Journal Physiotherapy Interventions
ISSN 2810-7748

Artículo

High-Intensity Interval Training as a Strategy forAttenuating Low-Grade Chronic Inflammation in Individuals with Obesity: Clinical Implications for Exercise Prescription

Pérez Casillas José Manuel[1]

[1]Departamento de Vida Saludable y Promoción de la Salud, Centro Universitario de Tlajomulco, Universidad de Guadalajara, México.

Correspondence: jose.perez@academicos.udg.mx

Received: 24.03.2026 Revised: 09.04.2026 Accepted: 21.04.2026
Published: 12.05.2026

Conflicts of interest: The author declares no conflicts of interest.
Funding: This research received no external funding.
Institutional review board statement: Not applicable.

Abstract

Background: Obesity is a multifactorial disease that has reached pandemic proportions and is characterized by excessive accumulation of adipose tissue, primarily in the abdominal region. Individuals with obesity present with low-grade chronic inflammation (LGCI). Current scientific evidence suggests that LGCI can be attenuated through the benefits of regular physical exercise, which are attributed to its ability to reduce the concentrations of certain pro-inflammatory molecules, such as interleukin-6 (IL-6), tumor necrosis factor-alpha (TNF-α), and C-reactive protein.

Objective: To analyze the available evidence on the effects of high-intensity interval training (HIIT) on the modulation of LGCI in individuals with obesity, as well as to examine dosing and prescription criteria.

Methods: A narrative review of the literature was conducted using PubMed, Scopus, and Web of Science, considering studies published up to January 2026 in the English language. Clinical trials, systematic reviews, and meta-analyses involving adults with overweight or obesity that evaluated the effects of HIIT on inflammatory markers were included.

Conclusion: HIIT emerges as a promising strategy for the modulation of LGCI in individuals with obesity. However, heterogeneity in protocols limits the standardization of its prescription; therefore, more precise methodological frameworks are required to guide its safe and effective application in clinical populations.

Keywords: High-intensity interval training; Low-grade chronic inflammation; Obesity; Inflammatory cytokines; Cardiometabolic risk; Physical training; Adipose tissue.

Introduction

In recent decades, it has been established that excess adiposity observed in obesity is closely associated with low-grade chronic inflammation (LGCI), a systemic state characterized by the persistent presence of pathophysiological processes mediated by elevated concentrations of inflammatory biomarkers, among which IL-6, high-sensitivity C-reactive protein (hs-CRP), and TNF-α are particularly notable [1].

In terms of treatment and prevention, various strategies have been explored as part of the multidisciplinary approach to obesity. In this context, physical activity constitutes an essential component of non-pharmacological interventions aimed at promoting lifestyle changes. Therefore, there is growing interest in identifying exercise modalities that are both efficient and safe for this population. Current evidence indicates that physical exercise can act as a mediator in the long-term reduction of systemic inflammation; consequently, structured training programs may represent an effective intervention for attenuating LGCI [2].

High-intensity interval training (HIIT) has emerged as a strategy of increasing interest in the management of obesity and various non-communicable chronic diseases (NCDs). Available evidence suggests that HIIT may induce significant reductions in fat mass, blood pressure, and circulating lipids, in addition to improving insulin sensitivity, all of which are factors closely linked to the pathophysiology of obesity [3,4,5].

Based on the above, it is essential for physical activity professionals to become familiar with the methodological foundations of HIIT, as well as its prescription and safety criteria, given that their role within the multidisciplinary team is fundamental in the design and implementation of therapeutic exercise programs. Accordingly, the aim of the present article is to analyze the available evidence on the effects of HIIT on the modulation of LGCI in individuals with obesity, as well as to examine dosing and prescription criteria.

Methods

A narrative review of the scientific literature was conducted with the aim of synthesizing the available evidence on the effects of HIIT on the modulation of LGCI in individuals with obesity, as well as analyzing dosing and prescription criteria.

The search was carried out in databases including PubMed, Scopus, and Web of Science. Medical Subject Headings (MeSH) terms were used in PubMed, and combinations of the following terms were applied in the other databases: *high-intensity interval training*, *obesity*, *inflammation*, *cytokines*, *cardiometabolic risk*, and *exercise training*.

Inclusion and exclusion criteria were defined a priori. Studies published up to January 2026 were included, specifically clinical trials, systematic reviews, and meta-analyses conducted in overweight or obese adults that evaluated the effect of HIIT on inflammatory markers. Only publications in the English language were included. Studies that failed to report training dosage criteria were excluded, as were interventions in which the effects of HIIT could not be isolated due to their combination with dietary or pharmacological strategies.

The methodological quality of the studies was assessed qualitatively, taking into account study type and design, methodology, and consistency of results. Most included studies correspond to clinical trials and systematic reviews, which provides a relatively solid level of evidence. However, due to substantial heterogeneity in intervention protocols, sample sizes, and population characteristics, a narrative review approach was adopted; therefore, no formal or standardized tools were applied to assess the risk of bias.

The information was organized into the following thematic axes: (1) relationship between obesity and LGCI, (2) impact of HIIT on inflammatory biomarkers, and (3) considerations for the dosing and prescription of HIIT in individuals with obesity. Due to the heterogeneity of the included studies, a meta-analysis was not performed; instead, a critical narrative synthesis of the findings was undertaken.

Relationship Between Obesity and Low-Grade Chronic Inflammation

The prevalence and incidence of obesity have increased steadily over recent decades, reaching pandemic proportions and representing one of the most significant contemporary public health challenges. This condition increases the risk of developing various comorbidities, including hypertension, type 2 diabetes mellitus, dyslipidemia, and acute myocardial infarction—scenarios that negatively impact quality of life and global morbidity and mortality rates [6].

The World Health Organization defines obesity as “an abnormal or excessive fat accumulation that may impair health” [7], resulting from an energy imbalance between calories consumed and calories expended. Various tools are available for its diagnosis; however, body mass index (BMI) remains one of the most widely used indicators, with obesity defined as a value $\geq$30 kg/m^2 [8].

Currently, adipose tissue is recognized as a metabolically active organ with endocrine and paracrine functions. This tissue promotes the secretion of various inflammatory mediators by adipocytes and macrophages, closely associated with the pathogenesis of multiple NCDs [9,1,10]. LGCI is defined as a pathological state characterized by the persistent presence of inflammatory markers arising as part of the immune response of the innate immune system to various stressors, both internal and external [2].

In this context, a close relationship between subcutaneous and visceral adipose tissue and LGCI is recognized, characterized by elevated concentrations of pro-inflammatory markers such as hs-CRP, IL-6, and TNF-α [1]. Research has further expanded this perspective: a study evaluating cytokine concentrations in 117 participants with obesity and 83 normal-weight individuals showed that obesity is associated with significant increases in IL-5, IL-10, IL-12, and IL-13, reflecting immunological alterations related to LGCI [11].

Impact of HIIT on Inflammatory Biomarkers

In recent years, growing interest has emerged in investigating the effects of HIIT in clinical populations, particularly in individuals with NCDs. Several studies have reported promising effects in patients with obesity, coronary artery disease, heart failure, hypertension, and metabolic syndrome [12,13,14,15]. Moreover, multiple studies have documented significantly greater increases in maximal oxygen uptake (VO_2max) and aerobic capacity following HIIT programs compared with moderate-intensity continuous training (MICT) [16,17].

It has been documented that physical exercise has the potential to reduce the concentrations of various pro-inflammatory cytokines, as well as hs-CRP and TNF-α, in both healthy populations and those with NCDs [18,19,20,15]. This reduction may be partially mediated by decreases in visceral adipose tissue induced by physical training [21]. Results from a study conducted in sedentary older adults showed that aerobic exercise is associated with reductions in TNF-α and IL-6 concentrations, while levels of IL-10 increased in the physically active group, suggesting that exercise represents a useful non-pharmacological strategy for modulating LGCI [22].

A study including 417 participants demonstrated that HIIT may suppress the overexpression of pro-inflammatory cytokines, particularly in young individuals, through the reduction of ASC gene expression associated with the inflammasome [23]. A meta-analysis of 29 studies comparing HIIT versus MICT in participants with metabolic disorders found that HIIT was associated with significant reductions in leptin and TNF-α compared to MICT, while evidence regarding IL-6 and hs-CRP was inconsistent, suggesting a dependence on total training volume and intervention duration [24].

The inconsistencies observed in the IL-6 response to HIIT may be explained by several factors. First, by the dual nature of this cytokine, which acts as a myokine released during exercise-induced muscle contractions. In this context, IL-6 participates in the regulation of the inflammatory response by promoting the expression of anti-inflammatory cytokines such as IL-10 and inhibiting the production of TNF-α, which may contribute to the long-term modulation of the inflammatory state [25]. Therefore, acute increases in IL-6 do not necessarily reflect a pro-inflammatory state, but rather a physiological adaptive response to exercise [26]. The transient kinetics of IL-6 may bias results, and the standardization of post-intervention measurement timing may play a relevant role in the interpretation of findings.

Second, short-duration programs ($<$3 weeks) may not be sufficient to induce sustained anti-inflammatory modulation; longer interventions have been proposed to generate more consistent reductions in IL-6 concentrations [24,27].

Regarding hs-CRP, although it is recognized as a more stable biomarker of LGCI, baseline characteristics of participants—such as sedentary behavior, degree of obesity, or the presence of comorbidities—may condition the magnitude of the response to exercise [28]. Its close relationship with visceral adipose tissue further suggests that interventions producing modest changes in body composition may limit the decreases observed in this biomarker [24]. Finally, heterogeneity in training protocols, including differences in intensity, structure, and duration of interventions, may contribute to the variability observed in both biomarkers.

Considerations for the Dosing and Prescription of HIIT in Individuals with Obesity

HIIT is defined as a modality of aerobic exercise characterized by repeated short-duration intervals performed at intensities close to maximal heart rate (HR_{max}), interspersed with periods of active recovery at lower intensity [29]. This modality allows for the manipulation of various variables, including intensity, duration of work and recovery intervals, number of intervals, and total training volume [30].

From a methodological perspective, no universal criteria have been established for the dosing and prescription of HIIT in clinical settings due to the wide diversity of available protocols [31]. Consequently, several authors have emphasized the need to develop more precise methodological frameworks to guide its application in clinical populations [32,33,34].

With the aim of establishing a practical framework for prescription and facilitating clinical application in individuals with obesity, Table 1 presents general recommendations for HIIT dosing, derived from the synthesis of systematic reviews, meta-analyses, and randomized controlled trials. These recommendations should be individualized according to each individual's clinical status, functional capacity, and medical history.

Regarding intensity calculation, it is recommended to integrate both objective and subjective methods. Initially, HR_{max} is estimated, either through direct exercise testing or predictive equations—for example: $HR_{max} = 211 - (0.64 \times \text{age})$ [35]. Based on this value, target heart rate for high-intensity intervals typically ranges between 85% and 95% of HR_{max}, while active recovery periods recommend intensities between 50% and 70% of HR_{max} [33,36].

Complementarily, some authors suggest using the rating of perceived exertion (RPE) scale [37,38] as an additional monitoring tool in clinical settings [39]. Under this approach, high-intensity intervals typically correspond to RPE values between 17 and 18 (very hard), while recovery intervals correspond to 9–13 (light to moderate) [40,33]. Combining both metrics improves accuracy in intensity control [32,33].

Regarding training volume, high-volume protocols (>15 minutes of high-intensity effective work) may be more effective in these populations than low-volume protocols (<15 minutes) [32]. Structured models consisting of 4 intervals of 4 minutes interspersed with 3-minute periods of moderate intensity are highlighted as one of the most efficient and widely used formats [33,41]. Other authors propose models with work intervals of 2–4 minutes accompanied by active recovery of 1–3 minutes [31,42]. Regarding weekly frequency, three to four sessions per week over periods longer than 12 weeks are recommended [3,43,42].

Regarding general safety recommendations, these training models should be carefully prescribed and supervised by qualified physical activity professionals with experience in managing clinical populations, prioritizing close supervision during the early phases of the programs. A comprehensive clinical evaluation is emphasized, including identification of potential contraindications and risk factors and, when appropriate, the performance of a maximal or submaximal exercise test [33]. Ongoing monitoring and documented tracking of physiological responses using quantitative variables—

such as heart rate, oxygen saturation, and blood pressure—as well as identification of signs or symptoms such as dizziness, chest pain, or excessive fatigue, are also recommended. Maintaining documented monitoring allows for the early identification of adverse events and facilitates appropriate adjustments in training dosing [32,33].

Table 1: General recommendations for HIIT dosing in individuals with obesity.

Variable	General Recommendation
Type	High-volume HIIT (>15 min of effective work)
Warm-up	5–10 min (40–60% HR_{max})
Frequency	3–4 sessions per week
Intensity	High-intensity interval: 85–95% HR_{max} (RPE 17–18) Low-intensity interval: 50–70% HR_{max} (RPE 11–13)
Interval duration	High-intensity interval: 2–4 minutes Low-intensity interval: 1–3 minutes
Number of intervals	3–7 intervals
Cool-down	5 minutes (40–60% HR_{max})
Program duration	>12 weeks

Note: Recommendations based on previous studies [3,16,30,33,32,43,42].

Limitations

Despite the growing body of evidence supporting the application of HIIT and its benefits in clinical settings, several limitations persist and should be considered when interpreting the available findings. First, current studies exhibit substantial heterogeneity with respect to training dosing criteria, particularly in variables such as the duration and number of intervals, total training volume, equipment used, and progression structure.

Furthermore, a considerable number of investigations involve small sample sizes, and in some cases, participant selection criteria are not fully homogeneous. Potentially influential factors such as sex, age, baseline physical activity level, diet, and sleep quality and duration are not always adequately considered or controlled in study designs. Future interventions should extend follow-up periods beyond 12 weeks and incorporate long-term outcome assessments in order to determine whether physiological adaptations induced by HIIT are sustained over time.

As another important limitation, the present study aimed to isolate the effect of HIIT on LGCI; therefore, interventions combined with dietary or pharmacological treatments were excluded. However, it is acknowledged that, in clinical settings, the management of obesity is typically approached in a multidisciplinary manner integrating nutritional interventions or individualized pharmacological therapy. The results should therefore be interpreted with caution, within the context of exercise-based recommendations.

Regarding methodological limitations, it is important to consider the presence of publication bias associated with exercise-based interventions, in which studies reporting significant results are more likely to be published than those with non-significant findings. Moreover, due to the nature of narrative reviews, no standardized tool was used to assess the quality of the evidence; therefore, a risk of bias in the findings cannot be excluded. Additionally, language bias should be considered, as only studies published in English were included, which may have led to the exclusion of relevant evidence published in other languages.

Conclusion

LGCI is closely associated with a wide spectrum of cardiometabolic diseases and with obesity. Beyond the observed clinical outcomes, it is important to highlight that chronic elevation of IL-6 is associated with LGCI and metabolic dysfunction. In contrast, during exercise, IL-6 is identified as a myokine with anti-inflammatory potential, capable of inhibiting TNF-α production and increasing IL-10 expression, thereby contributing to the modulation of LGCI. This dual role of IL-6 may represent a relevant mechanism in understanding the molecular effects of exercise.

Overall, the available evidence suggests that HIIT represents a promising strategy for the management of obesity and the attenuation of LGCI and could be safely incorporated within non-pharmacological therapeutic approaches for individuals with obesity. However, heterogeneity in protocols limits the generalizability of findings, underscoring the need to establish standardized criteria for dosing and prescription in clinical populations.

Physical activity professionals play a fundamental role in the prescription, supervision, and monitoring of HIIT-based exercise programs, ensuring appropriate individualization, progression, and control of training load according to the clinical and functional characteristics of each individual. The present article proposes a set of general recommendations for the prescription and dosing of HIIT in individuals with obesity to serve as a practical reference for clinical application.

Funding

This research received no external funding.

Ethical Declarations

Institutional Review Board Statement: Not applicable.
Informed Consent Statement: Not applicable.
Data Availability Statement: Not applicable.

How to cite this article

Pérez Casillas JM. High-intensity interval training as a strategy for attenuating low-grade chronic inflammation in individuals with obesity: clinical implications for exercise prescription. *J. Physiother. Interv.* 2026;1. https://doi.org/10.15443/JPI.2026.1.1

References

1. Berg AH, Scherer PE. Adipose tissue, inflammation, and cardiovascular disease. Circ Res. 2005;96(9):939–49. doi:10.1161/01.RES.0000163635.62927.34

2. You T, Arsenis NC, Disanzo BL, Lamonte MJ. Effects of exercise training on chronic inflammation in obesity: current evidence and potential mechanisms. Sports Med. 2013;43(4):243–56. doi:10.1007/s40279-013-0023-3

3. Kessler HS, Sisson SB, Short KR. The potential for high-intensity interval training to reduce cardiometabolic disease risk. Sports Med. 2012;42(6):489–509. doi:10.2165/11630910-000000000-00000

4. Feito Y, Heinrich KM, Butcher SJ, Poston W. High-intensity functional training (HIFT): definition and research implications for improved fitness. Sports. 2018;6(3):76. doi:10.3390/sports6030076

5. Gallo-Villegas J, Aristizabal JC, Estrada M, Valbuena LH, Narvaez-Sanchez R, Osorio J, et al. Efficacy of high-intensity, low-volume interval training compared to continuous aerobic training on insulin resistance and skeletal muscle structure in adults with metabolic syndrome. Trials. 2018;19:144. doi:10.1186/s13063-018-2541-7

6. Blüher M. Obesity: global epidemiology and pathogenesis. Nat Rev Endocrinol. 2019;15(5):288–98. doi:10.1038/s41574-019-0176-8

7. World Health Organization. Obesity and overweight [Internet]. WHO; 2017 [cited 2026 May]. Available from: https://www.who.int/features/factfiles/obesity/es/

8. World Health Organization. Obesity and overweight [Internet]. WHO; 2020 [cited 2026 May]. Available from: https://www.who.int/es/news-room/fact-sheets/detail/obesity-and-overweight

9. Wilson PW, D'Agostino RB, Parise H, Sullivan L, Meigs JB. Metabolic syndrome as a precursor of cardiovascular disease and type 2 diabetes mellitus. Circulation. 2005;112(20):3066–72. doi:10.1161/CIRCULATIONAHA.105.539528

10. Kataru RP, Park HJ, Baik JE, Li C, Shin J, Mehrara BJ. Regulation of lymphatic function in obesity. Front Physiol. 2020;11:459. doi:10.3389/fphys.2020.00459

11. Schmidt FM, Weschenfelder J, Sander C, Minkwitz J, Thormann J, Chittka T, et al. Inflammatory cytokines in general and central obesity and modulating effects of physical activity. PLoS One. 2015;10(3):e0121971. doi:10.1371/journal.pone.0121971

12. Sari-Sarraf V, Aliasgarzadeh A, Naderali M, Esmaeili H, Naderali E. A combined continuous and interval aerobic training improves metabolic syndrome risk factors in men. Int J Gen Med. 2015;8:203–10. doi:10.2147/IJGM.S79563

13. Fisher G, Brown AW, Bohan Brown MM, Alcorn A, Noles C, Winwood L, et al. High intensity interval- vs moderate intensity-training for improving cardiometabolic health in overweight or obese males: a randomized controlled trial. PLoS One. 2015;10(10):e0138853. doi:10.1371/journal.pone.0138853

14. Vella CA, Taylor K, Drummer D. High-intensity interval and moderate-intensity continuous training elicit similar enjoyment and adherence levels in overweight and obese adults. Eur J Sport Sci. 2017;17(9):1203–11. doi:10.1080/17461391.2017.1347962

15. Ahn N, Kim K. Can active aerobic exercise reduce the risk of cardiovascular disease in prehypertensive elderly women by improving HDL cholesterol and inflammatory markers? Int J Environ Res Public Health. 2020;17(16):5910. doi:10.3390/ijerph17165910

16. Weston KS, Wisløff U, Coombes JS. High-intensity interval training in patients with lifestyle-induced cardiometabolic disease: a systematic review and meta-analysis. Br J Sports Med. 2014;48(16):1227–34. doi:10.1136/bjsports-2013-092576

17. Støa EM, Meling S, Nyhus LK, Mangerud KM, Helgerud J, Bratland-Sanda S, et al. High-intensity aerobic interval training improves aerobic fitness among persons with type 2 diabetes. Eur J Appl Physiol. 2017;117(3):455–67. doi:10.1007/s00421-17-3540-1

18. Kohut ML, McCann DA, Russell DW, Konopka DN, Cunnick JE, Franke WD, et al. Aerobic exercise reduces serum IL-18, CRP, and IL-6 in older adults. Brain Behav Immun. 2006;20(3):201–9. doi:10.1016/j.bbi.2005.08.002

19. Kadoglou NP, Iliadis F, Angelopoulou N, Perrea D, Ampatzidis G, Liapis CD, et al. The anti-inflammatory effects of exercise training in patients with type 2 diabetes mellitus. Eur J Cardiovasc Prev Rehabil. 2007;14(6):837–43. doi:10.1097/HJR.0b013e3282efaf50

20. Walther C, Möbius-Winkler S, Linke A, Bruegel M, Thiery J, Schuler G, et al. Regular exercise training reduces inflammatory markers in patients with coronary artery disease. Eur J Cardiovasc Prev Rehabil. 2008;15(1):107–12. doi:10.1097/HJR.0b013e3282f2b4c4

21. Ihalainen JK, Schumann M, Eklund D, Hämäläinen M, Moilanen E, Paulsen G, et al. Combined aerobic and resistance training decreases inflammation markers in healthy men. Scand J Med Sci Sports. 2018;28(1):40–7. doi:10.1111/sms.12906

22. Abd El-Kader SM, Al-Jiffri OH. Aerobic exercise modulates cytokine profile and sleep quality in elderly. Afr Health Sci. 2019;19(2):2198–207. doi:10.4314/ahs.v19i2.45

23. Nakajima K, Takeoka M, Mori M, Hashimoto S, Sakurai A, Nose H, et al. Exercise effects on methylation of ASC gene. Int J Sports Med. 2010;31(9):671–5. doi:10.1055/s-0030-1255118

24. Khalafi M, Symonds ME. The impact of high-intensity interval training on inflammatory markers in metabolic disorders: a meta-analysis. Scand J Med Sci Sports. 2020;30(11):2020–36. doi:10.1111/sms.13750

25. Poorhabibi H, Weiss K, Rosemann T, Knechtle B, Eslami R, Tartibian B, et al. Short-lived exercise-induced exerkines modulate inflammation for chronic disease prevention: a systematic review and meta-analysis. Biomolecules. 2025;15(11):1590. doi:10.3390/biom15111590

26. Wang YH, Tan J, Zhou HH, Cao M, Zou Y. Long-term exercise training and inflammatory biomarkers in healthy subjects: a meta-analysis of randomized controlled trials. Front Psychol. 2023;14:1253329. doi:10.3389/fpsyg.2023.1253329

27. Guo Y, Qian H, Xin X, Liu Q. Effects of different exercise modalities on inflamma-

tory markers in the obese and overweight populations: unraveling the mystery of exercise and inflammation. Front Physiol. 2024;15:1405094. doi:10.3389/fphys.2024.1405094

28. Hayashino Y, Jackson JL, Hirata T, Fukumori N, Nakamura F, Fukuhara S, et al. Effects of exercise on C-reactive protein, inflammatory cytokine and adipokine in patients with type 2 diabetes: a meta-analysis of randomized controlled trials. Metabolism. 2014;63(3):431–40. doi:10.1016/j.metabol.2013.08.018

29. Mezzani A, Hamm LF, Jones AM, McBride PE, Moholdt T, Stone JA, et al. Aerobic exercise intensity assessment and prescription in cardiac rehabilitation: a joint position statement. Eur J Prev Cardiol. 2013;20(3):442–67. doi:10.1177/2047487312460484

30. Viana RB, de Lira C, Naves J, Coswig VS, Del Vecchio FB, Ramirez-Campillo R, et al. Can we draw general conclusions from interval training studies? Sports Med. 2018;48(9):2001–9. doi:10.1007/s40279-018-0925-1

31. Andreato LV, Esteves JV, Coimbra DR, Moraes AJ, de Carvalho T. The influence of high-intensity interval training on anthropometric variables of adults with overweight or obesity: a systematic review and network meta-analysis. Obes Rev. 2019;20(1):142–55. doi:10.1111/obr.12766

32. Dun Y, Smith JR, Liu S, Olson TP. High-intensity interval training in cardiac rehabilitation. Clin Geriatr Med. 2019;35(4):469–87. doi:10.1016/j.cger.2019.07.011

33. Taylor JL, Holland DJ, Spathis JG, Beetham KS, Wisløff U, Keating SE, et al. Guidelines for the delivery and monitoring of high intensity interval training in clinical populations. Prog Cardiovasc Dis. 2019;62(2):140–6. doi:10.1016/j.pcad.2019.01.004

34. Bo B, Guo A, Kaila SJ, Hao Z, Zhang H, Wei J, et al. Elucidating the primary mechanisms of high-intensity interval training for improved cardiac fitness in obesity. Front Physiol. 2023;14:1170324. doi:10.3389/fphys.2023.1170324

35. Nes BM, Janszky I, Wisløff U, Støylen A, Karlsen T. Age-predicted maximal heart rate in healthy subjects: the HUNT fitness study. Scand J Med Sci Sports. 2013;23(6):697–704. doi:10.1111/j.1600-0838.2012.01445.x

36. Zhu Y, Nan N, Wei L, Li T, Gao X, Lu D. The effect and safety of high-intensity interval training in the treatment of adolescent obesity: a meta-analysis. Ann Palliat Med. 2021;10(8):8596–606. doi:10.21037/apm-21-757

37. Borg GA. Psychophysical bases of perceived exertion. Med Sci Sports Exerc. 1982;14(5):377–81. doi:10.1249/00005768-198205000-00012

38. Rosales W, Cofré C, Cicchitti A, Bertona C, Vizcaya A, González J, et al. Validación de la escala de Borg en personas con diabetes mellitus tipo 2. Rev Med Chile. 2016;144(9):1159–63. doi:10.4067/S0034-98872016000900009

39. Iellamo F, Manzi V, Caminiti G, Vitale C, Massaro M, Cerrito A, et al. Validation of rate of perceived exertion-based exercise training in patients with heart failure. Int J Cardiol. 2014;176(2):394–8. doi:10.1016/j.ijcard.2014.07.076

40. Wisløff U, Støylen A, Loennechen JP, Bruvold M, Rognmo Ø, Haram PM, et al. Superior cardiovascular effect of aerobic interval training versus moderate continuous training in heart failure patients. Circulation. 2007;115(24):3086–94.

doi:10.1161/CIRCULATIONAHA.106.675041

41. Cheng H, Song S, Shu H, Li H, Tao M, Liu B. The effects of HIIT and MICT on body fat composition and cardiopulmonary fitness in adults: a meta-analysis of randomized controlled trials. BMC Sports Sci Med Rehabil. 2026;18(1):94. doi:10.1186/s13102-025-01519-2

42. D'Amuri A, Sanz JM, Capatti E, Di Vece F, Vaccari F, Lazzer S, et al. Effectiveness of high-intensity interval training for weight loss in adults with obesity: a randomised controlled non-inferiority trial. BMJ Open Sport Exerc Med. 2021;7(3):e001021. doi:10.1136/bmjsem-2020-001021

43. Batacan RB Jr, Duncan MJ, Dalbo VJ, Tucker PS, Fenning AS. Effects of high-intensity interval training on cardiometabolic health: a systematic review and meta-analysis of intervention studies. Br J Sports Med. 2017;51(6):494–503. doi:10.1136/bjsports-2015-095841