, or not applicable to the scope of the study.

Table 2. Characteristic Studies Included from 10 RCTs

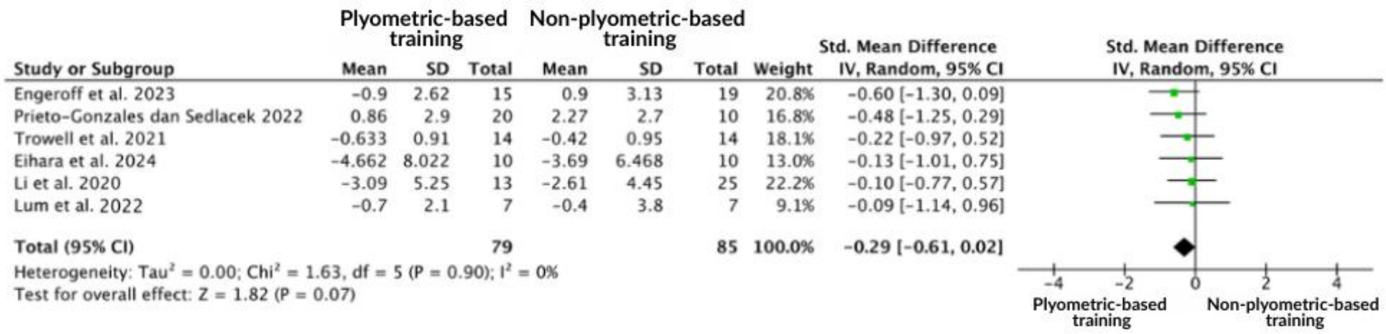
Author (year)	Population	Plyometric-based training	Frequency, Duration	Economy	VO_2 max	Time Trial
Prieto-González et al. (2022)	Male recreational endurance runners (n=30)	Hurdle hops with another isometric strength training alone and in combination with endurance training	3 days/week 12 weeks	12 km/h 14 km/h	Using treadmill	N/A
Trowell et al. (2021)	Moderately trained distance runners (n=30)	Ankle bouncing, Hurdle jumps (40 cm), Split squat jump, Sidestepping, Countermovement jump or drop jump (45 cm)	2 days/week 10 weeks	3.33 m/s	Using treadmill	2 km time trial
Lum et al. (2022)	Endurance runners (n=30)	40 cm depth jump, Single leg bounding, Split jump	2 days/week 6 weeks	12 km/h 14 km/h	Using treadmill	2,4 km time trial
Lum et al. (2019)	Moderately trained male endurance runners (n=14)	Alternate leg bounding, Double-leg 30 cm hurdle hop, 40-60 cm depth jump	2 days/week 6 weeks	10 km/h 12 km/h	Using treadmill	10 km time trial
Li et al. (2020)	Recreational marathon runners from local running clubs (n=21)	3 sets of 3 complex pairs: 1. squat + a DJ from a 30 cm box 2. split squat + a single leg hop 3. lunge walking + a double leg 30 cm hurdle hop	2 days/week 6 weeks	12 km/h 14 km/h	Using treadmill	N/A
Buckley et al. (2015)	Recreationally active women (n=32)	Doing HIIT with some plyometric exercises: Top-end burpees, Lateral hurdle hops, Lateral hurdle hops, Box jumps,	3 days/week 6 weeks	N/A	Using treadmill	N/A
Engeroff et al. (2023)	Amateur runners (n=34)	Variable amount of double-legged 10-s hopping bouts	daily 6 weeks	10 km/h 12 km/h 14 km/h	Using treadmill	N/A
Garcia-Pinillos et al. (2020)	Amateur endurance runners (n=96)	Jump rope	2–4 Sessions/week 10 weeks	N/A	N/A	3 km time trial
Eihara et al. (2024)	Middle-aged recreational runners (n=20)	Countermovement jump (CMJ), Rebound jump, Hurdle hop, and Drop jump	2 days/week 10 weeks	8 km/h 10 km/h 12 km/h	Using treadmill	5 km time trial
Machado et al. (2019)	Amateur runner for at least six months and should have participated in at least a 10 km race running (n=24)	Squat jump and Drop jump	2 days/week 8 weeks	N/A	N/A	5 km time trial

3.1 Effects of Plyometric-based Training on the Economy

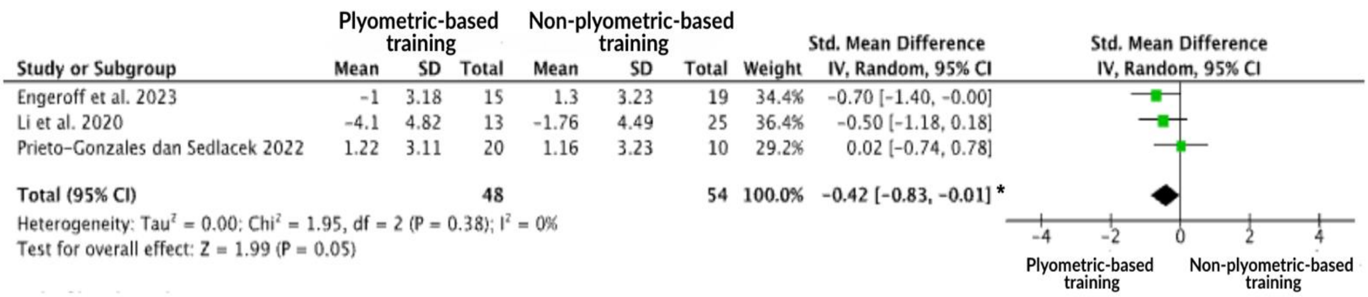
Three meta-analyses were conducted to compare plyometric-based and non-plyometric-based training based on RE at speeds of 10 km/h, 12 km/h, and 14 km/h. No heterogeneity was observed across the three meta-analyses ($I^2 = 0\%$). The meta-analysis showed a significant beneficial effect of plyometric-based training on RE at 14 km/h compared to non-plyometric-based training (SMD = –0.42, 95% CI: –0.83 to –0.01, p = 0.05). Since the confidence interval (CI) does not cross the line of no effect, this result is considered statistically significant, indicating a likely true difference between the compared interventions. Plyometric-based training at 10 km/h and 12 km/h also demonstrated small to moderate beneficial effects, although not statistically significant (SMD = –0.30, 95% CI: –0.79 to 0.18, p = 0.22 and SMD = –0.29, 95% CI: –0.61 to 0.02, p = 0.07, respectively) (**Figure 2**).



(a)



(b)



(c)

Figure 2. Forest Plot Plyometric-based Training on Economy. (a) Economy at 10 km/h.; (b) Economy at 12 km/h. (c) Economy at 14 km/h. Asterisks (*) indicate statistically significant results where the confidence interval does not cross the line of no effect

3.2 Effects of Plyometric-based Training on VO_2max

VO_2max in this study was divided into two subgroups: short duration and long duration. No significant effects ($p>0.05$) were found in the short-duration subgroup (SMD = –0.18, 95% CI: –0.63 to 0.28, p = 0.45) and long-duration subgroup (greater than 10 weeks) (SMD = –0.05, 95% CI: –0.50 to 0.40, p = 0.83). Overall, plyometric-based training showed a small effect on VO_2max, although not statistically significant (SMD = -0.11, 95% CI -0.43 to 0.21, p = 0.49). The heterogeneity was low for both subgroups and overall analysis (I^2 = 0%), indicating that the studies included in the analysis were consistent in their findings (**Figure 3**).

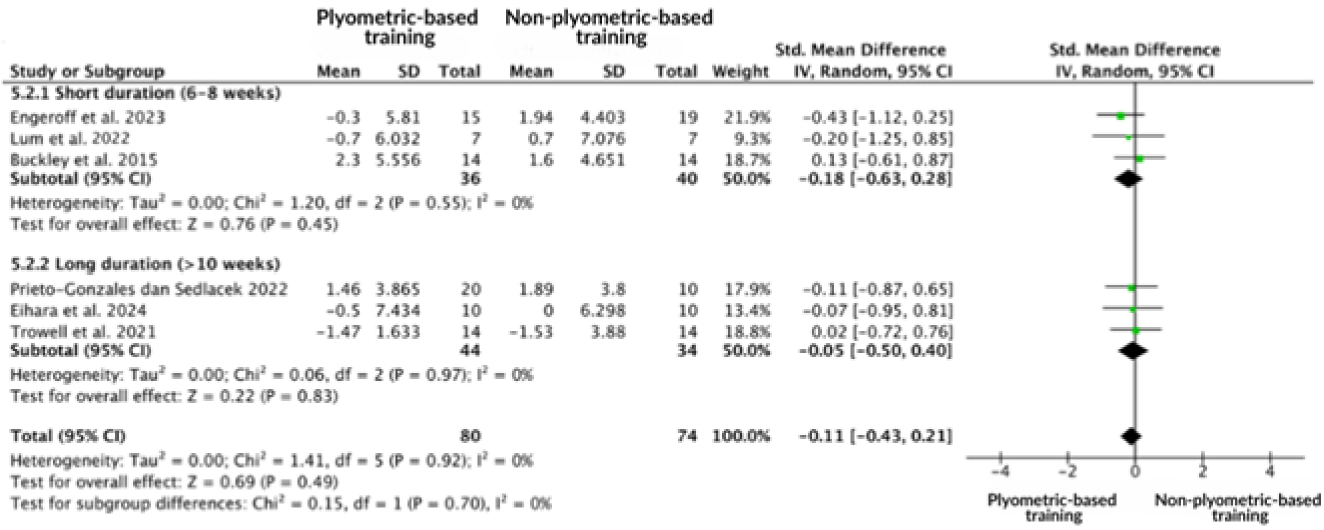


Figure 3. Forest Plot Plyometric-based Training on VO_2 max.

3.3 Effects of Plyometric-based Training on Time Trial

TT performance in this study was divided into two subgroups: >3 km and ≤3 Km. No significant differences or heterogeneity were found between the subgroups (p = 0.28, I^2 = 15.3%). Overall, plyometric-based training showed varied effects on TT performance across the studies, with a large overall effect, although not statistically significant (SMD = -1.02, 95% CI -2.56 to 0.52, p = 0.19). Subgroup analysis revealed a small effect of plyometric-based training in the >3 km subgroup (SMD = -0.20, 95%, CI = -0.92 to 0.51, p = 0.58) and a large effect in the ≤3 km subgroup (SMD = -1.83, 95% CI = -4.68 to 1.02, p = 0.21), although not statistically significant. The heterogeneity in the >3km subgroup was moderate (I^2 = 49.6%) and in the ≤ 3 km subgroup was high (I^2 = 95%), suggesting variation in the effectiveness of plyometric training across studies (**Figure 4**).

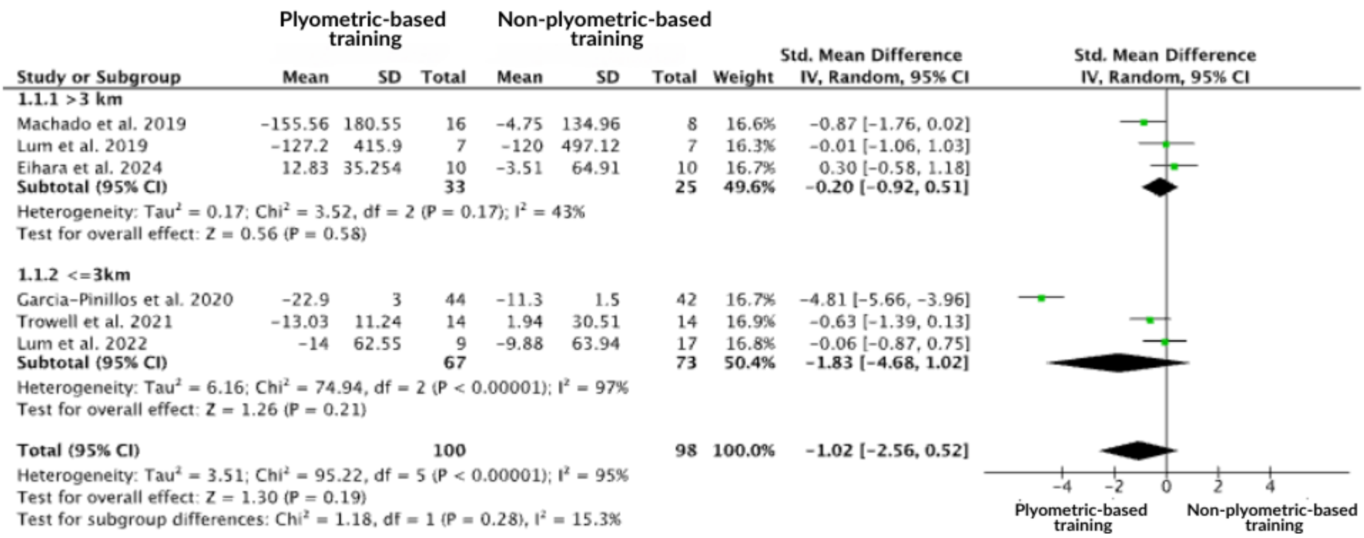


Figure 4. Forest Plot Plyometric-based Training on Time Trial.

3.4 Assessment of Methodological Quality and Risk of Bias

The evaluation of the studies revealed varying levels of methodological quality based on the risk of bias assessment. Buckley et al. (2015) and Gracia-Pinillos et al. (2023) demonstrated high-quality methodology, with a low risk of bias across all domains. However, Engeroff et al. (2024) showed moderate-quality methodology. The remaining studies showed a high risk of bias, indicating that although some methodological aspects were unclear the overall findings were still reliable but require careful interpretation (**Figure 5**).

(b)

Figure 5. Risk of Bias. (a) The figure presents the Risk of Bias summary and distribution for the included studies across different domains.; (b) The figure displays the Risk of Bias assessment for individual studies across seven key domains.

4. Discussion

This meta-analysis demonstrated that plyometric-based training significantly improves RE in recreational runners with moderate effect (SMD = -0.42, p = 0.05, the confidence interval does not cross zero), while no statistically significant effects were observed for VO_2max and TT performance (SMD = -0.11, p = 0.49 and SMD = -1.02, p = 0.19, respectively). These results indicate that even without substantial improvements in cardiorespiratory fitness and running speed, increased economy alone can provide significant advantages to recreational runners. Prior studies have similarly reported improvements in RE following plyometric-based training among both trained and recreational populations (9, 16, 17). The underlying mechanisms are likely attributed to neuromuscular adaptations, including enhanced rate of force development, increased musculotendinous stiffness, reduced ground contact time, higher step frequency, and improved push-off strength, collectively contributing to a more efficient running pattern with reduced energy expenditure per stride (18, 19). Achilles tendon stiffness, for example, has been associated with reduced oxygen consumption during submaximal running (20). Additionally, gains in lower-limb power may improve running agility and movement economy, particularly over uneven terrain or during pace variation (21-23). Evidence from Ramirez-DelaCruz (24) also indicates hypertrophic adaptations in the vastus lateralis and rectus femoris following plyometric-based training, potentially contributing to improved force output and joint stabilization. Enhanced intermuscular coordination, particularly between the quadriceps and hamstrings, may further reduce injury risk while supporting more efficient running kinematics (25, 26). An enhanced economy means that recreational runners can maintain a specific pace or cover longer distances with reduced energy expenditure. For recreational athletes who often contend with time constraints or physical limitations, boosting the economy without raising training volume or intensity can be a beneficial and sustainable approach.

The effects of plyometric-based training on RE exhibit variability among individuals, likely influenced by a multitude of factors, including training frequency, volume, duration, and prior exposure to resistance training(16). Environmental factors, such as ambient temperature, humidity, and altitude, may also modulate neuromuscular and metabolic adaptations(27-29). Not all included studies standardized or reported these contextual variables, which may partly explain the observed inter-study variability. Barrio et al. (16) highlight those substantial improvements in RE are typically observed in training programs that consist of more than 15 sessions, extend over a minimum of 7 weeks, and involve a frequency of training exceeding 2 days per week, allowing for enhanced physiological adaptations. The integration of plyometric-based training and strength training modalities has been shown to provide a synergistic effect on RE via synergistic improvements in hypertrophy, power output, tendon compliance, and oxygen utilization efficiency (30-32). Previous research has established that progressive load regiments can enhance cardiorespiratory fitness, it's important to note that not all training programs included in this study adhered to this progressive loading principle (33, 34). Studies by Knechtle et al., Wang et al., and Saunders et al. provide evidence that these environmental conditions can markedly influence economy and performance outcomes, underscoring the complexity of factors that contribute to an individual's RE (27-29).

Despite significant improvements in RE, cardiorespiratory fitness (VO_2max) did not change significantly, indicating that plyometric-based training supports mechanical efficiency without compromising cardiorespiratory fitness. This outcome aligns with the physiological profile of plyometric-based training, which primarily elicits neuromuscular rather than central cardiovascular adaptations (35-37). Enhancements in VO_2max are typically associated with aerobic modalities such as continuous endurance training or high-intensity interval training (HIIT), which maintain elevated heart rates over prolonged durations (38, 39). While plyometric-based training consists of brief and high-intensity anaerobic exercises that do promote muscular adaptation, such as increased fascicle length, muscle thickness, nervous system efficiency, and reflex responses, these changes predominantly support explosive strength and movement economy rather than cardiorespiratory fitness (24, 40) and may not induce the same level of fatigue typically associated with continuous endurance training (41). Suggesting that plyometric-based training can coexist with aerobic training without negative effects on VO_2max (6, 42). Accordingly, for recreational runners aiming to optimize both efficiency and endurance performance, plyometric-based training should be integrated as a complementary modality, ideally alongside aerobic base training, interval sessions, and strength exercises to target distinct physiological domains and support comprehensive performance development. Variabilities in intervention design, such as program duration, session frequency, or concurrent aerobic training, may have contributed to the inconsistent effects on VO_2max across studies. Clarifying the interaction between plyometric-based training load parameters and cardiovascular adaptation may help refine program design for dual benefits in economy and aerobic performance.

Although no significant improvements in TT performance were observed, the enhancement in RE remains a valuable outcome for recreational runners. This research indicates that a brief training duration (6-12 weeks) leads to less than optimal adaptations, limiting significant changes in running speed. However, improvements in RE indicate greater movement efficiency, which can lead to reduced fatigue and enhanced comfort during training or longer runs, even if running speed remains unchanged. For non-competitive individuals, the goal is not always to achieve faster race times but to enjoy running with less effort, a lower risk of overuse injuries, and a shorter recovery phase. Consequently, although plyometric-based training may not directly boost TT outcomes in the short term, it acts as a crucial foundational strategy that supports long-term performance and running sustainability. The results of this research assist coaches in managing realistic expectations for runners, highlighting that improvements in time trial performance might necessitate a more extended timeframe. Moreover, TT performance is shaped by various factors, such as training intensity distribution and load, pacing techniques, resilience to fatigue, and exposure to speed-specific training, which may not be effectively addressed through plyometric-based training alone (43, 44). This implies the necessity for more extended, structured, and integrated training approaches when pursuing measurable performance improvements among recreational long-distance runners, such as focusing on enhancing RE before advancing to speed development.

The findings support integrating plyometric-based training as a complementary component within running programs for recreational runners. Most interventions implemented 6–12 week programs with 2–3 weekly sessions, primarily using lower-limb drills such as drop jumps (30–60 cm), split squat jumps, hurdle hops, and jump rope. Several practical considerations should guide coaches in implementing plyometric-based training safely and effectively. Coaches should consider introducing plyometric-based training after a foundational phase of strength and core training to prepare musculoskeletal structures for high-impact loading (45). Although most studies focused on lower-limb drills, integrating core engagement (e.g., rotational jump squats, unilateral hops with static hold, plank-based hopping drills, etc) may enhance postural stability and kinetic transfer during running for more holistic training interventions, despite not being explicitly studied in the included studies (46, 47). Progression in load (volume/intensity, e.g., start from 30–100 ground contacts per session) and individualization based on training background are essential. Low-impact drills (e.g., A-skips, ankle bounces) are suitable for beginners, while advanced athletes may benefit from higher-complexity movements (e.g., bounding, box jumps, single leg hops) (48-50). Monitoring jump quality, fatigue, and soreness can inform load adjustments. Plyometric-based training sessions are ideally placed before low-intensity runs or on non-running days to mitigate cumulative fatigue (17).

This systematic review has several limitations that warrant consideration, including the limited number of studies for certain outcomes (e.g., VO_2max and TT), along with heterogeneity in protocols, which limits the ability to determine standardized plyometric-based training prescriptions. Most interventions focused solely on lower-limb exercises, with limited exploration of a core engagement or combined strategies with strength, running drills, and endurance training. Additionally, long-term effects, safety profiles, and adherence rates were rarely reported. Future research with more consistent methodologies, including larger sample sizes and longer intervention periods should compare or explore dose-response relationships across training volume, frequency, intensity, and load; evaluate combined plyometric, core, and endurance training; also stratify analyses by sex, age, body composition, running backgrounds, and baseline fitness level, as well as standardized plyometric-based training protocols is needed.

5. Conclusions

This meta-analysis demonstrates that plyometric-based training may improve RE in recreational runners without compromising cardiorespiratory fitness, though brief plyometric-based training does not significantly enhance TT performance. Coaches are encouraged to integrate plyometric exercises progressively with aerobic training over 6–12 weeks with 2-3 weekly sessions, while managing expectations that improvements in running speed require longer durations and multimodal comprehensive training strategies. Future studies should address current gaps by implementing standardized plyometric training protocols and conducting larger RCTs, while also exploring the role of core training, long-term adherence, and stratified responses based on sex, age, and training background.

Acknowledgments: The author would like to thank all the literature included into this metanalysis for dataset availability

Funding: This research received no external funding

Conflicts of Interest: The authors declare no conflict of interest

List of Abbreviations

RE	Economy
TT	Time trial
HRV	Heart rate variability
SMD	Standard Mean Differences
SD	Standard Deviation
HIIT	High-intensity interval training
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RCTs	Randomized controlled trials

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