The Journal of Sexual Medicine, 2023, 1–7
https://doi.org/10.1093/jsxmed/qdad130
Review Article

Effect of aerobic exercise on erectile function: systematic review and meta-analysis of randomized controlled trials

Mohit Khera, MD[1], Samir Bhattacharyya, PhD, MS, MSc[2], Larry E. Miller, PhD, PStat[3,*]

[1]Baylor College of Medicine, Houston, TX, 77030, United States
[2]Health Economics and Market Access, Boston Scientific, Marlborough, MA, 01752, United States
[3]Department of Biostatistics, Miller Scientific, Johnson City, TN, 37604, United States

*Corresponding author: Department of Biostatistics, Miller Scientific, 3101 Browns Mill Rd, Ste 6, #311, Johnson City, TN 37604, United States.
Email: larry@millerscientific.com

Abstract

Background: The health benefits of regular aerobic exercise are well established, although there is limited high-quality evidence regarding its impact on erectile function.
Aim: To determine the effect of aerobic exercise on erectile function in men and to identify factors that may influence this effect.
Methods: This systematic review and meta-analysis included randomized controlled trials that evaluated the effects of aerobic exercise on erectile function via the Erectile Function domain of the International Index of Erectile Function (IIEF-EF). The mean difference in IIEF-EF scores between the aerobic exercise and nonexercising control groups was estimated by a random-effects meta-analysis. Meta-regression was used to evaluate the association of moderator variables on meta-analysis results.
Outcomes: The IIEF-EF score is reported on a 6-30 scale, with higher values indicating better erectile function.
Results: Among 11 randomized controlled trials included in the analysis, aerobic exercise resulted in statistically significant improvements in IIEF-EF scores as compared with controls, with a mean difference of 2.8 points (95% CI, 1.7-3.9; $P < .001$) and moderate heterogeneity among studies ($I^2 = 53\%$). The effect of aerobic exercise on erectile function was greater in men with lower baseline IIEF-EF scores, with improvements of 2.3, 3.3, and 4.9 points for mild, moderate, and severe erectile dysfunction, respectively ($P = .02$). The meta-analysis results were not influenced by publication bias or individual study effects.
Clinical Implications: Health care providers should consider recommending regular aerobic exercise as a low-risk nonpharmacologic therapy for men experiencing erectile difficulties.
Strengths and Limitations: The primary strength of this review was the generation of level 1 evidence on a topic of general interest regarding sexual health in men. However, the included studies evaluated diverse groups, which may complicate data interpretation for specific segments of the population.
Conclusion: Regular aerobic exercise can improve the erectile function of men, particularly those with lower baseline IIEF-EF scores.

Keywords: ED; erectile function; exercise; IIEF-EF; International Index of Erectile Function; physical activity.

Introduction

Erectile function tends to decline in aging men due to various factors, including decreased testosterone, decreased libido, changes in vasculature and endothelium, and an increased likelihood of comorbidities (eg, hypertension, diabetes, and obesity).[1–3] The age-related decline in erectile function manifests as erectile dysfunction (ED) in most older men,[4] which is characterized by the inability to achieve or maintain an erection sufficient for satisfactory sexual performance.[5] Men experiencing erectile difficulties may experience sexual dissatisfaction, lower quality of life, anxiety, depression, and relationship difficulties.[6,7] Furthermore, declines in erectile function may serve as an early warning sign of underlying chronic diseases, such as cardiovascular disease and diabetes, which may present years after the onset of erectile symptoms.[8,9] Thus, erectile difficulties may indicate the need for closer monitoring and potential interventions to improve overall health outcomes.

Despite the well-established health benefits of regular aerobic exercise, limited high-quality evidence is available regarding its impact on erectile function. Previous reviews on exercise and erectile function have combined evidence from nonrandomized studies[10,11] and nonaerobic training regimens[12,13] or presented results in a narrative or descriptive format only,[11,14,15] resulting in unclear conclusions regarding the effects of aerobic training on erectile function. Furthermore, the effects of aerobic exercise on erectile function tend to be greater in nonrandomized studies,[10,11] highlighting the need for a synthesis of randomized trials to determine efficacy while minimizing bias. To our knowledge, no meta-analysis has reported the effects of aerobic exercise on erectile function. To address this research gap, we performed a systematic review and meta-analysis of randomized controlled trials (RCTs) to determine the effect of aerobic exercise on the erectile function of men and to identify factors that may influence this effect. We hypothesized that men would

Received: May 22, 2023. **Revised:** August 27, 2023. **Accepted:** September 4, 2023

Table 1. MEDLINE search strategy[a]

Design search terms
1. Control*
2. Random*
Intervention search terms
3. Aerobic
4. Endurance
5. Exercise
6. Lifestyle
7. Physical activity
8. Training
9. Walking
Diagnosis search terms
10. Androgen deficien*
11. ED
12. Erectile dysfunction
13. Erectile function
14. Hypogonadism
15. IIEF
16. Impotence
17. International Index of Erectile Function
18. Rehabilitation
19. Sexual function
Combination terms
20. or/1-2
21. or/3-9
22. or/10-19
23. and/20-22

Abbreviations: ED, erectile dysfunction; IIEF, International Index of Erectile Function–Erectile Function. [a]The asterisk (*) is a wild card symbol used in a search query to represent end truncation.

experience improved erectile function by engaging in regular aerobic exercise.

Methods

This review followed the PRISMA guidelines (Preferred Reporting Items for Systematic Reviews and Meta-analyses)[16] and was prospectively registered at www.researchregistry.com (reviewregistry1604).

Search strategy

We systematically searched Medline, Embase, and the Cochrane Central Register of Controlled Trials to identify RCTs comparing aerobic exercise with nonexercising controls. Additionally, we manually searched the Directory of Open Access Journals, Google Scholar, and the reference lists of relevant studies and review articles. The searches used combinations of terms related to study design, intervention, and diagnosis, with no restrictions on publication date or language (Table 1). We used EndNote X9 (Clarivate) for systematic searching and reference management.

In accordance with Cochrane guidance,[17] 2 researchers with extensive experience performing systematic reviews independently reviewed titles and abstracts to identify potentially eligible studies. We excluded nonrandomized studies, studies involving nonaerobic exercise only (eg, resistance and pelvic floor training), studies with an exercising control group, studies that did not report primary outcome data, studies published as abstracts or presentations, and duplicate publications. We obtained the full text of the remaining articles that were deemed eligible or had uncertain eligibility. Study eligibility disagreements were resolved by discussion. The most recent searches were performed in April 2023.

Data extraction and outcomes

The same researchers independently extracted data from the studies using piloted data collection forms. Key study elements were recorded: study metadata, participant characteristics, study characteristics, treatment regimens, and the primary outcome—which was the change in the Erectile Function domain of the International Index of Erectile Function (IIEF-EF). The IIEF-EF is a validated questionnaire used to assess the erectile function of men and is scored on a scale from 5 to 25 (IIEF-EF-5) or 6 to 30 (IIEF-EF-6), with higher scores indicating better erectile function.[18] We standardized all IIEF-EF scores to a 6-30 scale by multiplying the mean and SD of IIEF-EF-5 values by 1.2 to ensure data consistency among trials for statistical analysis. IIEF-EF scores of 26 to 30 indicated no ED; 22 to 25, mild ED; 17 to 21, mild to moderate ED; 11 to 16, moderate ED; and 6 to 10, severe ED.[19] The risk of bias in individual studies was assessed with the Cochrane Collaboration tool.[20]

Data analysis

Using a restricted maximum-likelihood random-effects meta-analysis, we estimated the mean difference (MD) in IIEF-EF scores between the aerobic exercise and control groups. Positive MD values indicated higher IIEF-EF scores with aerobic exercise, while negative values indicated higher scores in controls. The MD and 95% CI were calculated for each study, and the overall result was presented in a forest plot. We assessed heterogeneity among studies using the I^2 statistic, with values >50% indicating significant heterogeneity.[21] We performed meta-regression to determine the association of study-level factors with the MD in the IIEF-EF score. The variables of interest were age, baseline IIEF-EF score, percentage of men with ED diagnosis, percentage of men taking a phosphodiesterase 5 inhibitor (PDE5i), duration of aerobic exercise intervention, and supervision of the exercise program. Publication bias was evaluated with an Egger regression test.[22] Additionally, the trim-and-fill method was used to identify potential publication bias by estimating the number of studies missing from the meta-analysis due to publication bias and recalculating the results.[23] The influence of single-study effects was evaluated in a 1-study-removed sensitivity analysis where the primary outcome was reestimated following iterative removal of each study from the analysis. *P* values were 2-sided and considered statistically significant if <.05. Statistical analyses were performed with Stata version 18 (Stata Corp), and risk of bias was classified with Review Manager version 5.4 (Cochrane Collaboration).

Results

The systematic review identified 11 RCTs[24–34] with 1147 men included in the meta-analysis: 636 assigned to aerobic exercise and 511 to control (Figure 1).

Participant characteristics

There was considerable variation among trials in participant comorbidities, concurrent PDE5i utilization, and exercise regimen characteristics (Table 2). Overall, comorbidities were reported inconsistently among trials, with overweight/obesity a common characteristic. The percentage of men with ED ranged from 35% to 100% (median, 96%). Concurrent ED medication use varied widely, from 0% to 100% (median,

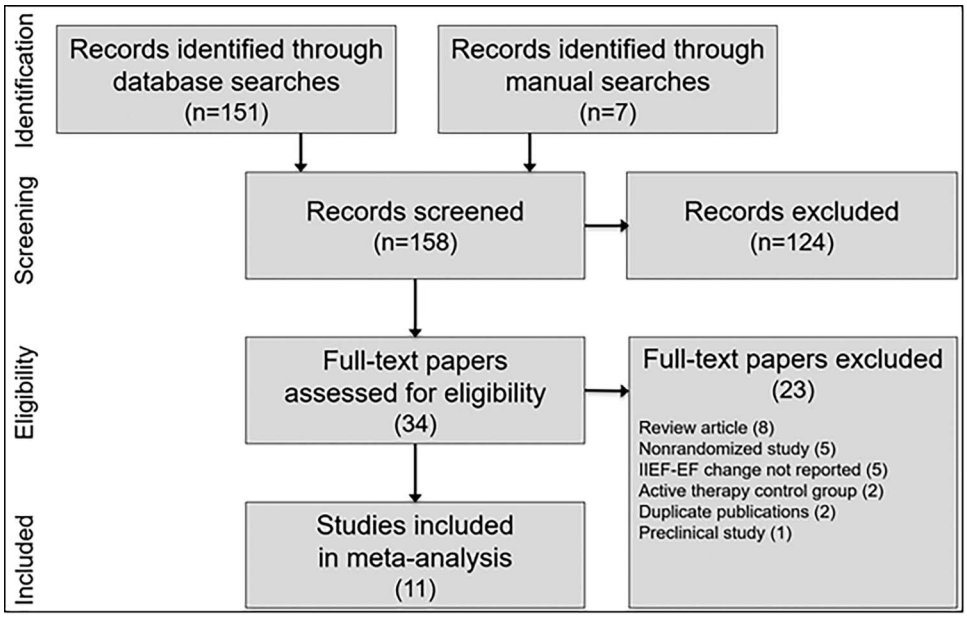

Figure 1. PRISMA flow diagram. IIEF-EF, International Index of Erectile Function–Erectile Function.

9%). The mean baseline IIEF-EF score across all studies was 17.7 (range, 9.7-25.6), indicating mild to moderate ED overall.

Interventions

The exercise interventions ranged from 2 to 24 months (median, 6). Six studies implemented supervised aerobic exercise sessions, while 5 provided resources and counseling intended to increase unsupervised physical activity. In all 5 studies that utilized unsupervised exercise, the exercise group performed more physical activity than the control group. Exercise session lengths were typically 30 to 60 minutes, and frequency was 3 to 5 times per week. Three studies also incorporated resistance training. Control groups typically engaged in "usual care," generally described as a continuation of the current lifestyle. In 3 trials, the control group was provided resources and support for improving health, with little or no guidance on increasing physical activity.

Risk of bias

The risk-of-bias summary for each trial is provided in Figure 2. The overall risk of bias across the 11 randomized trials was moderately low. Most studies were judged to have a low risk of bias for random sequence generation, incomplete outcome data, and selective reporting. Descriptions of allocation concealment were unreported in most trials. The risk of bias was high in all trials for performance and detection biases due to the inability to blind the treatment groups.

Effect of aerobic exercise on erectile function

Aerobic exercise resulted in statistically significant improvements in IIEF-EF scores as compared with the control group, with an MD of 2.8 (95% CI, 1.7-3.9; $P < .001$). Moderate heterogeneity ($I^2 = 53\%$) was observed among the studies (Figure 3).

Meta-regression

In the meta-regression, the effect of aerobic exercise on erectile function was greater in men with lower baseline IIEF-EF scores (Table 3, Figure 4), with improvements of 2.3, 3.3, and 4.9 points for mild, moderate, and severe ED, respectively ($P = .02$). None of the following statistically modified the treatment benefit of aerobic exercise: exercise supervision ($P = .07$), age ($P = .12$), percentage of men with ED ($P = .12$), percentage of men taking PDE5i ($P = .51$), and exercise intervention duration ($P = .87$).

Sensitivity analyses

A trim-and-fill analysis to adjust for potential publication bias imputed 2 missing studies, slightly increasing the MD from 2.8 to 3.0 (Figure 5). The Egger test showed no statistical evidence of small-study effects or publication bias ($P = .83$). Overall, the influence of possible publication bias on erectile function outcomes with aerobic exercise was minimal, and the publication bias–adjusted results were consistent with the primary analysis. The conclusions derived from the primary analysis were also confirmed in a 1-study-removed sensitivity analysis, where iterative removal of 1 study at a time resulted in MD values ranging from 2.2 to 3.0 (all $P < .001$), suggesting that the overall findings were robust and not significantly influenced by any single trial.

Discussion

In this systematic review and meta-analysis of 11 RCTs, men participating in regular aerobic exercise reported improved erectile function when compared with nonexercising controls. Furthermore, the beneficial effect of aerobic exercise on erectile function was greater in men with lower baseline IIEF-EF scores. However, the effect of aerobic exercise on erectile function was significant across all levels of baseline IIEF-EF scores, indicating that even men experiencing mild erectile difficulties may still benefit from aerobic exercise. Therefore, regular aerobic exercise can be considered a low-risk and effective nonpharmacologic therapy for men at risk of or currently experiencing ED.

Regular aerobic exercise can maintain or improve erectile function through various mechanisms. Physical activity

Table 2. Study characteristics in randomized controlled trials of aerobic training for erectile function.

Study	Comorbidity (%)	Sample size[a]	Mean age, y	Exercise group	Control group	ED medication, %	Duration, mo
Collins (2013)[24]	Overweight (100), ED (35)	96/49	47	Availability of weight loss resources promoting diet and unsupervised aerobic exercise	No intervention	—	6
Esposito (2004)[25]	Obese (100), ED (96)[b]	55/55	43	Resources available for weight loss with advice on reducing body weight by at least 10%, including unsupervised aerobic exercise	Availability of general information about healthy eating and exercise	0	24
Jones (2014)[26]	Post-RP (100), ED (80)	25/25	59	Supervised walking 5×/wk at 55%-100% VO_2 peak for 30-45 min/session	Usual activity	56	6
Kalka (2013)[27]	Post-PCI/CABG (100), ED (100)	115/35	62	Supervised cycling and general fitness exercises 3×/wk at 40%-70% maxHR for 45 min/session; resistance training 2×/wk	Received advice about active lifestyle	0	6
Lamina (2009)[28]	Hypertension (100), ED (100)	22/21	63	Supervised cycling 3×/wk at 60%-79% maxHR for 45-60 min/session	Usual activity	—	2
Leitao (2021)[29]	Androgen deficiency (100), ED (74)[b]	11/12	47	Supervised treadmill activity 3×/wk at "moderate-somewhat strong" on the Borg scale; resistance training 3×/wk	No intervention	9[b]	6
Maio (2010)[30]	ED (100), Overweight (58)	30/30	50	Provided detailed resources promoting unsupervised aerobic activities 3-5×/wk at 55%-64% maxHR for 20-60 min/session	Usual care	100	3
Maresca (2013)[31]	Metabolic syndrome (100), ED (100),	10/10	69	Supervising cycling or treadmill 3×/wk at 65% VO_2 max for 40 min/session	Usual care	100	2
Palm (2018)[32]	Ischemic heart disease (100), ED (100)	75/79	62	Supervised interval cycling 3×/wk for 30-min resistance training; pelvic floor exercise; psychoeducation	Usual care	9	3
Reis (2009)[33]	Morbid obesity (100), ED (65)[b]	10/10	39	Unsupervised moderate exercise at least 5×/wk for at least 30 min/d	Usual care	0	4
Wing (2010)[34]	Diabetes mellitus (100), overweight (100), ED (56)	187/185	61	Focus on changing diet and increasing unsupervised aerobic exercise, with a goal of inducing a loss ≥7% of initial weight	Received diabetes support and education	36	12

Abbreviations: CABG, coronary artery bypass graft; ED, erectile dysfunction; maxHR, maximum heart rate; PCI, percutaneous coronary intervention; RP, radical prostatectomy; VO_2, volume oxygen. [a]Exercise/control groups.

positively affects cardiovascular health, which is closely associated with erectile function.[35] Additionally, regular aerobic exercise helps reduce body weight in overweight or obese individuals, lower blood pressure, and improve glycemic control in people with diabetes—all risk factors for ED that could be mitigated through aerobic activity.[36] Aerobic exercise also improves endothelial function through increased nitric oxide production and endothelial progenitor cell growth, which regulate vascular function and maintain normal erectile function.[37] Testosterone concentration is augmented with aerobic training by activating the hypothalamic-pituitary-gonadal axis and reducing sex hormone–binding globulin.[37,38] Finally, regular aerobic exercise reduces oxidative stress and inflammation,[39] additional factors associated with ED development.

Various treatment options are available for men with ED, including PDE5i, vacuum erection devices, penile injections, and penile prostheses. However, aerobic exercise could provide additional benefits for men with ED. This statement is supported by the observation in this meta-analysis that exercise improved erectile function independent of PDE5i utilization. Thus, men experiencing erectile difficulties should be informed about all available treatment modalities and encouraged to engage in regular aerobic activity, as the benefits complement traditional ED treatments. Overall, the results of this meta-analysis suggest that aerobic exercise may be a low-risk approach to improve erectile function in men without contraindications to physical activity.

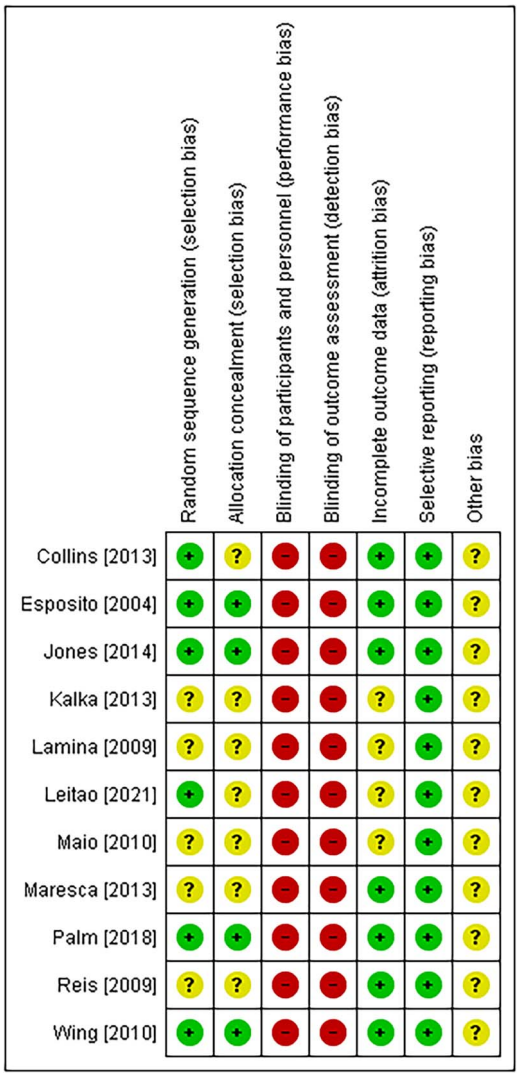

Figure 2. Risk-of-bias summary. Review authors' judgments about each risk-of-bias item per study.

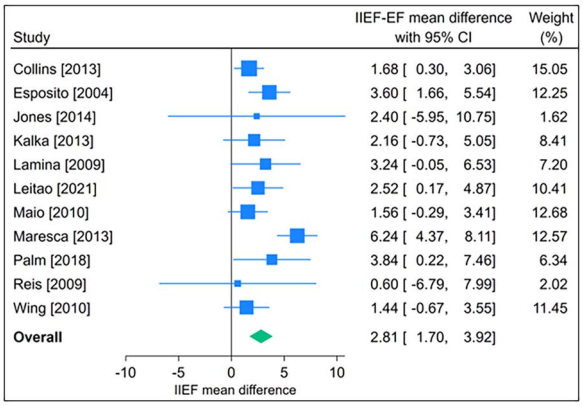

Figure 3. Effect of aerobic exercise on erectile function. Values are reported as the difference in IIEF-EF (6-30 scale) between the aerobic exercise and control groups. The mean difference and 95% CI are plotted for each study. The pooled mean difference (diamond apex) and 95% CI (diamond width) are calculated via a random-effects model. Mean difference = 2.8 (95% CI, 1.7-3.9; $P < .001$). Heterogeneity: $I^2 = 53\%$. IIEF-EF, International Index of Erectile Function–Erectile Function.

Table 3. Association of participant and study factors on the mean difference in the IIEF-EF between the exercise and control groups.[a]

Variable	*z* score[b]	*P* value
Lower baseline IIEF-EF score	2.30	.02
Exercise with supervision	1.83	.07
Older age	1.57	.12
Higher percentage with ED	1.57	.12
Higher percentage of PDE5i use	0.67	.51
Shorter treatment duration	0.17	.87

Abbreviations: ED, erectile dysfunction; IIEF-EF, International Index of Erectile Function–Erectile Function; PDE5i, phosphodiesterase type 5 inhibitor. [a]Results derived from random-effects meta-regression. [b]Positive *z* value indicates that the variable improved the overall benefit of aerobic exercise.

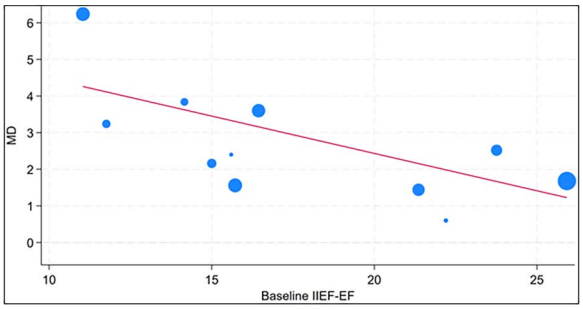

Figure 4. Association between the mean group difference in IIEF-EF and baseline IIEF-EF. Open circles represent values of individual studies, where the circle size is proportional to the study weight in the random-effects model. The diagonal line represents the regression line of best fit. Regression equation for the mean difference with aerobic exercise: 6.5 – (0.2 × baseline IIEF-EF), where the IIEF-EF is measured on a 6-30 scale ($P = .02$). IIEF-EF, International Index of Erectile Function–Erectile Function; MD, mean difference.

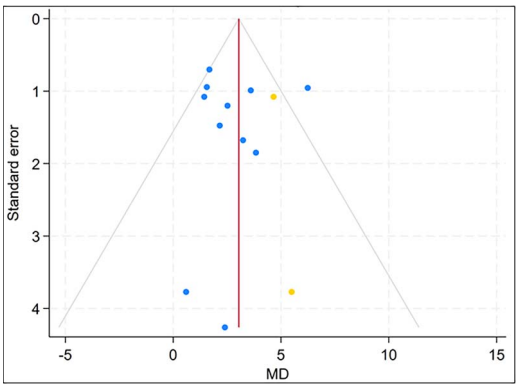

Figure 5. Publication bias–adjusted funnel plot of the MD in the IIEF-EF with aerobic exercise. The trim-and-fill method was used to identify potential publication bias by estimating the number of studies missing from the meta-analysis due to publication bias and recalculating the results. The MD and SE for the IIEF-EF are plotted in blue for observed studies and orange for imputed studies, where the IIEF-EF is measured on a 6-30 scale. The MD of aerobic exercise on the IIEF-EF was 2.8 in the primary analysis and 3.0 in the publication bias–adjusted analysis (vertical line), with pseudo 95% CIs represented by the diagonal lines. Egger regression test for small-study effects: $P = .83$, indicating no evidence of publication bias. IIEF-EF, International Index of Erectile Function–Erectile Function; MD, mean difference.

The degree of erectile function improvement observed with aerobic exercise in this meta-analysis was not only statistically significant but also clinically meaningful. The minimum clinically important difference for the IIEF-EF

on the 6-30 scale is 2.4 points for men with mild ED (17-25), 6.0 for moderate (11-16), and 8.4 for severe (6-10).[40] The meta-regression results indicated that aerobic exercise improved IIEF-EF scores by 2.3, 3.3, and 4.9 points for mild, moderate, and severe ED, respectively, corresponding to approximately 60% to 100% of the minimum clinically important difference, depending on baseline erectile function. For reference, IIEF-EF improvements with other ED therapies are 2 points for testosterone replacement, 4 for shockwave therapy, and 4 to 8 for PDE5i.[41] Consequently, aerobic exercise may serve as a valuable nonpharmacologic strategy for managing ED, particularly for men who prefer or cannot tolerate medications or interventional treatments.

The strengths of this review include the generation of level 1 evidence within a meta-analysis of RCTs and the identification of factors influencing the response of erectile function to aerobic exercise. However, several limitations of the review warrant discussion. First, various factors may influence the degree of improvement in erectile function with exercise, such as the severity and underlying causes of ED, the type and intensity of exercise, individual variations in response, concomitant therapies, dietary factors, and body weight changes. Although attempts were made to analyze some of these variables by meta-regression, the potential for confounding due to unmeasured factors must be acknowledged. For example, race, obesity, hypertension, smoking, and diabetes mellitus are associated with an increased risk of ED,[42] yet they were reported with insufficient detail to determine their independent associations with erectile function. Additionally, individuals who engage in aerobic exercise may concomitantly alter their lifestyle in other ways, such as diet modification, that could contribute to changes in erectile function. Since changes in dietary and lifestyle factors were rarely reported in the studies, their independent influence could not be determined in this review. Second, diverse groups were evaluated in the studies, which may complicate data interpretation for specific segments of the population. Third, the aerobic exercise regimens were incompletely described in some studies and differed in exercise modality, frequency, intensity, and duration. Thus, the optimal duration, intensity, and frequency of aerobic exercise required to produce significant improvements in erectile function remain unclear. Fourth, this review exclusively focused on the effect of aerobic exercise on erectile function and did not examine the effects of other types of physical activity, such as resistance or pelvic floor training, which have been discussed in separate reviews.[43,44] Finally, before recommending regular aerobic exercise, health care providers should acknowledge that it may not be feasible or safe for certain individuals, and they should first consider identifying and addressing potential barriers to exercise as appropriate.[45]

Conclusion

Regular aerobic exercise can improve the erectile function of men, particularly those with lower baseline IIEF scores, and it can be considered a low-risk and effective nonpharmacologic therapy for men at risk of or currently experiencing ED. Future RCTs should explore optimal exercise regimens to support the development of prescriptive guidelines for improving erectile function.

Acknowledgments

We thank David Fay, PhD (Miller Scientific), for assistance with the literature review and data extraction.

Author contributions

Conceptualization: S.B., L.E.M. Data curation: L.E.M. Formal analysis: L.E.M. Investigation: M.K., S.B., L.E.M. Methodology: S.B., L.E.M. Project administration: S.B., L.E.M. Supervision: S.B., L.E.M. Writing: M.K., S.B., L.E.M. Editing: M.K., S.B., L.E.M.

Funding

This study was supported by Boston Scientific. The funding body was involved in the study design, data interpretation, critical review of the article, and the decision to submit the article for publication.

Conflicts of interest

M.K. reports consultancy for Boston Scientific, Endo, Petros, AbbVie, Marius, and Halozyme, all unrelated to the current study. S.B. reports employment with Boston Scientific. L.E.M. reports consultancy with Boston Scientific, related to the current study.

Data availability statement

Data are available from the authors upon reasonable request.

References

1. Feldman HA, Goldstein I, Hatzichristou DG, Krane RJ, McKinlay JB. Impotence and its medical and psychosocial correlates: results of the Massachusetts Male Aging Study. *J Urol*. 1994;**151**(1):54–61.
2. Wu FC, Tajar A, Beynon JM, *et al*. Identification of late-onset hypogonadism in middle-aged and elderly men. *N Engl J Med*. 2010;**363**(2):123–135.
3. Bivalacqua TJ, Usta MF, Champion HC, Kadowitz PJ, Hellstrom WJ. Endothelial dysfunction in erectile dysfunction: role of the endothelium in erectile physiology and disease. *J Androl*. 2003;**24**(6):S17–S37.
4. Shiri R, Koskimaki J, Hakama M, *et al*. Prevalence and severity of erectile dysfunction in 50 to 75-year-old Finnish men. *J Urol*. 2003;**170**(6, pt 1):2342–2344.
5. NIH Consensus Conference. Impotence: NIH Consensus Development Panel on Impotence. *JAMA*. 1993;**270**(1):83–90.
6. Liu Q, Zhang Y, Wang J, *et al*. Erectile dysfunction and depression: a systematic review and meta-analysis. *J Sex Med*. 2018;**15**(8):1073–1082.
7. Fisher WA, Rosen RC, Eardley I, Sand M, Goldstein I. Sexual experience of female partners of men with erectile dysfunction: the Female Experience of Men's Attitudes to Life Events and Sexuality (FEMALES) study. *J Sex Med*. 2005;**2**(5):675–684.
8. Gandaglia G, Briganti A, Montorsi P, Mottrie A, Salonia A, Montorsi F. Diagnostic and therapeutic implications of erectile dysfunction in patients with cardiovascular disease. *Eur Urol*. 2016;**70**(2):219–222.
9. Gowani Z, Uddin SMI, Mirbolouk M, *et al*. Vascular erectile dysfunction and subclinical cardiovascular disease. *Curr Sex Health Rep*. 2017;**9**(4):305–312.
10. Cheng JY, Ng EM, Ko JS, Chen RY. Physical activity and erectile dysfunction: meta-analysis of population-based studies. *Int J Impot Res*. 2007;**19**(3):245–252.
11. Gerbild H, Larsen CM, Graugaard C, Areskoug JK. Physical activity to improve erectile function: a systematic review of intervention studies. *Sex Med*. 2018;**6**(2):75–89.

12. Gupta BP, Murad MH, Clifton MM, Prokop L, Nehra A, Kopecky SL. The effect of lifestyle modification and cardiovascular risk factor reduction on erectile dysfunction: a systematic review and meta-analysis. *Arch Intern Med*. 2011;**171**(20):1797–1803.
13. Silva AB, Sousa N, Azevedo LF, Martins C. Physical activity and exercise for erectile dysfunction: systematic review and meta-analysis. *Br J Sports Med*. 2017;**51**(19):1419–1424.
14. Kim KL. The role of aerobic exercise in erectile dysfunction: a review of randomized controlled trials. *Exercise Science*. 2021;**30**:147–157.
15. Lamina S, Agbanusi E, Nwacha RC. Effects of aerobic exercise in the management of erectile dysfunction: a meta analysis study on randomized controlled trials. *Ethiop J Health Sci*. 2011;**21**(3): 195–201.
16. Liberati A, Altman DG, Tetzlaff J, *et al*. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *Ann Intern Med*. 2009;**151**(4):W65–W94.
17. Cochrane. *Cochrane handbook for systematic reviews of interventions*. Published 2023. Accessed May 12, 2023. https://training.cochrane.org/handbook/current
18. Cappelleri JC, Rosen RC, Smith MD, Mishra A, Osterloh IH. Diagnostic evaluation of the erectile function domain of the International Index of Erectile Function. *Urology*. 1999;**54**(2):346–351.
19. Rosen RC, Riley A, Wagner G, Osterloh IH, Kirkpatrick J, Mishra A. The International Index of Erectile Function (IIEF): a multidimensional scale for assessment of erectile dysfunction. *Urology*. 1997;**49**(6):822–830.
20. Higgins JP, Altman DG, Gotzsche PC, *et al*. The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. *BMJ*. 2011;**343**:d5928.
21. Higgins JP, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. *BMJ*. 2003;**327**(7414):557–560.
22. Egger M, Davey Smith G, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. *BMJ*. 1997; **315**(7109):629–634.
23. Duval S, Tweedie R. Trim and fill: a simple funnel-plot-based method of testing and adjusting for publication bias in meta-analysis. *Biometrics*. 2000;**56**(2):455–463.
24. Collins CE, Jensen ME, Young MD, Callister R, Plotnikoff RC, Morgan PJ. Improvement in erectile function following weight loss in obese men: the SHED-IT randomized controlled trial. *Obes Res Clin Pract*. 2013;**7**(6):e450–e454.
25. Esposito K, Giugliano F, Di Palo C, *et al*. Effect of lifestyle changes on erectile dysfunction in obese men: a randomized controlled trial. *JAMA*. 2004;**291**(24):2978–2984.
26. Jones LW, Hornsby WE, Freedland SJ, *et al*. Effects of nonlinear aerobic training on erectile dysfunction and cardiovascular function following radical prostatectomy for clinically localized prostate cancer. *Eur Urol*. 2014;**65**(5):852–855.
27. Kalka D, Domagala Z, Dworak J, *et al*. Association between physical exercise and quality of erection in men with ischaemic heart disease and erectile dysfunction subjected to physical training. *Kardiol Pol*. 2013;**71**(6):573–580.
28. Lamina S, Okoye CG, Dagogo TT. Therapeutic effect of an interval exercise training program in the management of erectile dysfunction in hypertensive patients. *J Clin Hypertens (Greenwich)*. 2009;**11**(3):125–129.
29. Leitao AE, Vieira MCS, Pelegrini A, da Silva EL, Guimaraes ACA. A 6-month, double-blind, placebo-controlled, randomized trial to evaluate the effect of *Eurycoma longifolia* (Tongkat Ali) and concurrent training on erectile function and testosterone levels in androgen deficiency of aging males (ADAM). *Maturitas*. 2021;**145**:78–85.
30. Maio G, Saraeb S, Marchiori A. Physical activity and PDE5 inhibitors in the treatment of erectile dysfunction: results of a randomized controlled study. *J Sex Med*. 2010;**7**(6):2201–2208.
31. Maresca L, D'Agostino M, Castaldo L, *et al*. Exercise training improves erectile dysfunction (ED) in patients with metabolic syndrome on phosphodiesterase-5 (PDE-5) inhibitors. *Monaldi Arch Chest Dis*. 2013;**80**(4):177–183.
32. Palm P, Zwisler AO, Svendsen JH, *et al*. Sexual rehabilitation for cardiac patients with erectile dysfunction: a randomised clinical trial. *Heart*. 2019;**105**(10):775–782.
33. Reis LO, Favaro WJ, Barreiro GC, *et al*. Erectile dysfunction and hormonal imbalance in morbidly obese male is reversed after gastric bypass surgery: a prospective randomized controlled trial. *Int J Androl*. 2010;**33**(5):736–744.
34. Wing RR, Rosen RC, Fava JL, *et al*. Effects of weight loss intervention on erectile function in older men with type 2 diabetes in the look AHEAD trial. *J Sex Med*. 2010;**7**(1, pt 1):156–165.
35. Meldrum DR, Gambone JC, Morris MA, Meldrum DA, Esposito K, Ignarro LJ. The link between erectile and cardiovascular health: the canary in the coal mine. *Am J Cardiol*. 2011;**108**(4):599–606.
36. Hannan JL, Maio MT, Komolova M, Adams MA. Beneficial impact of exercise and obesity interventions on erectile function and its risk factors. *J Sex Med*. 2009;**6**(suppl 3):254–261.
37. Seo DY, Lee SR, Kwak HB, *et al*. Exercise training causes a partial improvement through increasing testosterone and eNOS for erectile function in middle-aged rats. *Exp Gerontol*. 2018;**108**: 131–138.
38. Hayes LD, Herbert P, Sculthorpe NF, Grace FM. Exercise training improves free testosterone in lifelong sedentary aging men. *Endocr Connect*. 2017;**6**(5):306–310.
39. Sallam N, Laher I. Exercise modulates oxidative stress and inflammation in aging and cardiovascular diseases. *Oxidative Med Cell Longev*. 2016;**2016**:1–32.
40. Rosen RC, Allen KR, Ni X, Araujo AB. Minimal clinically important differences in the erectile function domain of the International Index of Erectile Function scale. *Eur Urol*. 2011;**60**(5):1010–1016.
41. Ciocanel O, Power K, Eriksen A. Interventions to treat erectile dysfunction and premature ejaculation: an overview of systematic reviews. *Sex Med*. 2019;**7**(3):251–269.
42. Saigal CS, Wessells H, Pace J, Schonlau M, Wilt TJ, Urologic Diseases in America Project. Predictors and prevalence of erectile dysfunction in a racially diverse population. *Arch Intern Med*. 2006;**166**(2):207–212.
43. Duca Y, Calogero AE, Cannarella R, *et al*. Erectile dysfunction, physical activity and physical exercise: recommendations for clinical practice. *Andrologia*. 2019;**51**(5):e13264.
44. Rosenbaum TY. Pelvic floor involvement in male and female sexual dysfunction and the role of pelvic floor rehabilitation in treatment: a literature review. *J Sex Med*. 2007;**4**(1):4–13.
45. Choi J, Lee M, Lee JK, Kang D, Choi JY. Correlates associated with participation in physical activity among adults: a systematic review of reviews and update. *BMC Public Health*. 2017;**17**(1):356.