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Human Kinetics
SYSTEMATIC REVIEW

Wearing Compression Socks During Running Does Not Change Physiological, Running Performance, and Perceptual Outcomes: A Systematic Review With Meta-Analysis

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Background: Compression socks are a popular feature for runners and are widely advertised by the industry. Limited high-quality evidence has summarized the effects of compression socks during running. We aimed to investigate the effects of wearing compression socks compared with placebo or regular socks during running on physiological parameters, running performance, and perceptual outcomes. ***Methods:*** The protocol was registered at PROSPERO (CRD42022330437). Five databases (MEDLINE, Embase, CINAHL, SPORTDiscus, and Web of Science) were searched. Clinical trials exploring the effect of compression socks during running on physiological parameters, performance, and perceptual outcomes were included. The Cochrane risk of bias 2 tool was used to assess the risk of bias. ***Results:*** We included 28 trials (600 runners), with 16 trials (284 runners) contributing to meta-analysis. For physiological outcomes (eg, heart rate mean difference [95% CI = 0.82 [–0.39 to 2.03] and blood lactate concentration mean difference [95% CI] = 0.30 [–0.39 to 0.98]), pooled analysis indicated low to moderate-certainty evidence that compression socks do not differ from regular socks. For running performance (eg, running speed mean difference [95% CI] = –0.24 [–0.79 to 0.31] and time to exhaustion standardized mean difference [95% CI] = –0.26 [–0.65 to 0.13]), pooled analysis indicated very low to low-certainty evidence that compression socks do not differ from regular socks. For perceptual outcomes (eg, perceived exertion standardized mean difference [95% CI] = 0.06 [–0.17 to 0.29] and lower limb muscle soreness standardized mean difference [95% CI] = 0.08 [–0.35 to 0.51]), pooled analysis indicated very low to moderate-certainty evidence that compression socks do not differ from regular socks. ***Conclusion:*** There is very low to moderate-certainty evidence that wearing compression socks during running does not benefit physiological, running performance, or perceptual outcomes compared with regular socks.

Keywords: exercise recovery, athletic performance, sports science, cardiovascular response, endurance

Key Points

- Very low to moderate-certainty evidence indicates that wearing compression socks during running does not change physiological, running performance, and perceptual outcomes compared to wearing regular socks.
- Wearing compression socks does not appear to have any detrimental effect on physiological, running performance, and perceptual outcomes

Running is one of the most popular sports worldwide[1] and has been associated with many health benefits, including mortality reduction.[2] Despite the overall benefits, running-related injuries have a high incidence (40.2%) and prevalence (44.6%).[3] Running-related injuries might lead to economic costs and discontinuation of running.[4,5] Due to the biomechanics of running, runners can experience delayed muscle soreness, which could impact their training routine.[6] As a result, runners often seek strategies to enhance performance and minimize injury risk or delayed muscle soreness.

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Compression socks are a popular feature for runners—runners are the most prevalent users of compression socks among endurance athletes.[7] During running, inflammation enzymes are released due to muscle demands such as eccentric contractions.[8] This mechanism can lead to delayed muscle soreness.[6] The rationale for wearing compression socks relies on improving blood flow return to reduce delayed onset muscle soreness and improve physical recovery.[9,10] Compression socks would then theoretically improve physiological response, running performance, and perceptual outcomes (eg, perceived effort, comfort).[11] Despite the high rates of real-world adoption by runners and advertising campaigns by the compression socks industry, the research evidence around the effect of compression socks is conflicting for physiological and recovery outcomes, and scarce for performance outcomes.[12–14]

No high-quality systematic review has focused on exploring the effects of compression socks during running. Previous systematic reviews[12–14] included participants from different sports modalities, and the latest search update was made in 2017. Since then, at least 8 new clinical trials[15–22] have explored the effects of compression socks during running, which could change evidence synthesis certainty.[12–14] Millions of runners worldwide will benefit from our evidence synthesis. We aimed to systematically appraise the effects of wearing compression socks during running on physiological, performance, and perceptual outcomes.

Methods

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA),[23] the implementing PRISMA in Exercise, Rehabilitation, Sport medicine and SporTs Science[24] and the recommendations presented in the Cochrane Handbook for systematic reviews of interventions.[25] The protocol was prospectively registered on the International Prospective Register for Systematic Reviews (PROSPERO) in May 2022 (CRD42022330437). Deviations from the protocol were minimal and are described in the Supplementary Material S1 (available online).

Consumer Involvement

The research team consulted 2 experienced runners (>5 y running at least 20 km/wk, 1 man and 1 woman) during the development of the research question of our systematic review. Informal qualitative feedback from both runners suggested that summarizing the effect of using compression socks during running would be more relevant than prerunning or postrunning. Before the protocol publication, we modified our research question to accommodate this need. They were also interested in the effect of compression socks on running performance, which was added to our research question.

Inclusion and Exclusion Criteria

The selection criteria were established a priori using the Population, Intervention, Comparison, Outcome (PICO) framework. The following eligibility criteria were applied:

Population

We only included trials with noninjured runners with no restrictions on participants' age or sex. We excluded trials with runners presenting any cardiovascular, metabolic, or neurological disorders, cervical or back pain, and trials including populations with a history of lower limb or spine surgery. Trials assessing specific sports other than running, or, trials that do not include running activities were also excluded.

Types of Intervention

We included trials using below-knee compression socks or sleeves as the intervention. We excluded trials using thigh, shorts, and whole-body compression.

Types of Control Intervention

A placebo or nonexposed group, such as regular socks, and sleeves was considered as the control intervention.

Types of Outcomes Measures

We included trials that reported physiological outcomes (eg, heart rate and maximal oxygen consumption [VO_2]), performance outcomes (eg, speed and pace), and perceptual outcomes (eg, perceived exertion, thigh and calf muscle soreness). We excluded trials that did not report any of these outcomes.

Trial Design

We included randomized clinical trials, nonrandomized clinical trials, crossover clinical trials, and pre–post interventional trials. We did not include editorials, comments, letters, abstracts, review articles, case trials, cross-sectional trials, or trials with animals.

Literature Search Strategy

Following the PRISMA statement, the search was carried out by one reviewer (GFT), who combined relevant terms for population, intervention, and outcome. The terms were based on previous systematic reviews.[10,26] We searched, without restriction, including publication year or language, the following databases: MEDLINE and Embase (via OVID), CINAHL and SPORTDiscus (via EBSCO), and Web of Science. The database searches were conducted on April 24, 2022 and updated on August 15, 2024. Our review team is fluent in English, Portuguese, and Spanish and decided to use professional translation services if trials published in other languages were deemed eligible. We hand-searched the reference lists of all included trials. We did not explore gray literature as the academic field is relatively mature.[27] The search combined terms related to "compression socks," "physiological parameters," "perceived exertion," "muscle soreness," and "running performance." The full electronic search strategy for each database is presented in Supplementary Material S2 (available online).

Trial Selection

Two reviewers (GFT and LRS) independently screened the titles and abstracts of all identified trials using the Covidence (Veritas Health Innovation, Melbourne, Australia) tool to determine potential eligibility. Then, both reviewers independently assessed the full text of each trial according to our eligibility criteria. Trials deemed eligible by both reviewers were included in the review. Any disagreements between the 2 reviewers were resolved with the input of a third reviewer (DOS).

Data Extraction

One reviewer (GFT) independently extracted the data from the included trials into a data extraction spreadsheet. All extracted data were independently reviewed for accuracy by a second reviewer (LRS). Disagreements were resolved by a consensus meeting between the 2 reviewers, which was overseen by 2 other team members (DOS and MFP). We made 3 attempts to contact the trial authors when the required data were missing or incomplete. We used the Web Plot Digitizer software (Ankit Rohatgi; accessible at https://automeris.io/WebPlotDigitizer) to extract acceptable data from graphical forms where the authors could not be contacted or when data could not be retrieved.[28] Trials that could not be retrieved using the Web Plot Digitizer software were described narratively. Information regarding the trials where authors were contacted can be found in the online Supplementary Material S3 (available online).

We extracted the following information from eligible trials:

- Trial characteristics: author, year of publication, trial design, study protocol, and sample size.
- Participant characteristics: age, sex, body mass index, and population (eg, marathon runners, recreational runners).

- Intervention and comparator characteristics: sock compression level (provided by the manufacturer) in millimeters of mercury (mmHg) and type of comparator (eg, placebo or no intervention).
- Outcomes: all available data on physiological parameters (eg, blood lactate concentration), running performance (eg, total running time), and perceptual outcomes (eg, perceived exertion evaluated by the perceived exertion scale) from each trial's intervention and comparator arm were extracted, including the point estimated and the corresponding measures of variability (SD), *P* value, or 95% CI). Where available, data were extracted for the following time points: during running, postrunning, and 24-h postrunning.

Risk of Bias Assessment

The risk of bias for each trial was independently assessed by 2 reviewers (GFT and MFP) using the Revised Cochrane Risk of Bias 2 tool for randomized parallel trials (RoB2) and the version of this tool for crossover trials.[29,30] Five domains were examined: (1) bias arising from the randomization process, and from period, and carryover effects (only for crossover trials); (2) bias due to deviations from intended interventions; (3) bias due to missing outcome data; (4) bias in the measurement of the outcome; and (5) bias in the selection of the reported result. Each domain was individually graded as low risk, some concerns, or high risk of bias by the 2 reviewers. In the event of a disagreement, a third author (DOS) independently evaluated the trial, and the research team met until a consensus was established.

Certainty of Evidence

We used Grading of Recommendations Assessment, Development and Evaluation (GRADE) to assess the certainty of evidence for each meta-analysis.[31,32] Two reviewers (GFT and LRS) independently assessed the findings for each outcome using GRADEpro software (McMaster University, 2015, developed by Evidence Prime Inc, available at gradepro.org). Evidence was considered as high certainty but was downgraded if there was a concern about bias, indirectness, inconsistency, or imprecision. Disagreements were resolved by a third reviewer (DOS). Full details of upgrade and downgrade criteria for all GRADE categories can be found in the online Supplementary Material S4 (available online).

Data Synthesis and Analysis

We grouped data when 3 or more studies were similar by comparator regular socks or placebo; outcome physiological variables, running performance variables, and perceptual variables; and time points (eg, during running or 24-h postrunning). Where possible, we subgrouped the data to perform separated analyses considering running on different surfaces (eg, treadmill and overground running).

As recommended by the Cochrane Handbook[25] (section 6.5.2.10), for trials with 2 or more groups of the same intervention category (eg, 2 groups wearing compression socks with different pressure levels were compared to a control group), results from intervention groups were combined and considered as a single intervention. The formulas for combining groups were applied using StatsToDo software (accessible at https://www.statstodo.com). The Review Manager statistical software (RevMan version 5.4.1, The Cochrane Collaboration, 2020) was used to calculate both mean difference (MD) and standardized mean difference (SMD) and 95% CIs to pool and compare results. We estimated the SD in cases where trials reported 95% CIs but no SD using the Review Manager statistical program, as recommended by Cochrane in section 7.7.3.2 of the Cochrane Handbook.[25] For continuous data, we calculated the MD (for outcomes with the same metrics) or SMD (for outcomes with different metrics) with 95% CIs. SMDs were interpreted as minimal < 0.2, small 0.2 to 0.49, medium 0.50 to 0.79, and large > 0.8. Interpretation of effect estimates and GRADE findings followed published recommendations.[31]

We analyzed the data for each outcome, irrespective of reported participant dropout (intention-to-treat analysis). Data were synthesized by data collection time point (during running, postrunning, or 24-h postrunning). Skewed data were not transformed and were described narratively using medians and interquartile ranges. Where there were 3 or more trials that were sufficiently similar, random-effects meta-analysis with the inverse variance method was performed using the Review Manager.[33] The random effects were used as heterogeneity was expected in the intervention, comparator, and population. Statistical heterogeneity was assessed by visually inspecting forest plots and examining X^2 test for heterogeneity. I^2 values of 30%, 50%, and 75% were considered moderate, substantial, and considerable statistical heterogeneity, respectively.[25,34] The I^2 statistic was used to assess statistical heterogeneity among the trials included in each meta-analysis and during the certainty of evidence assessment.

Results

Trial Selection and Characteristics

The PRISMA flowchart for trial selection can be found in Figure 1. We identified 6667 trials through database searches, with 4363 remaining after removing duplicates. Twenty-eight trials were included in this review. Supplementary Material S5 (available online) provides the reasons for the exclusion of full texts. From 28 trials, 16 (n = 284 runners) were included in the meta-analysis. Supplementary Material S6 (available online) outlines the reasons why trials could not be pooled. The most common reasons included differences in the variables assessed across trials, the absence of reported mean and standard deviation values in some trials, and variations in the time points of data collection.

Eighteen trials[15,17,19–21,35–46] were based on treadmill protocols, while 10 trials[18,47–55] were based on different protocols, including running on an artificial surface,[50] marathon,[47,51,52] ultramarathon,[18] trail running,[49,53] outdoor,[48] simulated trail race,[55] and running on flat and hilly terrain.[54] Twenty-three trials[15–17,19–21,35–46,48–50,54,55] had a crossover design and 5 trials[18,47,49,51,52] had a parallel design. The sock compression level reported by each trial ranged from 8 to 37 mmHg. Although studies usually reported sock compression levels in range, measures of central tendency (mean = 20.70 mmHg), and frequency (mode = 15 mmHg) were estimated. Detailed trials characteristics are presented in Supplementary Material S7 (available online). Two trials that presented more than one intervention group (different sock compression levels) had their groups combined into a single group.

Risk of Bias

Regarding crossover trials, we rated 20 trials[15–17,19–21,35–42,44,46,48,49,54,55] as "high risk," 2 trials[43,45] as "some concerns," and 1 trial[50] as "low risk"

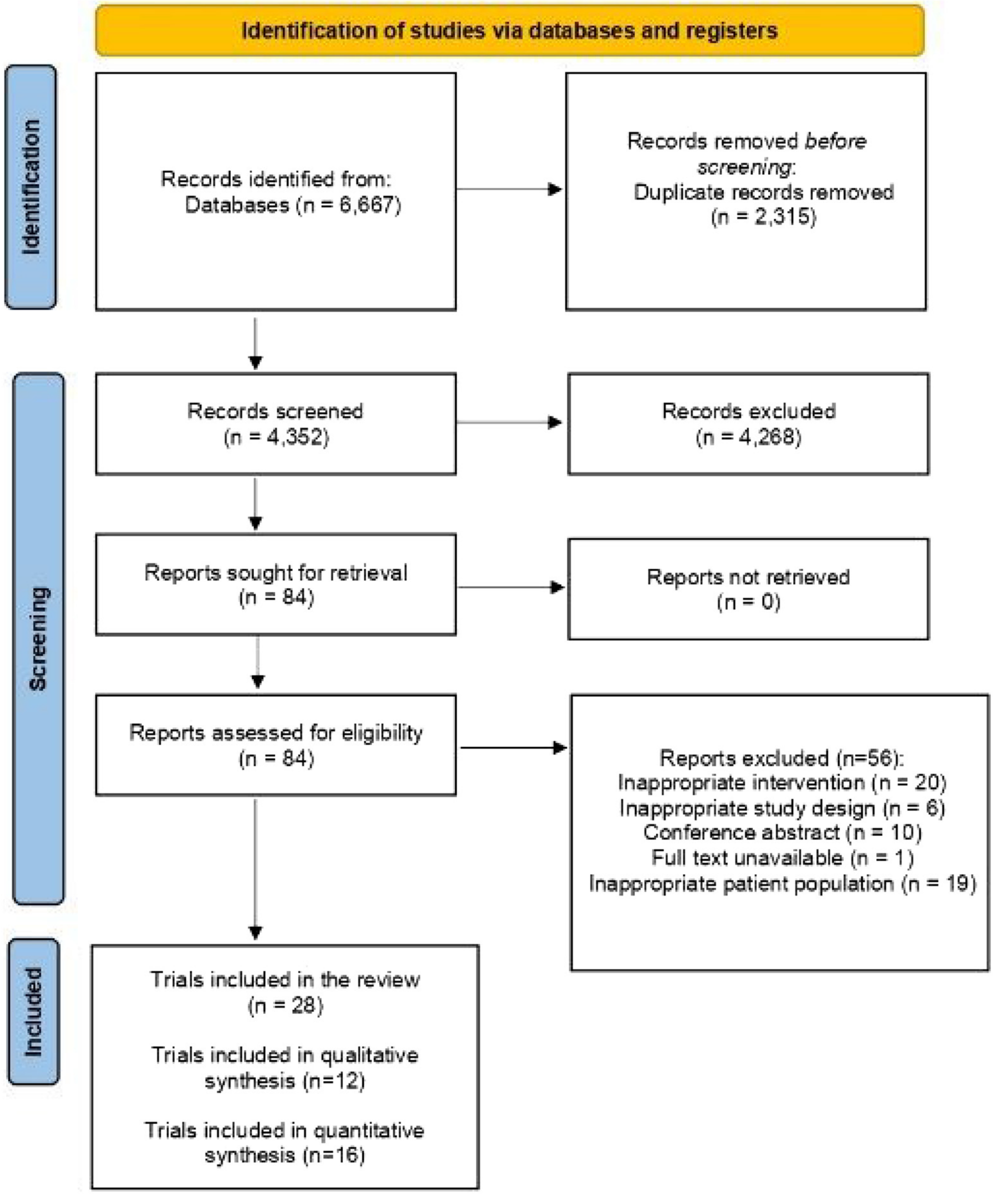

Figure 1 — Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow chart.

(Figure 2A). Regarding parallel trials, all 5 trials[18,47,51,53] were rated as "high risk" (Figure 2B). The risk of bias was largely consistent between the trials. Most trials scored a high risk of bias due to a need for more information regarding the randomization process and reporting insufficient details about the outcomes or intervention.

Data Synthesis

Results from pooled analyses and the certainty of the evidence are summarized in Table 1. The pooled analyses were performed considering the outcomes evaluated during running and postrunning. All data pooled were derived from crossover trials. Summary GRADE tables for all pooled comparisons are presented in Supplementary Material S7 (available online). Results for outcomes in trials ineligible for pooling are presented in the Supplementary Material S8 (available online), including their MD or SMD, 95% CI and a narrative synthesis. The summary of the included outcomes and their definitions is presented in Supplementary Material S9 (available online).

Physiological Outcomes

Heart Rate

Twelve trials (211 runners) compared the effect of compression socks on heart rate during running.[16,17,20,35,36,38,39,41,45,46,48,50] Data from 10 trials ($n = 197$ runners) were pooled for analysis.[16,17,20,35,36,38,39,41,46,48] The results indicate there is moderate-certainty evidence with low statistical heterogeneity ($I^2 = 0\%$) to suggest that compression socks are not significantly different from regular socks (MD [95% CI] = 0.82 [−0.39 to 2.03], $P = .18$) (Figure 3A).

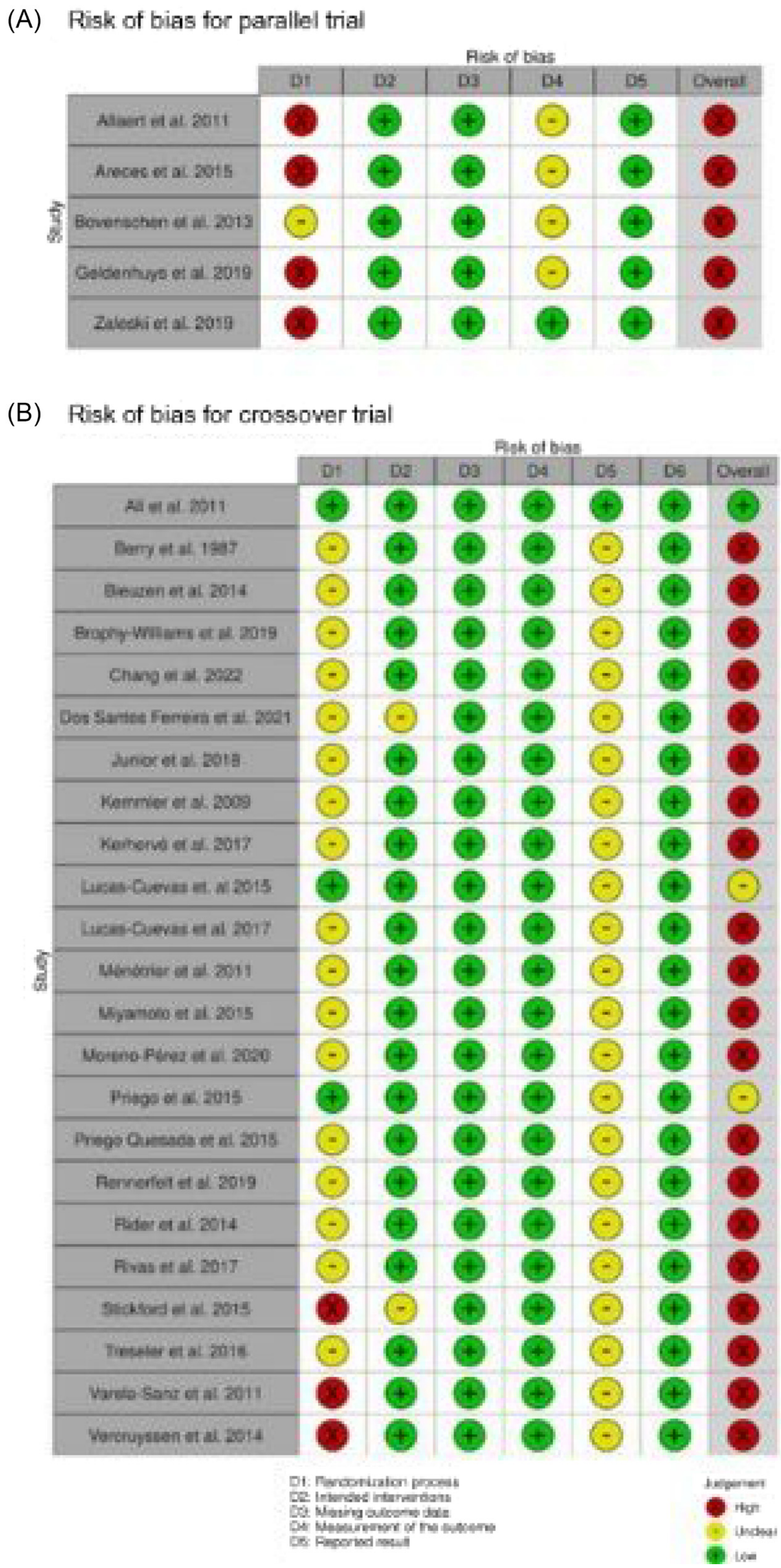

Figure 2 — Risk of bias of crossover trial trials (A) and parallel trial trials (B).

Table 1 Summary of Findings

Outcomes	Time points	MD or SMD (95% CI)	No of participants (trials)	Certainty of the evidence (GRADE)	Comments
Physiological outcomes—compression socks compared to regular socks					
Heart rate	During running	MD **0.82 higher** (0.39 lower to 2.03 higher)	179 (10)	⊕⊕⊕◯ MODERATE	Downgraded because of risk of bias and publication bias
Percentage of maximal heart rate	During running	MD **0.68 higher** (0.83 lower to 2.19 higher)	45 (3)	⊕◯◯◯ VERY LOW	Downgraded because of risk of bias, inconsistency, imprecision, and publication bias
Blood lactate concentration	Postrunning	MD **0.30 higher** (0.39 lower to 0.98 higher)	108 (7)	⊕⊕◯◯ LOW	Downgraded because of risk of bias and publication bias
Maximal oxygen consumption (VO_2max)	During running	MD **0.18 higher** (0.68 lower to 1.04 higher)	98 (7)	⊕◯◯◯ VERY LOW	Downgraded because of risk of bias and publication bias
Maximal oxygen consumption (VO_2max)	Postrunning	MD **0.39 higher** (2.49 lower to 3.27 higher)	33 (3)	⊕◯◯◯ VERY LOW	Downgraded because of risk of bias, imprecision, and publication bias
Respiratory exchange ratio	During running	SMD **0.27 lower** (0.80 lower to 0.27 higher)	44 (3)	⊕◯◯◯ VERY LOW	Downgraded because of risk of bias, imprecision, and publication bias
Performance outcomes—compression socks compared to regular socks					
Total running time	Postrunning	SMD **0.06 higher** (0.27 lower to 0.38 higher)	73 (5)	⊕⊕⊕◯ MODERATE	Downgraded because of risk of bias and publication bias
Running speed	During running	MD **0.24 lower** (0.79 lower to 0.31 higher)	49 (3)	⊕◯◯◯ VERY LOW	Downgraded because of risk of bias, imprecision, and publication bias
Time to exhaustion	Postrunning	SMD **0.26 lower** (0.65 lower to 0.13 higher)	51 (4)	⊕⊕◯◯ LOW	Downgraded because of risk of bias, imprecision, and publication bias
Perceptual outcomes—compression socks compared to regular socks					
Perceived exertion	During running	SMD **0.06 higher** (0.17 lower to 0.29 higher)	236 (13)	⊕⊕⊕◯ MODERATE	Downgraded because of risk of bias and publication bias. Upgraded because of precision
Lower limb muscle soreness	Postrunning	SMD **0.08 higher** (0.35 lower to 0.51 higher)	42 (3)	⊕◯◯◯ VERY LOW	Downgraded because of risk of bias, inconsistency, and publication bias

Abbreviations: GRADE, Grading of Recommendations Assessment, Development and Evaluation; MD, mean difference; SMD, standardized mean difference. Note: GRADE Working Group grades of evidence: High certainty: we are very confident that the true effect lies close to that of the estimate of the effect. Moderate certainty: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different. Low certainty: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect. Very low certainty: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect. SMD of <0.2, 0.2 to 0.49, 0.50 to 0.79, and >0.8 represents a minimal, small, medium, and large effect, respectively.

Percentage of Maximal Heart Rate

Three trials (n = 45 runners) compared the effect of compression socks on percentage of maximal heart rate during running[17,41,48] (Figure 3B). Pooled analysis indicates that there is very low-certainty evidence with low statistical heterogeneity ($I^2 = 0\%$) to suggest that compression socks are not significantly different from regular socks (MD [95% CI] = 0.68 [–0.83 to 2.19], $P = .38$).

Blood Lactate Concentration

Seven trials (n = 108 runners) compared the effect of compression socks on blood lactate postrunning[15,16,20,35,39,41,46] (Figure 3C). Pooled analysis indicates there is low-certainty evidence with low statistical heterogeneity ($I^2 = 0\%$) to suggest that compression socks are not significantly different from regular socks (MD [95% CI] = 0.30 [–0.39 to 0.98], $P = .40$).

Maximal Oxygen Consumption (VO_2max)

Seven trials (n = 98 runners) compared the effect of compression socks on VO_2 during running[15,17,35,39–41,46] (Figure 3D), while 3 trials[17,39,46] made this comparison postrunning (n = 33 runners) (Figure 3E). Pooled analysis indicates very low-certainty evidence with low statistical heterogeneity ($I^2 = 0\%$), to suggest that compression socks are not significantly different from regular socks at either time point during running (MD [95% CI] = 0.18 [–0.68 to 1.04], $P = .68$) and postrunning (MD [95% CI] = 0.39 [–2.49 to 3.27], $P = .79$).

Respiratory Exchange Ratio

Three trials (n = 44 runners) compared the effect of compression socks on respiratory exchange ratio during running[35,39,46] (Figure 3F). Pooled analysis indicates that there is low-certainty evidence with moderate statistical heterogeneity ($I^2 = 34\%$) to suggest that compression socks are not significantly different from regular socks (SMD [95% CI] = 0.27 [0.80 to 0.27], $P = .33$).

Running Performance Outcomes

Total Running Time

Five trials (n = 73 runners) compared the effect of compression socks on total running time[15,16,48,49,55] (Figure 4A). Pooled analysis indicates that there is moderate-certainty evidence with low statistical heterogeneity ($I^2 = 0\%$) to suggest that compression socks are

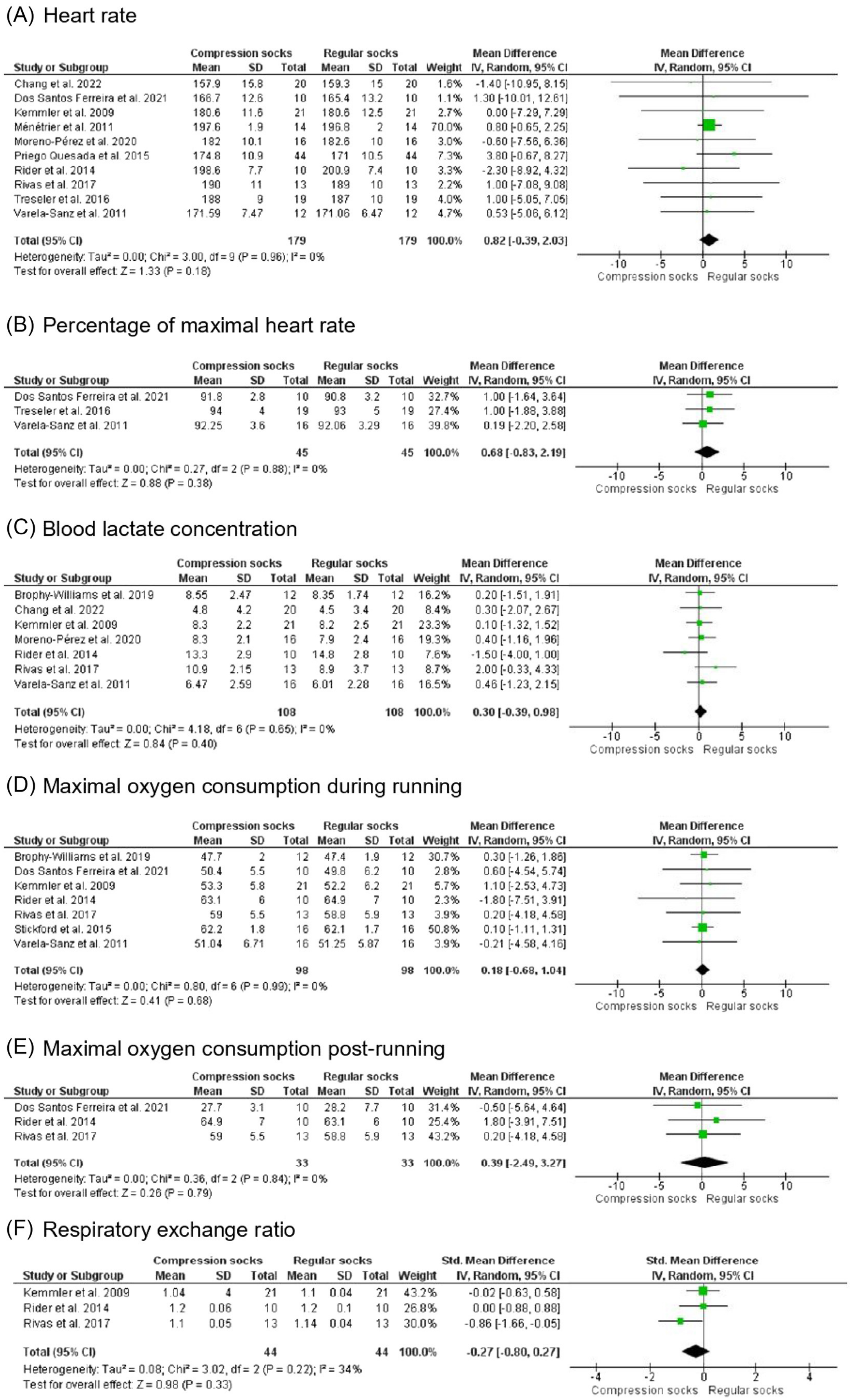

Figure 3 — Pooled data of physiological outcomes. (A) Heart rate. (B) Percentage of maximal heart rate. (C) Blood lactate concentration. (D) Maximal oxygen consumption during running. (E) Maximal oxygen consumption postrunning. (F) Respiratory exchange ratio. IV indicates inverse variance; MD, mean difference; Std, standard mean difference.

not significantly different from regular socks (SMD [95% CI] = 0.06 [–0.27 to 0.38], $P = .74$).

Running Speed

Three trials (n = 49 runners) compared the effect of compression socks on running speed[20,35,41] (Figure 4B). Pooled analysis indicates that there is very low-certainty evidence with low statistical heterogeneity ($I^2 = 0\%$) to suggest that compression socks are not significantly different from regular socks (MD [95% CI] = –0.24 [–0. 79 to 0.31], $P = .39$).

Time to Exhaustion

Four trials (n = 51 runners) compared the effect of compression socks on time to exhaustion[35,36,39,41] (Figure 4C). Pooled analysis indicates that there is low-certainty evidence with low statistical heterogeneity ($I^2 = 0\%$) to suggest that compression socks are not significantly different from regular socks (SMD [95% CI] = –0.26 [–0.65 to 0.13], $P = .20$).

Perceptual Outcomes

Perceived Exertion

Thirteen trials (n = 236 runners) compared the effect of compression socks on perceived exertion[15–17,20,36–39,41,44,46,48,55] (Figure 5A). Pooled analysis indicates that there is moderate-certainty evidence with moderate statistical heterogeneity ($I^2 = 33\%$) to suggest that compression socks are not significantly different from regular socks (SMD [95% CI] = 0.06 [–0.17 to 0.29], $P = .59$).

Lower Limbs Muscle Soreness

Three trials (n = 42 runners) compared the effect of compression socks on lower limb muscle soreness postrunning[15,48,55] (Figure 5B). Pooled analysis indicates that there is very low-certainty evidence with low statistical heterogeneity ($I^2 = 0\%$) to suggest that compression socks are not significantly different from regular socks (SMD [95% CI] = 0.08 [–0.35 to 0.51], $P = .71$).

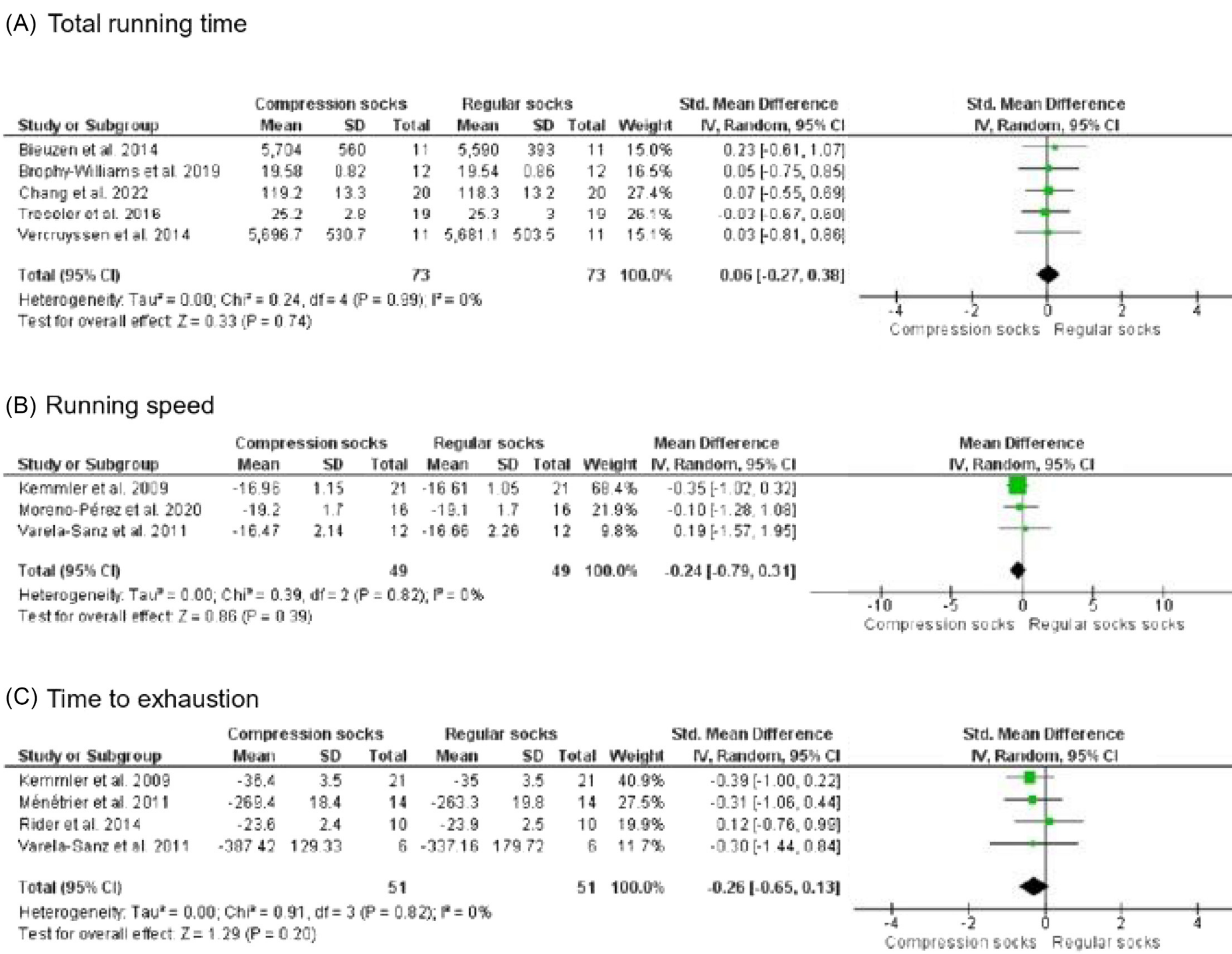

Figure 4 — Pooled data of running performance. (A) Total running time. (B) Running speed. (C) Time to exhaustion. IV indicates inverse variance; MD, mean difference; Std, standard mean difference.

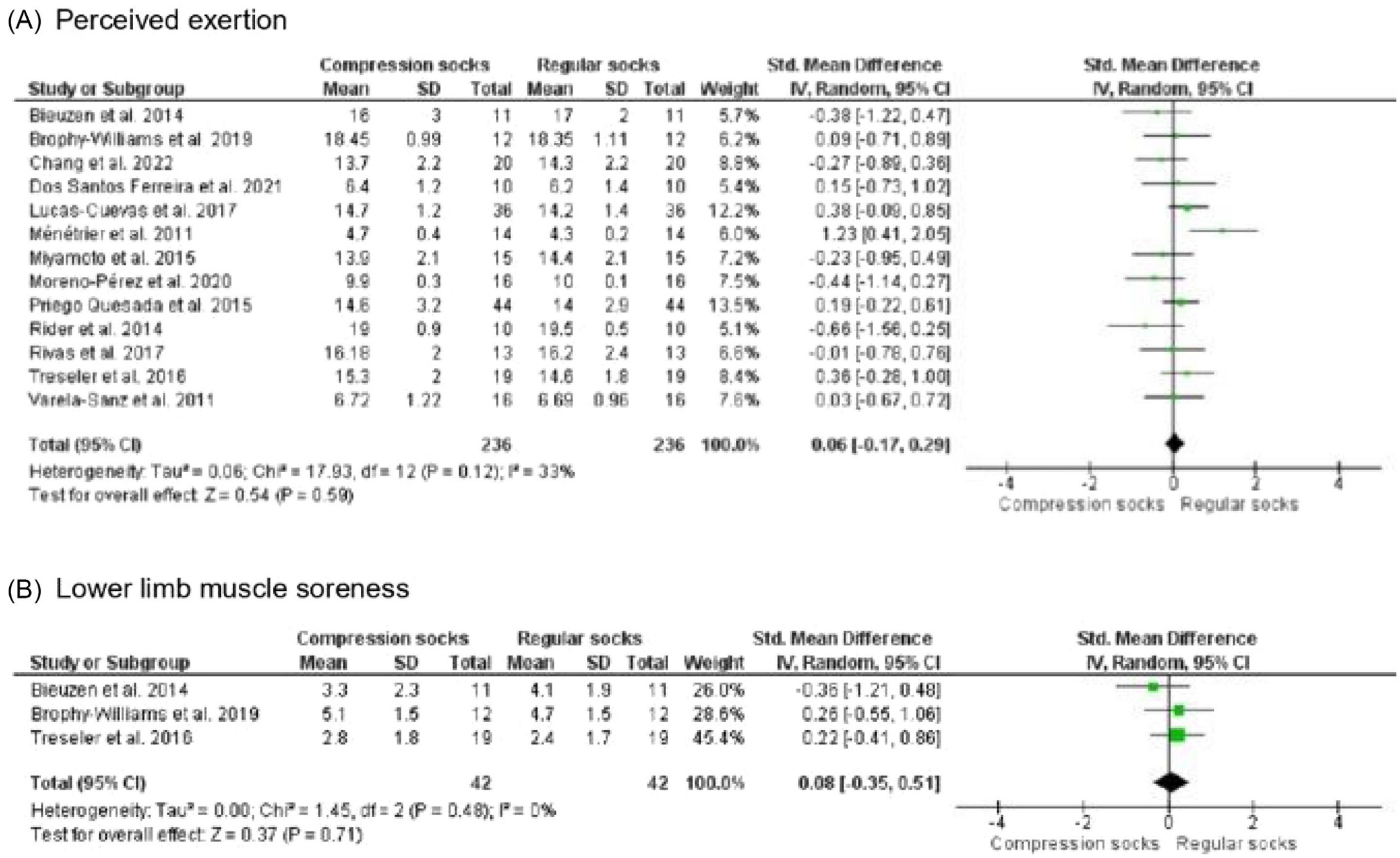

Figure 5 — Pooled data of perceptual outcomes. (A) Perceived exertion. (B) Lower limb muscle soreness. IV indicates inverse variance; MD, mean difference; Std, standard mean difference.

Subgroup Analysis

Subgroup analysis of running on a treadmill was possible only for the perceived exertion (Supplementary Material S10 [available online]). Data from 11 trials (n = 206 runners) compared the effect of compression socks on perceived exertion.[15–17,20,36,37,39,41,44–46] Pooled analysis indicates that there is very moderate-certainty evidence with moderate statistical heterogeneity ($I^2 = 38\%$) to suggest that compression socks are not significantly different from regular socks (SMD [95% CI] = 0.06 [–0.20 to 0.32], $P = .64$).

Discussion

Our systematic review explored the effect of wearing compression socks during running on physiological, running performance, and perceptual outcomes. We identified 28 trials and included data from 16 trials (n = 284 runners) on the meta-analyses. Pooled analysis indicated that compression socks do not benefit runners on physiological, running performance, and perceptual outcomes compared to regular socks.

Physiological Outcomes

Although the use of compression socks has been proposed to prevent performance deterioration and improve recovery by accelerating nutrient delivery[56,57] and metabolite removal[42,58] due to enhanced blood flow,[59] our findings suggest that they are not superior to regular socks for improving physiological parameters. These findings are consistent with previous systematic reviews[10,13] that evaluated the effects of wearing compression garments on physiological parameters in both runners and mixed populations. One systematic review[10] specifically examining the effects of wearing lower-limb and whole-body compression garments in runners found no effects of their use during or after long-distance running on heart rate, oxygen uptake, or blood lactate concentration compared with a noncompression garment intervention. Additionally, another systematic review[13] involving a mixed population found no differences of wearing lower-limb compression garments during high-intensity exercise compared to a noncompression condition.

The limited number of trials, their crossover design, and the variability in running protocols, and sock compression level used limit our ability to provide direct recommendations to clinical practice about the effect of specific compression socks. Therefore, caution should be used when interpreting our findings.

Running Performance Outcomes

Our findings align with previous systematic reviews[10,13] that have examined the effects of compression garments on running performance variables on a variety of sport populations. One systematic review[10] found a trivial effect of compression garments on running time across various running protocols and a small positive effect on time to exhaustion during incremental or step tests, compared to noncompression interventions. Conversely, another systematic review[13] reported no effect of lower-limb compression garments on high-intensity exercise performance—measured as the time difference in maximum running tests over specific distances (50–400 m, 800–3000 m, or >5000 m)—when compared with noncompression interventions or placebo garments.

Various factors can influence running performance, including physiological variables, such as an athlete's peak oxygen uptake and velocity at the lactate threshold, as well as effort duration, and environmental conditions.[10] As noted by Wang et al,[60] the use of compression garments did not demonstrate any beneficial effects on running performance. Our systematic review found similar results, suggesting that the lack of impact of compression socks on physiological variables may explain their lack of effect on running performance when compared with regular socks.

Compression socks might potentially improve performance by reducing muscle oscillations, enhancing muscle proprioception, and improving running economy.[11] However, improvements in the running speed of middle- and long-distance runners are more likely to be influenced by strength training with high loads (≥80% of one repetition maximum) and plyometric training, rather than by the use of compression socks.[61]

Perceptual Outcomes

In contrast to our findings, a systematic review observed a small positive effect of wearing compression garments on perceived exertion and a large positive effect on lower limb muscle soreness during both running and recovery.[10] A possible explanation for the conflicting findings is that, unlike our review, Engel et al[10] included studies with various compression garments, including whole-body compression garments. Although, to the best of the authors' knowledge, no trial has evaluated the differing effects of whole-body compression garments and compression socks, it is possible that whole-body compression garments, compared with compression socks, may offer greater benefits by reducing structural damage to muscles,[62,63] and/or improving lymphatic outflow[64] leading to reduced muscle swelling and greater comfort.[65] The lack of benefit from wearing compression socks on runners' perceived exertion may be aligned with the absence of change in the runners' heart rates.

Strength and Limitations

The strengths of our review include using a prespecified protocol with no language and date restriction criteria, informed by consumers, and the summary of the certainty of the evidence using the GRADE approach. As limitations, most trials were classified as high risk of bias, which impacts the certainty of the evidence produced by our systematic review. Most of the pooled analysis was based on a limited number of trials and only included crossover design trials and the interventions exhibited inherent differences (eg, different sock compression levels were applied across studies and different running protocols were performed) that make it difficult to draw definitive conclusions about the effects of different types of compression socks. Considering that runners used compression socks only once in the included trials, there is a lack of evidence regarding the continuous use of compression socks. Moreover, running sections were not long enough to show compression socks effects. Additionally, future trials should focus on including an adequate sample size and should be designed as a parallel randomized controlled trial with an appropriate comparator to control for placebo effects,[66] as the lack of blinding regarding the intervention applied may influence perceptual variables. Caution should be taken when interpreting our findings to specific running populations once we have trials ranging from recreational to ultramarathon runners. Most crossover trials (22/23) did not report period effect analysis to ensure the intervention order did not affect the final analysis. Therefore, findings from this systematic review should be interpreted with caution.

Implication for Clinicians

Our findings suggest that wearing compression socks during running may not benefit physiological, running performance, and perceptual outcomes compared with regular socks. These findings challenge the large adoption of compression socks by runners during competition and training. On the other hand, runners wearing compression socks during running do not appear to have any detrimental effect on physiological, running performance, and perceptual outcomes. This information may help runners and clinicians to make informed decisions about whether to wear compression socks while running based on treatment effect. However, we did not synthesize the literature on adverse events of wearing compression socks, as it was beyond the scope of this systematic review. These recommendations are based on very low to moderate-certainty evidence, highlighting the need for future high-quality research.

Conclusions

There is very low to moderate-certainty evidence that wearing compression socks during running does not benefit physiological, running performance, or perceptual outcomes compared with regular socks.

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