Acute effect of aerobic exercise on endothelial function in healthy and diseased populations. A systematic review.

Grado en Ciencias de la Actividad Física y el Deporte
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1. Abstract

Non-communicable diseases (NCDs) represent a global health crisis, with endothelial dysfunction serving as a primary precursor to cardiovascular and chronic conditions. Flow-mediated dilatation (FMD) is a gold-standard, non-invasive measurement for assessing endothelial health. While exercise is an established therapeutic intervention, there is a lack of consensus regarding the acute impact of different aerobic modalities specifically moderate aerobic exercise (MAE) and high-intensity interval exercise (HIIE) on vascular function.

A systematic review of a randomised crossovers in adults healthy or diseased was conducted following the PRISMA guidelines. Electronic databases were searched up to February 2026. Interventions were classified as HIIE and MAE. Interventions also were compared with a control condition (CON). Primary outcomes focused on FMD percentages measured at various intervals post-intervention.

Keywords: Cardiovascular health; Crossover studies; Flow-mediated dilatation (FMD); High-intensity interval exercise; Moderate aerobic exercise.

2. Introduction

Non-communicable diseases (NCDs) are the leading cause of death globally. Each year over 40 million people die from NCDs such as cardiovascular diseases, cancer, diabetes, and chronic respiratory diseases. However, there are a set of modifiable behavioural factors like tobacco use, unhealthy diet, and sedentary lifestyle, which in turn leads to overweight and obesity, raised blood pressure, raised cholesterol and ultimately resulting in chronic disease. NCDs are projected to cause 47 billion dollars in global economic loses by 2030, representing 75% of global Gross Domestic Product (GDP). Beyond the financial impact, healthcare systems in low- and middle- income countries often lack universal health coverage consequently public healthcare funding fails to provide necessary protection against chronic disability (Kazibwe et al., 2021).

One of the first structures altered in NCD is the endothelium, which is a specialised monolayer of cells that maintains vascular homeostasis and acts as a biological barrier. It regulates vascular tone and permeability by synthetising essential relaxing factors such as nitric oxide (NO) (He et al., 2022). Endothelial dysfunction involves an increased secretion of pro-inflammatory mediator and pro-coagulants molecules. This dysfunction is a critical early biomarker that often precedes clinical manifestations of chronic diseases (Abrashev et al., 2025). In chronic kidney disease, systemic NO bioavailability is reduced significantly. This impairment leads to systemic microangiopathy, resulting capillary rarefaction and organ failure (Cho et al., 2025). Furthermore, endothelial injury is associated with decreased cognitive performance and memory loss (Wang et al., 2025).

Brachial flow-mediated Dilatation (FMD) is a non-invasive measurement using ultrasound to compare the brachial artery’s baseline diameter with its peak diameter following five minutes of suprasystolic cuff occlusion(Thijssen et al., 2019). Brachial FMD is a robust independent predictor of cardiovascular mortality and other chronic diseases, because it serves as a systemic “barometer” of vascular health, specifically assessing the ability of the endothelium to release NO. FMD identifies early atherosclerotic processes and cumulative vascular damage that traditional risk factors like high blood pressure may not fully capture (Gokce, 2011). Consequently, a diminished FMD response reflects a compromised vascular state that directly correlates with an increased risk of future adverse cardiac events (Yeboah et al., 2007).

Normal vascular endothelial function can be restored not only through drug treatment but also through exercise (Paravlic & Drole, 2025). Physical exercise serves as a critical tool for optimising physical condition and cardiovascular health by inducing physiological adaptations that directly enhance endothelial function. Aerobic exercise, in particular, has been shown to improve vascular function by reducing arterial stiffness in middle-aged and older populations (Tanaka, 2019). These improvements are primarily reflected in an increase in FMD. During the exercise, an elevated cardiac output generates a mechanical stress on arterial walls known as shear stress, acting as a stimulus for de NO production (Soto-Rodríguez et al., 2024).

Aerobic exercise can be performed either continuously or intermittently to improve cardiovascular capacity (Paravlic & Drole, 2025). However, it is primarily categorised by intensity into Moderate Aerobic Exercise (MAE) and High-Intensity Interval Exercise (HIIE). MAE involves sustained or intervallic activity performed at a moderate intensity, usually between the first and second ventilatory thresholds. HIIE involves repeated short-to-long bouts of high-intensity exercise interspersed with recovery periods. High-intensity is considered above the second ventilatory threshold or above 80% of the peak oxygen uptake (VO_2 peak) (Buchheit & Laursen, 2013).

Chronic exercise training, defined as structures programs lasting at least four weeks, improves endothelial function measured by FMD with HIIE and MAE. Additionally, the total time of work weekly is a crucial determinant of these results (Chen et al., 2025). Within HIIE protocols, interval duration is key, as long-intervals bouts (above one minute) are significantly more effective than MAE, whereas short intervals (less than a minute) often fail to provide same superior benefits than MAE (Fuertes-Kenneally et al., 2026). However, the acute effect of aerobic exercise on endothelial function, as well as whether there are differences based on the aerobic exercise modality, remains unclear (Briceño Torres & Moncada Jiménez, 2018). Due to the high degree of methodological heterogeneity across studies regarding FMD conditions before the measurement and the categorisation of the exercise modality (Fuertes-Kenneally et al., 2023). Consequently, these discrepancies lead to conflicting results, making it necessary to clarify how aerobic stress specifically impacts this primary marker of vascular health.

3. Objective

The objective of this systematic review is to qualitatively analyse whether acute aerobic exercise influences endothelial function, specifically as measured by FMD, compared to a control condition. Additionally, it was analysed whether the effect on endothelial function differs depending on the intensity of the exercise (i.e., MAE and HIIE).

4. Methods

The current systematic review was performed following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis PRISMA (Page et al., 2021). The protocol was prospectively registered on the PROSPERO database (CRD420261338032). This review was approved by Miguel Hernández University whose code of good research practices (TFG.GAF.AMR.SRB.251030).

4.1 Data Search and Sources

The literature search was conducted using the databases PubMed, Embase, and Web of Science, with the last search performed in February 2026. The search strategy was structured based on the PICOS components (Population, Intervention, Comparison, Outcome, and Study Design), combining relevant keywords with the Boolean operators AND and OR. The search was specifically restricted to the title and abstract fields of the databases. Additionally, the corresponding authors of all included studies were contacted via email to inquire about any ongoing research and unpublished data regarding the topic of the current review. The search strategy for each individual database was adjusted as necessary (see Supplementary Material).

4.1 Study selection

The eligibility criteria were established in accordance with the PICOS (participants, intervention, comparison, outcomes and study design) guideline as follows: (a) Participants: sedentary or physical active, healthy or diseased individuals regardless of sex and aged ≥ 18 years; (b) Intervention: aerobic training (MAE or HIIE); (c) Comparisons: a control condition (a period of rest or a non-exercise). Additionally, studies that directly compared different modalities of aerobic exercise (i.e., HIIE versus MAE) were also included; (d) Outcomes: brachial FMD percentage in each measurement window (Time 1 [less than 60 minutes post-intervention], Time 2 [from 60 minutes up to less than 120 minutes], and Time 3 [120 minutes or longer]); and (e) Study design: randomised crossover studies. Studies written in English or Spanish were eligible for inclusion.

Two authors (S.R) and (R.C) independently conducted the study selection process. The study selection process was conducted systematically and divided in phases. First, all records retrieved from the databases were imported into EndNote reference management software, which was utilised to identify and remove duplicate citations. Second, a preliminary screening was performed by evaluating the titles and abstracts of the remaining articles against the predefined eligibility criteria. Unclear potential articles identified during this phase were progressed to the full-text review. Finally, the studies that successfully passed this initial screening were subjected to a comprehensive full-text review to determine their definitive inclusion in the qualitative synthesis. Disagreements were resolved through consensus. When necessary, a third author (A.M) assessed the study to reach an agreement.

4.2 Data Extraction and Coding Study Characteristics

The two authors utilised a standardised data extraction form to code the characteristics of the included studies. In case of disagreement, a third author was consulted. The following information was extracted: (a) Study characteristics (i.e., Author, publication year, and sample size); (b) Participant characteristics (i.e., Health status [healthy or diseased], sex [males, females or mixed sample], cardiorespiratory fitness [CRF], systolic and diastolic blood pressure [SBP and DBP, respectively]); (c) Intervention characteristics (i.e., condition realised [HIIT, MIT or control], exercise mode [treadmill or cyclo-ergometer], intensity ,and volume of the session); (d) Protocol description (i.e., cuff position [proximal or distal], occlusion pressure, occlusion duration, hyperaemia duration, number and time of FMD measures, conditions before measure [i.e., time resting before FMD and if they made a standardised protocol before attending to the laboratory], temperature of the laboratory, and time of washout).

In cases where relevant data were missing, the corresponding authors of the included studies were contacted via email to request additional information. In case of no response, the study was excluded if the missing information was considered critical for the analysis.

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6. Supplementary Material

Database search. 23/02/2026

PUBMED

(("aerobic training"[tiab] OR "aerobic exercise"[tiab] OR "moderate-intensity exercise"[tiab] OR "moderate-intensity training"[tiab] OR "high-intensity Interval training"[tiab] OR "high-intensity interval exercise"[tiab] OR "HIIT"[tiab] OR "HIIE"[tiab] OR "MICT"[tiab] OR "MICE"[tiab] OR "Exercise"[Mesh] OR "High-Intensity Interval Training"[Mesh]) AND ("single bout"[tiab] OR acute*[tiab] OR subacute[tiab]) AND ("FMD"[tiab] OR "flow-mediated dilation"[tiab] OR "flow-mediated dilatation"[tiab] OR "endothelial-dependent dilation"[tiab] OR "endothelium-dependent dilation"[tiab] OR "endothelial-dependent dilatation"[tiab] OR "endothelium-dependent dilatation"[tiab] OR "Vasodilation"[Mesh]))

EMBASE

(('aerobic training':ti,ab,kw OR 'aerobic exercise':ti,ab,kw OR 'moderate-intensity exercise':ti,ab,kw OR 'moderate-intensity training':ti,ab,kw OR 'high-intensity Interval training':ti,ab,kw OR 'high-intensity interval exercise':ti,ab,kw OR 'HIIT':ti,ab,kw OR 'HIIE':ti,ab,kw OR 'MICT':ti,ab,kw OR 'MICE':ti,ab,kw OR 'aerobic exercise'/exp OR 'high intensity interval training'/exp) AND ('single bout':ti,ab,kw OR acute*:ti,ab,kw OR subacute:ti,ab,kw) AND ('FMD':ti,ab,kw OR 'flow-mediated dilation':ti,ab,kw OR 'flow-mediated dilatation':ti,ab,kw OR 'endothelial-dependent dilation':ti,ab,kw OR 'endothelium-dependent dilation':ti,ab,kw OR 'endothelial-dependent dilatation':ti,ab,kw OR 'endothelium-dependent dilatation':ti,ab,kw OR 'endothelium dependent vasodilation'/exp))

WEB OF SCIENCE

TS=("aerobic training" OR "aerobic exercise" OR "moderate-intensity exercise" OR "moderate-intensity training" OR "high-intensity interval training" OR "high-intensity interval exercise" OR "HIIT" OR "HIIE" OR "MICT" OR "MICE") AND TS=("single bout" OR acute* OR subacute) AND TS=("FMD" OR "flow-mediated dilation" OR "flow-mediated dilatation" OR "endothelial-dependent dilation" OR "endothelium-dependent dilation" OR "endothelial-dependent dilatation" OR "endothelium-dependent dilatation")