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Effect of high-intensity interval training compared to moderate-intensity continuous training on body composition and insulin sensitivity in overweight and obese adults: A systematic review and meta-analysis

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ABSTRACT

Objective: To compare the effects of high-intensity interval training (HIIT) and moderate-intensity continuous training (MICT) on adults with overweight and obesity. Outcomes, including changes in insulin sensitivity, weight, body mass index (BMI), waist circumference, and body fat, were analyzed.
Methods: A systematic literature review was conducted. This review is registered in the International Prospective Register of Systematic Reviews (PROSPERO) under the number CRD42021281899. Clinical trials involving individuals who are overweight and obese and comparing HIIT with MICT effects on insulin sensitivity, weight, BMI, body fat percentage, and waist circumference were included. PubMed, Web of Science, Embase, and Scopus databases were searched using controlled vocabulary and free-text terms related to HIIT, obesity, and overweight. The search included studies published until September 2022. The Rob2 tool was used to assess the risk of bias. The results were presented through meta-analyses that provided summary estimators and confidence intervals. Subgroup analyses were conducted to assess the effect of the risk of bias on the outcomes. This research did not receive any specific funding.
Results: Of the 2534 articles, 30 met the eligibility criteria. The intervention duration ranged from 4 to 16 weeks. The observed effects for each outcome were as follows: insulin sensitivity ($p = 0.02$), weight ($p = 0.58$), BMI ($p = 0.53$), waist circumference ($p = 0.87$), body fat percentage ($p = 0.07$), body fat mass in kilograms ($p = 0.39$). The level of evidence obtained was moderate except for waist circumference, which was rated as low. Limitations included heterogeneity in training protocols, measurements, and study duration. Additionally, a risk of bias was identified in these studies.
Conclusion: HIIT and MICT did not significantly differ in their effects on weight, BMI, waist circumference, or body fat mass in adults with overweight and obesity. However, a moderate beneficial effect of HIIT was observed on insulin sensitivity. Therefore, further evidence is required to confirm these findings.

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1. Introduction

Obesity is a prominent global public health concern, as acknowledged by the World Health Organization. In 2016, the number of adults who are overweight or obese surpassed 2 billion, with over 650 million classified as obese [1]. Additionally, obesity substantially affects healthcare expenses, with medical costs for individuals with obesity being 30–40% higher than those for individuals with a normal weight [2].

Obesity and a sedentary lifestyle are associated with at least 18 endocrine and cardiovascular comorbidities [3,4]. This association is attributed to an increase in the size and number of adipocytes, leading to insulin resistance [5,6] and an imbalance in glucose homeostasis, resulting in metabolic complications [7,8]. Moreover, a previous study revealed that elevated insulin and triglyceride levels were associated with increased body composition measurements, such as abdominal area and adipose tissue content, regardless of type 2 diabetes [9].

Interval training involves a series of high-intensity exercises similar to or approaching anaerobic exercises, interspersed with periods of lower intensity [10]. High-intensity interval training (HIIT) targets intensities between 80% and 100% of the maximum heart rate or aerobic capacity, with intervals lasting from 6 s to 4 min, followed by a brief period of reduced oxygen consumption [11]. HIIT can be customized to accommodate individual conditions, making it suitable for patients with chronic illnesses [12], such as cardiovascular diseases [13,14] and type 2 diabetes [15–17].

Continuous training, also known as continuous exercise or steady-state training, encompasses any form of physical training performed without rest intervals and can be executed at low, moderate, or high exercise intensities [18]. Moderate-intensity continuous training (MICT) is characterized by exercising at 55–70% of the maximum heart rate, typically for durations of 20–60 min [19], 60–65% of maximal oxygen consumption, or 65% of the maximum power output [20].

When comparing HIIT and MICT in individuals with obesity, similar metabolic and cardiovascular improvements were reported for both interventions [21]. Evidence from small-sample experimental studies on adults with obesity suggests that HIIT may have stronger beneficial effects on body composition and insulin sensitivity than MICT [22]. Furthermore, moderate-level evidence indicates that HIIT can enhance insulin sensitivity and body composition in adults; however, this is more likely to occur in adults at a higher risk of cardiovascular disease and diabetes than in healthy adults [23].

Previous reviews examining the effects of HIIT and MICT on cardiovascular risk factors did not include their effect on insulin sensitivity [24,25], whereas the other review did not include their effect on waist circumference [25]. Insulin sensitivity and waist circumference measurements are crucial because of their close association with metabolic health and the risk of developing chronic diseases, especially type 2 diabetes and cardiovascular diseases [9]. However, evidence regarding the comparative effects of HIIT and MICT on changes in insulin sensitivity and improvements in body composition in adults who are overweight and obese remains inconclusive [26]. Furthermore, the effects of HIIT and MICT may vary based on population characteristics [27].

By conducting a systematic review and meta-analysis of the available studies, this study aimed to provide a comprehensive and rigorous synthesis of the existing evidence on the effects of HIIT and MICT on body composition and insulin sensitivity in this population. The findings of this study will offer robust and reliable information for healthcare professionals, researchers, and individuals who are overweight or obese, enabling them to make informed decisions regarding the most beneficial exercise approach for enhancing body composition and insulin sensitivity. Moreover, this research will facilitate the development of more effective and personalized interventions for weight management and disease prevention in this population.

We performed a systematic review assessing the effect of HIIT (I) compared with that of MICT (C) in adults with overweight and obese (P) by analyzing the changes in insulin sensitivity (O). The secondary outcomes were body weight, body mass index, abdominal waist circumference, and body fat. This study aimed to address the following question: What is the effect of HIIT compared with MICT on body composition and insulin sensitivity in adults with overweight and obesity?

2. Materials and methods

2.1. Systematic review with meta-analysis

The protocol for this systematic review was registered in the International Prospective Register of Systematic Reviews (PROSPERO) (CRD42021281899). This study adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (2020).

2.2. Structured question and outcome prioritization

The systematic review considered the following elements of the research using the PICO framework.

Acronym	Definition	Description
P	Population	Adults who are overweight and obese
I	Intervention	High-intensity interval training
C	Comparison	Moderate-intensity continuous training
O	Outcome	Insulin sensitivity
		Body weight

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Acronym	Definition	Description
		Body mass index Abdominal waist circumference Body fat

2.3. Search strategy and database

PubMed, Web of Science, Embase, and Scopus databases were searched. In our article search, we employed controlled vocabulary and free-text terms related to HIIT, including “high intensity interval training,” “high intensity interval training exercise,” and “high intensity interval training group.” Similarly, we employed terms related to obesity and overweight, including “obese,” “obese adult,” “overweight,” and “overweight adult.” During the article search, no restrictions were imposed on the publication start date, and articles published up to September 30, 2022, were included. One of the researchers on the team (JC) conducted this process. No filters were applied during the search to identify studies, and manual searches of the selected articles were not conducted.

In the systematic search, only the elements of the PICO question related to population (obesity) and intervention (HIIT) were considered to ensure a comprehensive search for relevant studies. The following search formulae were used in the respective scientific databases.

MEDLINE/PubMed	EMBASE/OVID	SCOPUS	WEB OF SCIENCE
(((“high intensity interval training"[Mesh]) OR (“high intensity interval training"[tiab]) OR (“high intensity interval training exercise"[tiab]) OR (“high intensity interval training group"[tiab]))) AND (((Obesity [Mesh]) OR (obese[tiab]) OR (“obese adult"[tiab]) OR (overweight[tiab]) OR (“overweight adult"[tiab]))	(((exp “high intensity interval training"/) OR (“high intensity interval training".tw.) OR (“high intensity interval training exercise". tw.) OR (“high intensity interval training group".tw.))) AND (((exp Obesity/) OR (obese.tw.) OR (“obese adult".tw.) OR (overweight.tw.) OR (“overweight adult".tw.)))	(((“high intensity interval training”) OR (“high intensity interval training”) OR (“high intensity interval training exercise”) OR (“high intensity interval training group"))) AND (((Obesity) OR (obese) OR (“obese adult”) OR (overweight) OR (“overweight adult")))	(((“high intensity interval training”) OR (“high intensity interval training”) OR (“high intensity interval training exercise”) OR (“high intensity interval training group"))) AND (((Obesity) OR (obese) OR (“obese adult”) OR (overweight) OR (“overweight adult")))

2.4. Inclusion and exclusion criteria

Clinical trials that involved individuals with obesity or overweight, determined by body mass index, body fat percentage, and/or waist circumference, were included. Additionally, studies involving adults aged 18 years and older, without sex restrictions, were included. Studies that evaluated HIIT and MICT programs using training protocols based on parameters such as maximum heart rate, maximal oxygen consumption, or maximum aerobic speed were included. In cases where two interval training protocols were employed, the interval regimen with the highest volume was selected for comparison with the MICT.

Studies that incorporated complementary nutritional interventions were only included if these interventions were the same for all participants. Studies that assessed insulin sensitivity using a homeostatic model assessment (HOMA) or a similar test with comparable physiological explanations were also included. Furthermore, studies that evaluated body composition, including weight (in kilograms), body mass index, waist circumference (in centimeters), visceral fat mass, or any other measurement of body fat, were included.

Studies that included participants with any type of chronic disease, pregnant or postpartum patients, or individuals engaged in elite athletic training were excluded. Furthermore, studies with HIIT and MICT programs lasting less than 3 weeks and those that incorporated an additional component of pharmacological intervention were excluded. Articles published in languages other than Spanish or English were also excluded.

2.5. Study selection

After the article search, the Rayyan program was used to eliminate duplicate articles, which was independently performed by two researchers (SS and ME). Discrepancies were resolved by a third researcher (CC). Subsequently, the remaining articles were reviewed based on their titles and abstracts using the eligibility criteria. Additionally, full-text articles were reviewed, and those that met the selection criteria were included. Two researchers (SS and ME) independently conducted these procedures, and any discrepancies were resolved by a third researcher (CC).

2.6. Data extraction and risk of bias assessment

In the selected studies, two researchers (SS and ME) independently extracted participant characteristics, the number of individuals in each group, outcome values for each variable of interest, and HIIT and MICT protocols. Mean and standard deviation values were calculated for insulin sensitivity, waist circumference, body mass index, and body fat mass. In case of data discrepancies, the full text of the article was re-examined to verify the extracted information. Two researchers (SS and ME) independently assessed the risk of bias in each study. The Rob2 tool was used for clinical trials, and any disagreements were resolved by a third researcher (CC).

2.7. Assessment of the certainty of the evidence

The quality of evidence was assessed using the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) approach [28]. The GRADEpro tool, as detailed on the website (https://gradepro.org), was utilized to construct evidence tables for the evaluated outcomes [29]. Two reviewers (SS and ME) rated the quality of evidence for each outcome. As is customary in systematic reviews, we adopted a partially contextualized approach to rate the certainty of evidence. This means that for a point estimate (or range) of a single outcome, we evaluated our certainty that the true effects lay within the boundaries of what we considered a trivial, small, medium, or large effect without considering evidence from other outcomes.

2.8. Data analysis plan

The means and pre-post-intervention mean differences for numerical outcomes and their respective standard deviations were extracted from the studies. Pooled effect sizes were estimated using a fixed-effects or random-effects model based on the heterogeneity among the studies and the chosen epidemiological approach. Weighted mean differences (WMD) were used to measure the variation in mean differences in the outcomes obtained from HIIT and MICT interventions. Heterogeneity among the studies was assessed by inspecting the forest plot for all outcomes, supplemented with the evaluation of the Q statistic and I^2 parameters for relative effects. Funnel plots were used to examine publication bias. A subgroup analysis was conducted based on the risk of bias presented in the different outcomes of the included studies. Analyses were performed using RevMan 5.4 software.

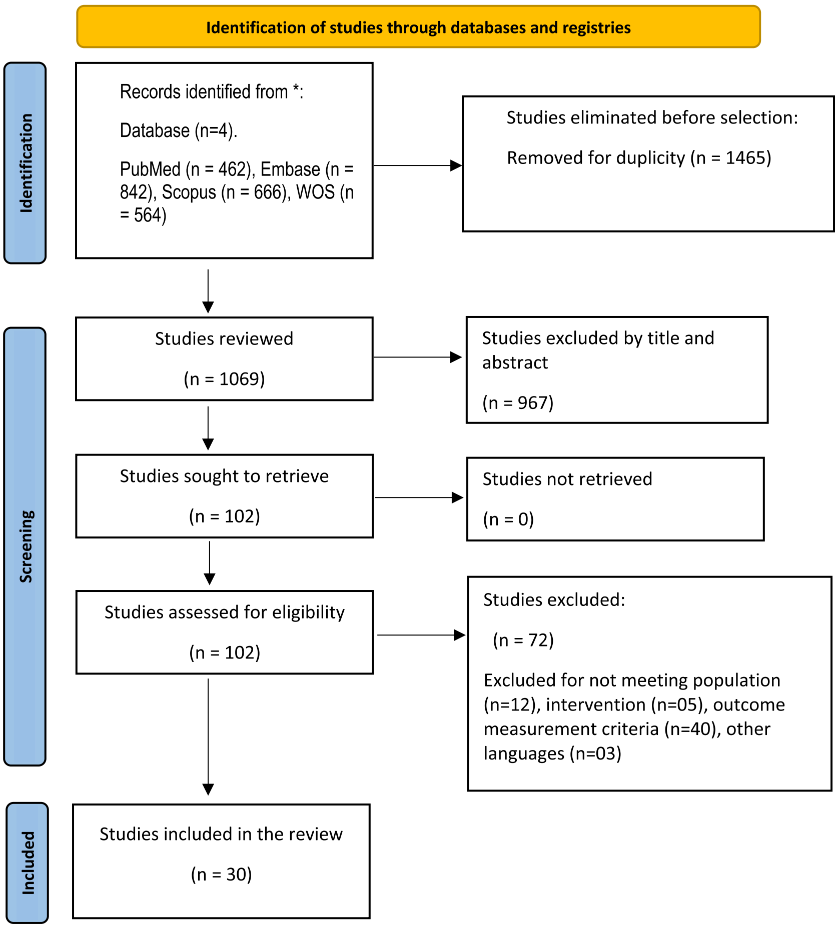

Fig. 1. PRISMA flowchart for the study selection.

Table 1
Characteristics of participants in the included studies and description of body weight and fat mass measurement instruments.

Study	Country	Population Characteristics	HIIT		MICT		Dietary Control (DC) and Regular Physical Activity (RPA)	Measure of TBM/FM
			Age (years)	Sample Size (M/F)	Age (years)	Sample Size (M/F)		
Ahmadizad[30]	Iran	Healthy overweight men, taking no medications with no experience of regular exercise	25 ± 1	10 (10 M)	25 ± 1	10 (10 M)	DC and RPA: recorded daily and instructed for its maintenance.	TBM: ES FM: BIA
Boukabous[31]	Canada	Women (60 and 75 years): with abdominal obesity (waist circumference ≥88 cm), non-smoker, physically inactive, moderate or no alcohol consumption, apparently healthy, and without medical treatment that could influence metabolism.	66.0 ± 3.4	9 (9 M)	64.2 ± 3.7	9 (9F)	DC: Instructed to maintain their dietary habits, recording 3 days before and after the study. RPA: NR	TBM: ES FM: DXA
Cheema[32]	Australia	Adults with abdominal obesity, without physical activity, who are apparently healthy.	43 ± 19	6 (3 M/3F)	36 ± 15	6(2 M/4F)	DC and RPA: lack of follow-up.	TBM: ES FM: SF
Chin[33]	China	Adult men, overweight and obese (BMI ≥23 kg/m^2, and percentage of body fat >20%), apparently healthy, without medical and chronic health conditions, and without high levels of physical activity.	22.8 ± 3.1	14 (14 M)	22.8 ± 3.1	9(9 M)	DC and RPA: instructed to maintain their dietary habits and daily physical activities	TBM and FM: BIA
D'Amuri[34]	Italy	Adults (18–50 years old), obese (BMI: 30–55 kg/m^2), without physical activity, apparently healthy.	40 ± 7	16 (9 M/7F)	37 ± 9	16 (8 M/8F)	DC: Received personalized hypocaloric diet and 4-day dietary record. RPA: NR	TBM and FM: BIA
Dupuit[35]	France	Postmenopausal women, overweight or obese (BMI: >25 kg/m^2 and ≤40 kg/m^2) with stable eating habits and low physical activity for at least the previous 3 months, without hormone replacement therapy, apparently healthy.	59.9 ± 5.9	10 (10F)	67.1 ± 7.2	8 (8F)	DC and RPA: instructed to maintain their dietary habits and daily physical activities.	TBM: MS FM: DXA
Galedari[36]	Iran	Adult men (20–40 years old) who are overweight (BMI over 27 kg/m^2), apparently healthy, without medications or supplements such as omega 3, and non-smokers.	30.8 ± 7.6	10 (10 M)	28.8 ± 6.1	12 (12 M)	DC: Received individually calorie-restricted diet. A 3-day record at the beginning and last week of training. RPA: NR	TBM: MS FM: DXA
Gerosa-Neto[37]	Brazil	Apparently healthy adults of both sexes who are overweight and obese without alcohol or drug abuse.	41.4 ± 9.3	10 (NR)	50.4 ± 11.6	10 (NR)	DC and RPA: NR	TBM and FM: NR
Gerosa-Neto[38]	Brazil	Adult men with obesity, healthy without physical activity, non-smokers, and not addicted to alcohol (≤30 g/day).	27.5 ± 6.9	11 (11 M)	29.8 ± 4.0	11(11 M)	DC and RPA: instructed to maintain their dietary habits and daily physical activities.	TBM and FM: NR
Gerosa-Neto[39]	Brazil	Men (18–35 years old) with obesity (BMI ≥30 kg/m^2), without regular physical activity, apparently healthy, non-smokers and without high alcohol consumption.	29.6 ± 4.9	13(13 M)	29.6 ± 4.9	13 (13 M)	DC: Instructed to maintain their usual food intake; no nutritional intervention was provided. RPA: Instructed to avoid other types of physical training during the study.	TBM: NR FM: BIA
Gripp[40]	Brazil	Adults (30–50 years) with overweight or obesity, non-smokers, with physical activity no more than 2 days a week during the last 3 months, and primarily involved in sedentary occupations, with prior medical clearance for participation.	38 ± 6	11 (11 M)	39 ± 5	11 (11 M)	DC: Dietary monitoring and recording for 3 non-consecutive days, instructed to maintain it. RPA: NR	TBM: MS FM: DXA
Hu[41]	China	Adult women (18–25 years) of Chinese ethnicity who are overweight (BMI: ≥23 kg/m^2 and percentage of body fat over 30%), with a sedentary lifestyle without regular physical activity, non-smokers, not accustomed to drinking alcohol, not using oral contraceptive pills, and medications known to affect body mass and metabolism.	21.5 ± 1.7	15 (15F)	21.5 ± 1.7	15 (15F)	Dietary record for 3 days over 4 weeks. DC and RPA: instructed to maintain their dietary habits and daily physical activities.	TBM and FM: DXA
Inoue[42]	Brazil	Adult men (18–36 years old), healthy, sedentary (≤1 day/week of structured physical activity), BMI 28–35 kg/m^2,	30.0 ± 5.4	10 (10 M)	30.0 ± 5.4	10(10 M)	DC and RPA: instructed to maintain their dietary habits and daily physical activities.	TBM and FM: NR

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Table 1 (*continued*)

Study	Country	Population Characteristics	HIIT		MICT		Dietary Control (DC) and Regular Physical Activity (RPA)	Measure of TBM/FM
			Age (years)	Sample Size (M/F)	Age (years)	Sample Size (M/F)		
		non-smokers, without medication or drug use or alcohol abuse.						
Kong[43]	China	Adults (18–30 years old), overweight or obese (BMI: ≥23 kg/m^2 and body fat percentage greater than 30%), not physically active, non-smokers, non-alcoholics, apparently healthy, not consuming oral contraceptive pills or any prescribed medication that affects body composition or the endocrine system.	19.8 ± 0.8	10 (10F)	19.9 ± 2.1	8 (8F)	DC: 3-day dietary record. RPA: Monitored. DC and RPA: instructed to maintain their dietary habits and daily physical activities.	TBM: ES FM: DXA
Martins[21]	Norway	Sedentary adults with obesity, not on a weight loss diet or unstable weight, not taking medication that affects appetite or weight.	33.9 ± 7.8	16(M/F = 0.4)	33.0 ± 9.9	14 (M/F = 0,6)	DC: Instructed to maintain their usual dietary habits, 3-day record at the beginning and in the last week. RPA: Daily record and instructed to maintain it.	TBM: ES FM: DXA
Nie[44]	China	Adult women (18–25 years old) with obesity (percentage of body fat ≥35%), without regular physical activity, non-smokers, apparently healthy, and without current use of prescription drugs (including contraceptive pills).	21.0 ± 1.1	16 (16F)	20.9 ± 1.6	14(14F)	DC and RPA: instructed to maintain their dietary habits and daily physical activities.	TBM and FM: BIA
Poon[45]	China	Adult men (40–59 years old) of Chinese ethnicity, with overweight/obesity (BMI: >22.9 kg/m^2), physically inactive, and without medical conditions and chronic health issues.	49.6 ± 7.8	12(12 M)	46.5 ± 3.6	12(12 M)	DC: Instructed to maintain their usual dietary habits, 3-day diet assessment (before and after the intervention). RPA: NR	TBM and FM: BIA
Ram[46]	Australia	Physically inactive adult men (40–59 years), overweight/obese (BMI: >22.9 kg/m^2), without chronic health and medical conditions.	30 ± 6	16(16 M)	26 ± 8	12(12 M)	DC and RPA: instructed to maintain their dietary habits and daily physical activities.	TBM: ES FM: DXA
Rodrigues[47]	Brazil	Adults who are overweight or obese (BMI: ≥25 kg/m^2 and waist circumference ≥80 cm for women and ≥90 cm for men), without drug or alcohol abuse, and without medication that alters autonomic modulation or participation in the study.	M 35.6 ± 4.2 F 52.0 ± 5.8	26 (7 M/19F)	M 35.6 ± 4.2 F 52.0 ± 5.8	19 (7 M/12F)	DC and RPA: NR	TBM: ES FM: NR
Ryan[48]	United States	Adults with obesity, sedentary, non-smokers, stable weight, not taking any medication or supplement that influences their metabolism, and had no history of cardiovascular or metabolic diseases. The women were premenopausal and not pregnant or lactating; some women were taking birth control medications.	32 ± 7	16 (7 M/9F)	30 ± 6	15(5 M/10F)	Instructed to maintain body mass. DC: If body mass started to deviate between 1% and 2% from the initial value, they received nutritional guidance to maintain weight. RPA: NR	TBM: NR FM: DXA
Sawyer[49]	United States	Adult women with obesity (BMI: 30 kg/m^2), free of known chronic disease, without regular physical activity.	35.6 ± 8.9	9(5 M/4F)	34.8 ± 7.7	9(4 M/5F)	DC: Instructed to maintain their usual dietary habits; there was no dietary control. RPA: NR	TBM: NR FM: DXA
Sun[50]	China	Adults (18–30 years old), overweight or obese (BMI: ≥23 kg/m^2), with stable weight, sedentary, healthy lifestyle, non-smokers, non-alcoholics, without medication or nutritional supplements.	20.8 ± 2.7	15 (15F)	21.5 ± 3.1	13(13F)	DC: Changed from a normal diet to a low-carbohydrate diet, received nutritional education, and recorded their diet. RPA: Instructed to maintain their usual daily routines and refrain from engaging in any additional exercise.	TBM: ES FM: NR
Sun[51]	China	Adults (18–30 years old) of Chinese ethnicity with overweight or obesity (BMI ≥23 kg/m^2), stable body weight, sedentary, healthy lifestyle, non-smokers, no alcohol	21.4 ± 2.9	13(13F)	21.8 ± 3.1	12(12F)	DC: Changed from a normal diet to a low-carbohydrate diet, received personalized dietary guidance, and recorded their diet for 3 days per	TBM: ES FM: NR

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Table 1 (*continued*)

Study	Country	Population Characteristics	HIIT		MICT		Dietary Control (DC) and Regular Physical Activity (RPA)	Measure of TBM/FM
			Age (years)	Sample Size (M/F)	Age (years)	Sample Size (M/F)		
		consumption, no use of prescription drugs or supplements to lose weight.					week. RPA: Instructed to maintain their usual daily routines and refrain from engaging in any additional exercise.	
Sun[52]	China	Adults (18 and 30 years old) with overweight (BMI: ≥23 kg/m^2, body fat ≥30%), stable body mass, non-smokers, non-alcoholics, without using oral contraceptive pills or any medication that would affect body mass, fasting glucose, or insulin levels.	21.5 ± 1.8	14(14F)	20.9 ± 1.4	14(14F)	DC: Instructed not to alter their usual diet or restrict intake, recorded their diet for 3 days a week before the intervention and in the fourth, eighth, and twelfth week during the intervention. RPA: Instructed to maintain normal daily physical activities and avoid additional exercises.	TBM and FM: BIA
Vaccari[53]	Italy	Adults (18 and 50 years old) with obesity, stable weight, apparently healthy, without medical and chronic health conditions, without consumption of drugs that influence energy metabolism and cardiorespiratory adjustments to exercise, without consumption of beta-blockers.	40.1 ± 0.4	16(NR)	37.3 ± 0.6	16(NR)	DC: Received personalized diets. RPA: NR	TBM: MS FM: BIA
Vella[54]	United States	Adults who are overweight or obese (18–44 years old), without chronic health and medical conditions, without antihypertensive or lipid-lowering medications, not currently pregnant or breastfeeding, do not have regular menstrual cycles, and non-smokers.	23.1 ± 6.6	8(2 M/6F)	28.9 ± 8.1	9(5 M/4F)	DC: Maintained a similar diet. RPA: NR	TBM and FM: NR
Zapata-Lamana[55]	Chile	Adults (20 and 40 years old) who are overweight or obese, without physical activity, without chronic medical and health conditions, not taking antidepressants, and not pregnant.	21.2 ± 1.4	14(14F)	21.3 ± 1.4	14(14F)	DC: Instructed to maintain usual nutritional habits; no recording was conducted. Standardized diet for 1 week before initial measurements and after the training. RPA: NR	TBM and FM: DXA
Zhang[56]	China	Adult women (18–22 years old) who are overweight or obese (BMI ≥25 kg/m^2, body fat percentage ≥30) with stable body weight participating in a physical education class twice a week, but not in other regular physical activities or training; no chronic health and medical conditions, no current use of prescription drugs.	21.5 ± 1.7	15(15F)	20.9 ± 1.4	15(15F)	DC: Daily recording. DC and RPA: Instructed to maintain their dietary habits and daily physical activities.	TBM and FM: DXA
Zhang[57]	China	Adult women (18–23 years old) who are overweight or obese (percentage of body fat ≥30%), with stable body weight, without regular physical activity except attending physical education classes twice a week, without medical and chronic health conditions, and no current use of prescription medications, including oral contraceptives.	19.7 ± 1.1	12(12F)	21.0 ± 2.4	11(11F)	DC and RPA: daily recording from 3 weeks before the end of the intervention.	TBM and FM: DXA
Zhang[58]	China	Overweight/pre-obese adults (BMI: ≥25 kg/m^2; body fat percentage ≥28), stable body weight, without regular physical training except for participation in physical education classes twice a week; no chronic medical and health conditions, no weight or metabolism medication use.	21.0 ± 1.0	12(12F)	20.6 ± 1.2	12(12F)	DC and RPA: instructed to maintain their usual dietary habits; daily recording during the 3 weeks before the intervention period.	TBM and FM: BIA

Total body mass (TBM), fat mass (FM): body mass index (BMI), mechanical scale (MS), electronic scale (ES), dual-energy X-ray absorptiometry (DXA), bioelectrical impedance analysis (BIA), skin fold (SF), not reported (NR), DC: dietary control, RPA: regular physical activity.

Table 2
Description of HIIT and MICT intervention protocols and main outcomes.

Study	Duration (weeks)	HIIT			MICT			Main outcomes
		Modality	Frequency (days/ weeks)	Protocol	Modality	Frequency (days/ weeks)	Protocol	
Ahmadizad et al., 2015	6	Treadmill	3	Warm-up: 10–15 min. HIIT: 8–11 exercise intervals with 2–3 min active rest. (Intensity: 90% of individual VO_{2max} values). Cool-down: 10 min.	Treadmill	3	Warm-up: 10–15 min. MICT: 30–70 min at 50–60% VO_{2max}, depending on HIIT energy expenditure. Cool-down: 10 min.	The HIIT and MCT groups had similar effects on body mass, fat mass, and insulin resistance in men who were overweight
Boukabous et al., 2019	8	Treadmill	3	Warm-up: 3 min (50–70% HRR). HIIT: 6 intervals of 1 min at 90% HRR with 2 min of active recovery at 40% HRR. Cool-down: 2 min at 40% HRR.	Treadmill	3	Warm-up: 2 min (40% HRR). MICT: 45 min (55% HRR). Cool-down: 3 min (40% HRR).	The HIIT and MCT groups had similar effects on body mass, fat mass, and abdominal circumference in inactive older women
Cheema et al., 2015	12	Boxing	4	Warm-up: 5 min. HIIT: 3 intervals - 2:1 (intense activity/rest). Total of 30 min at >75% at 50–60% HR_{max}.	Brisk walk	4	Warm-up: 5 min. MICT: 45 min (unsupervised).	The HIIT and MCT groups had similar effects on body mass, fat mass, and abdominal circumference in men and women with abdominal obesity and BMI >25 kg/m^2
Chin et al., 2020	8	Runs	3	Warm-up: 5 min. HIIT: 12 × 1 min at 90% HRR, interspersed with 11 × 1 min active recovery at 70% HRR. Cool-down: 5 min.	Runs	3	Warm-up: 5 min. MICT: 30 min at 60% HRR. Cool-down: 5 min.	Body fat mass significantly decreased in the HIIT group compared with the MICT group.
D'Amuri et al., 2021	12	Treadmill	3	Warm-up: 10 min at 50% VO_{2peak} HIIT: 3–7 repetitions of 3 min at 100% VO_{2peak} interspersed with 1.5 min at 50% $VO_{2peak.}$ Cool-down at 50% VO_{2peak}	Treadmill	3	Warm-up: 10 min at 50% VO_{2peak} MICT: progressively increased. 60% VO_{2peak}. Cool down to 50% VO_{2peak}	MICT and HIIT showed comparable effects within groups in weight loss and changes in fat mass. No significant changes were observed in plasma insulin.
Dupuit et al., 2020	12	Cycling	3	Warm-up: 5 min. HIIT: 60 min 8 s at 80–90% of HR_{peak} with 12 s of active recovery. Cool-down: 2 min.	Cycling	3	Warm-up: 5 min. MICT: 40 min at 55–60% of PPO Cool-down: 2 min.	Body weight, total fat mass, and hip circumference decreased in the HIIT and MICT groups after 12 weeks. However, MICT and HIIT showed comparable effects.
Galedari et al., 2017	12	Treadmill	3	Warm-up: 5 min. HIIT: 6–12 × 1 min at 90–95% at 50–60% HR_{max} (85–90% VO_2peak) interspersed with 1 min of active rest at 65–70% at 50–60% HR_{max} (50–55% VO_{2peak}). Total time for each session ranged from 12 to 24 min. Cool-down: 5 min.	Treadmill	3	Warm-up: 5 min. MICT: 18–35 min at 65–70% at 50–60% HR_{max} (50–55% VO_{2peak}). Cool-down: 5 min.	No significant difference was observed between the HIIT and MICT groups in the homeostatic model assessment-insulin resistance.
Gerosa-Neto et al., 2016	16	Treadmill	3	Warm-up: 10 min at 70% at 50–60% HR_{max}. HIIT: 4 intervals of 4 min at 90% of 50–60% HR_{max}, interspersed with 3	Treadmill	5	Warm-up: 10 min at 70% at 50–60% HR_{max}. MICT: 30 min at 70% at	No group exhibited significant changes in body composition; however, the HIIT group tended to exhibit reduced total body weight and BMI. In the HIIT group,

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Table 2 (*continued*)

Study	Duration (weeks)	HIIT			MICT			Main outcomes
		Modality	Frequency (days/weeks)	Protocol	Modality	Frequency (days/weeks)	Protocol	
				min of active recovery (70% at 50–60% HR_{max}). Cool-down: 5 min.			50–60% HR_{max}. Cool-down: 5 min.	insulin sensitivity showed a trend for improvement.
Gerosa-Neto et al., 2020	6	Treadmill	3	Warm-up: 7 min. HIIT: 10 efforts of 1 min at 100% MAV interspersed with 1 min passive interval.	Treadmill	3	Warm-up: 7 min. MICT: session at 65% MAV in the time necessary for the caloric expenditure of HIIT.	No significant difference was observed between the HIIT and MICT groups in insulin sensitivity
Gerosa-Neto et al., 2019	6	Treadmill	3	Warm-up: 5 min. HIIT: 10 efforts at 100% MAV of 1 min duration with 1-min intervals of passive recovery.	Treadmill	3	Warm-up: 5 min. MICT: 35 min at 65% MAV.	No significant difference was observed between the HIIT and MICT groups in BMI
Gripp et al., 2021	8	Cycling	3	Warm-up: 5 min. HIIT: 85–100% of shuttle test.	Cycling	3	Warm-up: 5 min. MICT: 60–75% shuttle test.	The HIIT and MCT groups had similar effects on BMI and fat mass.
Hu et al., 2021	12	Cycling	3	HIIT: 4 min at 90% VO_{2peak} followed by 3 min of recovery for ~60 min with equivalent mechanical work (200/300 kJ).	Cycling	3	MICT: ~65 min at 60% VO_{2peak} with equivalent mechanical work (200/300 KJ).	The HIIT and MCT groups had similar effects on body mass, BMI, and fat mass.
Inoue et al., 2020	6	Treadmill	3	Warm-up: 5 min. HIIT: 10 bouts of intermittent running of 1 min at 100% MAV, interspersed with 1 min of passive recovery.	Treadmill	3	Warm-up: 5 min. MICT: 40 min at 65% MAV.	The HIIT and MCT groups had similar effects on body mass, BMI, and fat mass.
Kong et al., 2016	5	Cycling	4	Warm-up: 3-min. HIIT: 60 repetitions: 8 s at ~90% of VO_{2peak} interspersed with 12 s of recovery for 20 min. Cool-down: 3-min.	Cycling	4	Warm-up: 3-min. MICT: 40 min at 60% $VO_{2\,peak}$. Cool-down: 3-min.	The HIIT and MCT groups had similar effects on body mass, BMI, and fat mass.
Martins et al., 2016	12	Cycling	3	Warm-up: 5min. HIIT: 8 s of speed and 12 s of recovery at 85–90% at 50–60% HR_{max}. Cool-down: 5 min.	Cycling	3	MICT: average 32 min 70% of at 50–60% HR_{max}.	The HIIT and MCT groups had similar effects on body mass and waist circumference.
Nie et al., 2018	12	Cycling	3–4	Warm-up: 10 min at 50–60% HR_{max}. HIIT: 4 min sessions at 90% VO_{2max} interspersed with 3 min rest until 300 kJ per session. Cool-down: 5 min at 50–60% HR_{max}.	Cycling	3–4	Warm-up: 10 min at 50–60% HR_{max}. MICT: 60% VO_{2max} until reaching 300 kJ of planned work. Cool-down: 5 min at 50–60% HR_{max}.	HIIT and MICT led to a similar decrease in body mass, BMI, and body fat mass
Poon et al., 2020	8	Running/walking on a treadmill or outdoors	3	Warm-up: 5 min at 60% HR_{max}. HIIT: 6–10 series of 1 min at 80–90% of HR_{max} separated by 1 min of active recovery at 50% of	Jog/walk briskly on a treadmill or outdoors	3	Warm-up: 5 min at 60% HR_{max}. HIIT: 30–50 min at 65–70% of HR_{max}.	No differences were observed in fat mass, BMI, and waist circumference between the HIIT and MICT groups.

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Table 2 (*continued*)

Study	Duration (weeks)	HIIT			MICT			Main outcomes
		Modality	Frequency (days/ weeks)	Protocol	Modality	Frequency (days/ weeks)	Protocol	
				HR_{max}. Cool-down: 5 min at 50% HR_{max}			Cool-down: 5 min at 50% HR_{max}.	
Ram et al., 2020	6	Cycling	3	Warm-up: 3 min at 65% of HR_{peak}. HIIT: 24 min, 10 × 1 min intervals at ~90% HR_{peak} with 1-min active recovery intervals at a low workload. Cool-down: 2 min at low intensity.	Cycling	3	MICT: 30 min of continuous exercise at 65–75% of HR_{peak}.	The HIIT and MCT groups had similar effects on body mass, BMI, and fat mass
Rodrigues et al., 2020	16	Cycling or treadmill	3	Warm-up: 10 min HIIT: 4 × 4 min bouts at 85–95% HR_{peak}, interspersed with 3 min of recovery at 50–70% HR_{peak}. Cool-down: 5 min	Cycling or treadmill	5	MICT: 30 min at 60–70% HR_{peak}.	The HIIT and MCT groups had similar effects on BMI and waist circumference
Ryan et al., 2020	12	Cycling, treadmill, elliptical, or rowing	4	Warm-up: 3 min at ~65% HR_{max}, HIIT: 10x1-min intervals at 90% of HR_{max} with 1 min of low-intensity active recovery between intervals. Cool-down: 3 min at ~65% HR_{max}.	Cycling, treadmill, or elliptical.	4	MICT: 45 min at 70% of HR_{max}.	The HIIT and MCT groups had similar effects on insulin sensitivity. When trained participants abstained from exercise for 4 days, insulin sensitivity returned to pre-training levels in both groups.
Sawyer et al., 2016	8	Cycling	3	Warm-up: 5 min at 50–60%. HIIT: 10 × 1 min of 90–95% HR_{max} separated by 1 min of active recovery. Cool-down: 5 min at 50–60% HR_{max}.	Cycling	3	Warm-up: 5 min at 50–60% of HR_{max}. MICT: 30 min of exercise at 70–75% of HR_{max}. Cool-down: 5 min at 50–60% of HR_{max}.	HIIT and MICT decreased waist circumference. Body fat percentage decreased in the HIIT group but not in the MICT group. However, neither group had a significant decrease in absolute fat mass. No significant changes were observed in body weight and BMI.
Sun et al., 2019	4	Cycling	5	HIIT: 10 repetitions × 6 s and rest intervals of 9 s.	Cycling	5	MICT: 30 min at 50–60% of VO_{2peak}.	A low-carbohydrate diet is a useful approach for improving body composition in women who are overweight or obese. Incorporated exercise training (HIIT or MICT) has no additional effects on weight loss, but has additional benefits on cardiorespiratory fitness, and HIIT is more time efficient than the traditional MICT
Sun et al., 2021	4	Cycling	5	HIIT: 10 repetitions × 6 s and rest intervals of 9 s.	Cycling	5	MICT: 30 min at 50–60% of VO_{2max}.	The short-term carbohydrate restriction diet caused significant weight loss and improved insulin sensitivity in women who are overweight/obese, although the combination with exercise training (HIIT or MICT) had no additional benefits on the examined cardiometabolic profiles.
Sun et al., 2019	12	Cycling	3	HIIT: 9 repetitions × 4 min at 90% of VO_{2peak} with 3 min of passive recovery until 200–300 kJ.	Cycling	3	MICT: ~61 min at 60% VO_{2peak} until reaching 200–300 kJ.	HIIT and MICT induced similar reductions in body mass. Insulin sensitivity was improved significantly on post-training measures in HIIT, but remained unchanged in MICT.

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Table 2 (*continued*)

Study	Duration (weeks)	HIIT			MICT			Main outcomes
		Modality	Frequency (days/ weeks)	Protocol	Modality	Frequency (days/ weeks)	Protocol	
Vaccari et al., 2020	12	Treadmill	3	Warm-up: 10 min (50% of V'O_{2peak}). HIIT: 3–7 repetitions of 3 min of bouts of walking (100% V'O_{2peak}), interspersed with 1.5 min of low-intensity walking (50% of V'O_{2peak}). Cool-down: 5 min (50% of V'O_{2peak}).	Treadmill	3	MICT: 44+-8 min corresponding to 60% of the initial V'O_{2peak}.	Body mass, BMI, and fat mass decreased in the MICT and HIIT groups. The HIIT and MCT groups had similar effects on body mass, fat mass, and insulin resistance in men who were overweight
Vella et al., 2016	8	Treadmill, cycle ergometer, elliptical, jogging, or biking outdoors	3–4	Warm-up: 5 min HIIT: 10x1-min bouts of high-intensity exercise at 75–80% HRR, separated by 1-min recovery bouts at 35–40% HRR. Cool-down: at 35–40% HRR.	Treadmill, cycle ergometer, elliptical, jogging, or biking outdoors	3	Warm-up: 5 min. MICT: 20 min continuous exercise at 55–59% of HRR. Cool-down: 35–40% HRR.	The HIIT and MCT groups had similar effects on body weight, BMI, and insulin.
Zapata-Lamana et al., 2018	12	Cycling	3	Warm-up: 5 min. HIIT: 4x4 at 90% VO_{2peak}, with 2 min of active recovery between intervals and 4 min of recovery.	Cycling	3	Warm-up: 5 min. MICT: 45–50 min of exercise at a constant cadence (70–80 rpm) at 95% of the first ventilatory threshold.	Before the intervention, no differences were observed between HIIT and MICT groups in total body mass and fat mass. Total body mass decreased significantly in the MICT group but not in the HIIT group. No changes were observed with HOMA-IR
Zhang et al., 2017	12	Cycling	3–4	HIIT: 4 min at 90% VO_{2max} intensity, followed by a 3-min passive recovery until reaching 300 kJ of work was achieved.	Cycling	3–4	MICT: intensity of 60% VO_{2max} until reaching 300 kJ of work was achieved.	The changes in body mass and body fat percentage did not differ significantly between the HIIT and MICT groups
Zhang et al., 2020	12	Cycling	3–4	Warm-up: 10 min. HIIT: 4 intervals of 4 min at 90% of VO_{2peak}, interspersed with passive recovery of 3 min. Cool-down: 5 min.	Cycling	3–4	Warm-up: 10 min. MICT: continuous exercise at an intensity of 60% of VO_{2peak} for a total work done of 200 kJ. Cool-down: 5 min.	The changes in body mass and body fat percentage did not differ significantly between the HIIT and MICT groups
Zhang et al., 2015	12	Treadmill	4	Warm-up: 10 min. HIIT: 4 sets at 4 min intervals at 85–95% HR_{peak}, interspersed with 3 min walks at 50–60% HR_{peak} and a 7 min rest. Cool-down: 5 min at 50–60% HR_{peak}.	Treadmill	4	Warm-up: 10 min. MICT: 33 min at 60–70% of HR_{peak}. Cool-down: 5 min at 50–70% HR_{peak}.	The changes in body mass, BMI, waist abdominal, and body fat percentage did not differ significantly between the HIIT and MICT groups

HIIT, high-intensity interval training; MICT, moderate-intensity continuous training; BMI, body mass index; HRR, heart rate reserve; HRpeak, peak heart rate; HRmax, maximum heart rate; MAV, maximal aerobic velocity; VO_2max, maximum oxygen consumption; PPO, peak power output; VO_2peak, peak oxygen Consumption, V'O_2peak: Pulmonary oxygen uptake; min, minute; s, second; rpm, revolutions per minute; kJ, kilojoule.

3. Results

3.1. Study Selection

The search strategy identified 2534 potentially relevant articles. Of these, 462, 842, 666, and 564 were from PubMed, Embase, Scopus, and Web of Science, respectively. After excluding 1465 duplicate articles, the remaining 1069 articles were screened based on their titles and abstracts, leaving 102 articles for full-text review. Following a comprehensive assessment of the full-text articles against the eligibility criteria, 30 articles were selected for the systematic review (Fig. 1).

3.2. Characteristics of Included Studies

The selected studies comprised 30 articles [21,30–58] published between 2015 and 2021, including adults with overweight and obesity. The number of participants in the selected studies ranged from 6 to 26 participants per study. Among the selected studies, nine studies [30,33,36,38–40,42,45,46] evaluated interventions in men only, 12 studies [31,35,41,43,44,50–52,55–58] in women only, and nine studies [21,32,34,37,47–49,53,54] in both men and women. Participants' age varied across the studies, with a minimum mean age of 19.8 ± 0.8 in the study by Kong et al. [45] and a maximum mean age of 66 ± 3.4 in the study by Boukabous et al. [33] (Table 1).

The follow-up duration for HIIT and MICT interventions in these studies varied from 4 to 16 weeks, with the exercise frequency ranging from three to five times per week. Similarly, the type of exercise, session duration, and intensity differed between the training interventions in the selected studies (Table 2). Additionally, most studies instructed participants to maintain their regular diet and physical activity.

Effect of the Interventions:

Weight: Among the selected studies, 22 [21,30,31,33–35,37,41–46,49–53,55–58] investigated individuals with overweight or obesity and compared the effect of HIIT and MICT interventions on weight variation. The HIIT and MICT groups included 273 and 259 participants, respectively. No significant differences were observed in weight variation [WMD = −0.01 (95% confidence interval [CI]: −0.38 to 0.35; $I^2 = 0\%$, p = 0.58)] between HIIT and MICT. Subgroup analysis based on the risk of bias also supported this finding (Fig. 2).

Body Mass Index: Among the selected studies, 20 [31,33–35,37,39–47,49–53,58] evaluated individuals with overweight or obesity and compared the variation in body mass index before and after HIIT and MICT interventions. The HIIT and MICT groups included 257 and 237 participants, respectively. No significant differences were observed in the variation of body mass index [WMD = 0.06 (95% CI: −0.12 to 0.23; $I^2 = 0\%$, p = 0.53)] between HIIT and MICT. Subgroup analysis based on the risk of bias also supported this finding (Fig. 3).

Waist Circumference: Only 13 studies [21,31,32,34,35,45–47,49,50,53,54,58] evaluated individuals with overweight or obesity

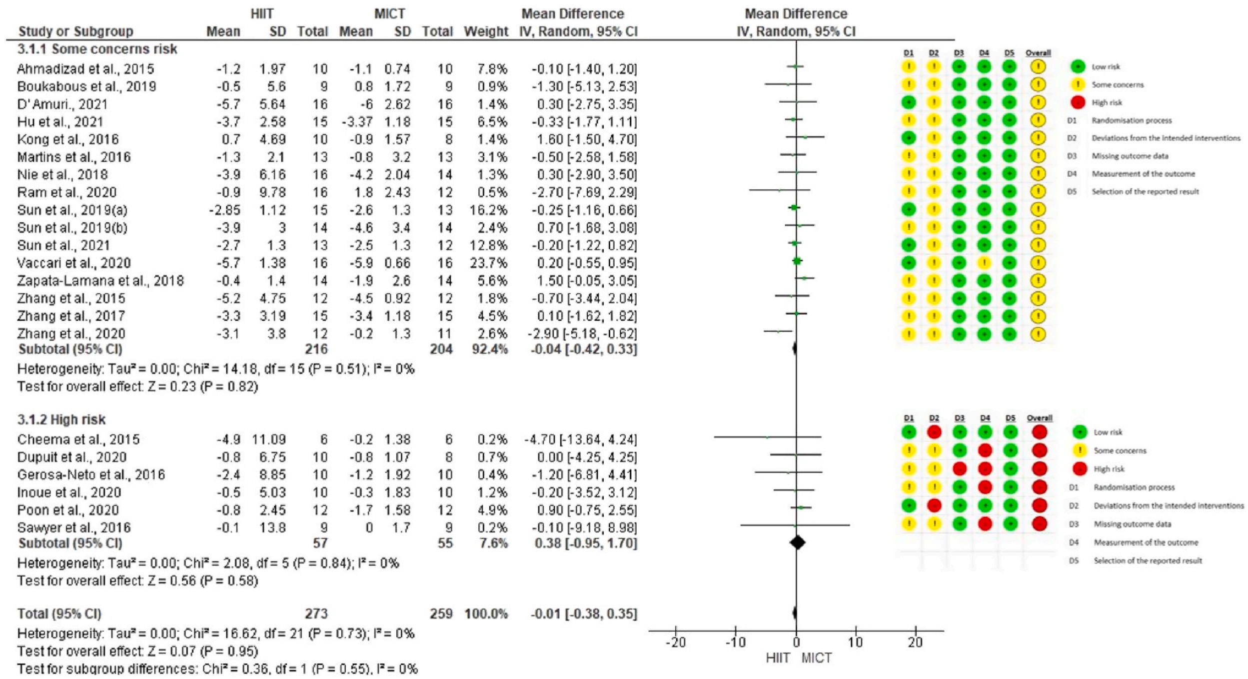

Fig. 2. Forest plot showing the results on weight variation comparing the HIIT with the MICT.

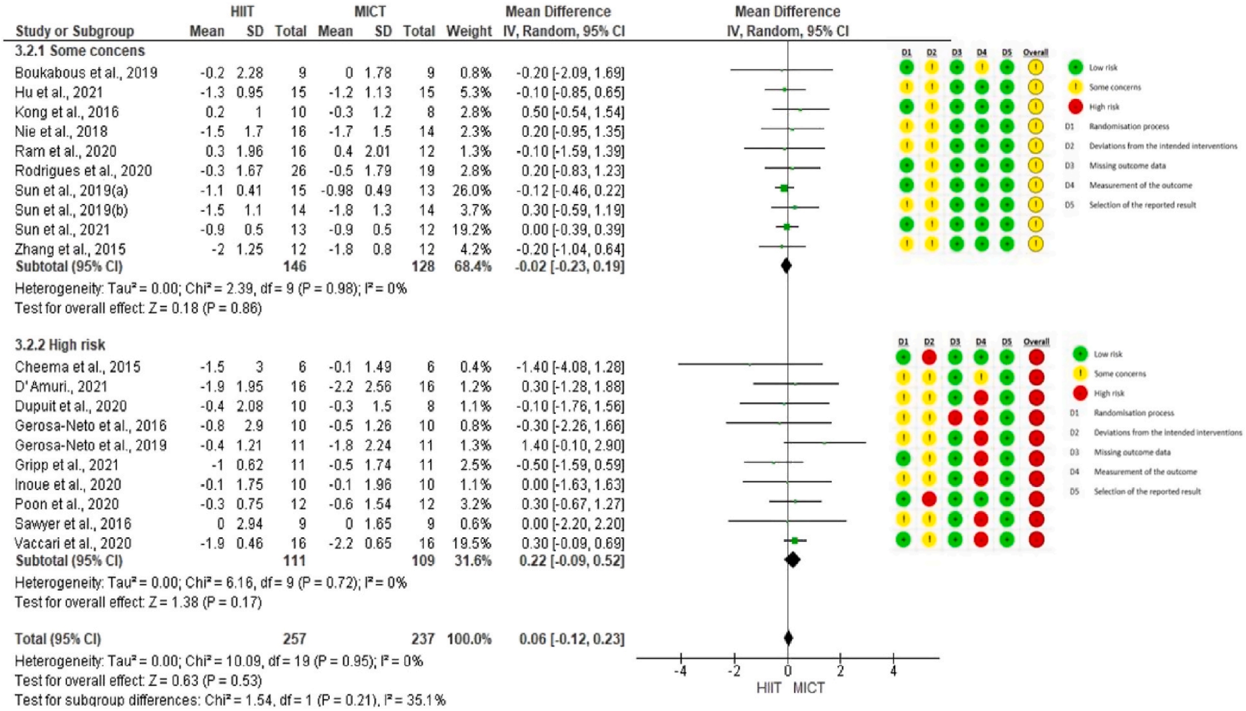

Fig. 3. Forest plot showing the results on body mass index variation comparing the HIIT with the MICT.

and compared the variation in waist circumference before and after HIIT and MICT interventions. The HIIT and MICT groups included 168 and 154 participants, respectively. No significant differences were observed in the variation of waist circumference [WMD = −0.11 (95% CI: −1.41 to 1.18; $I^2 = 75\%$, $p = 0.87$)] between HIIT and MICT. However, four [32,34,35,53] of the 13 included studies indicated a greater variation in waist circumference in favor of HIIT, whereas one study favored MICT [54]. Among the 13 studies, only the study by D'Amuri et al. [34] differentiated waist circumference by sex; therefore, both sex categories were included in the analysis. Subgroup analysis based on the risk of bias also revealed no significant differences in waist circumference variation between the HIIT

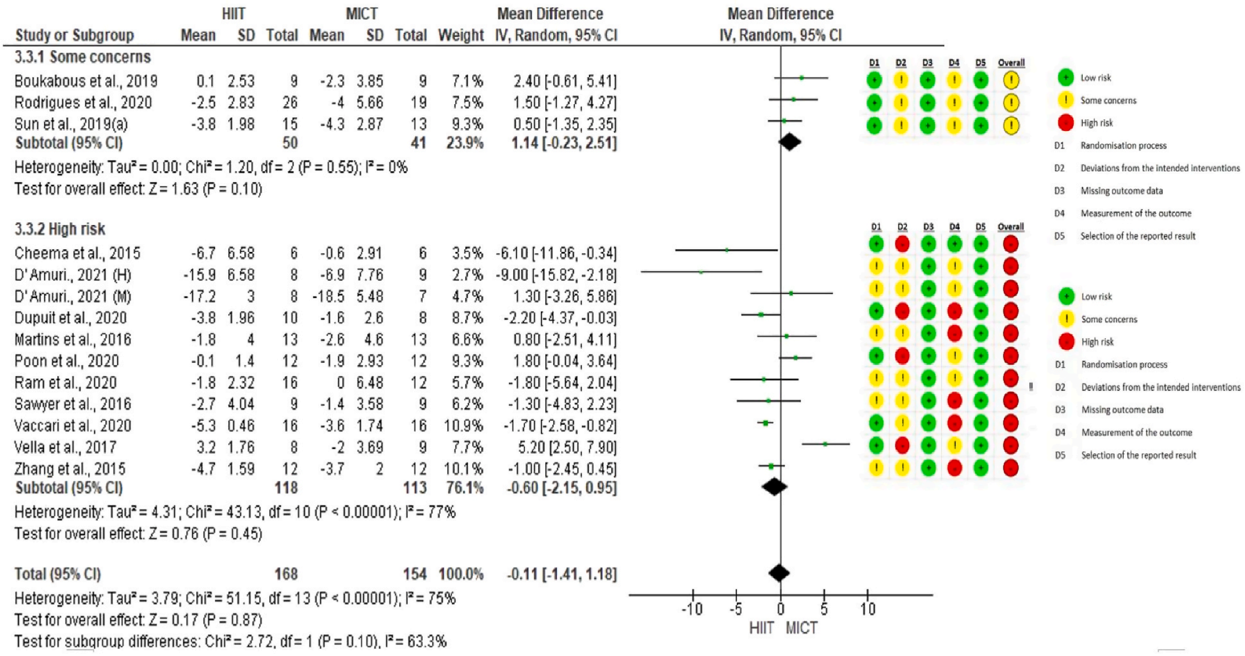

Fig. 4. Forest plot showing the results on abdominal waist variation comparing the HIIT with the MICT.

and MICT groups (Fig. 4).

Body Fat Percentage: Fourteen studies [30,32,34,35,40,41,43–46,49,55–57] evaluated individuals with overweight or obesity and compared the variation in body fat percentage before and after HIIT and MICT interventions. The HIIT and MICT groups included 175 and 159 participants, respectively. Among these studies, only the study by Zhang et al. [57] observed differences in body fat variation in favor of HIIT over MICT. However, when the studies were analyzed together, no significant differences were observed in body fat percentage [WMD = −0.50 (95% CI: −1.05 to 0.04; $I^2 = 0\%$, p = 0.07)] between HIIT and MICT. Similarly, a subgroup analysis based on the risk of bias revealed no significant differences in the variation in body fat percentage between HIIT and MICT (Fig. 5).

Body Fat Mass: Eleven studies [31,34,35,43,44,46,49,53,55–57] assessed individuals with overweight or obesity and compared variations in body fat mass before and after HIIT and MICT interventions. The HIIT and MICT groups included 143 and 132 participants, respectively. No significant differences were observed in body fat mass [WMD = −0.19 (95% CI: −0.64 to 0.25; $I^2 = 0\%$, p = 0.39)] between HIIT and MICT. Subgroup analysis based on the risk of bias also revealed no significant differences in the variations in body fat mass between the HIIT and MICT groups (Fig. 6).

Insulin Sensitivity: Eleven studies [30,33–38,40,49,51,52] assessed individuals with overweight or obesity and compared variation in insulin sensitivity measured using HOMA before and after HIIT and MICT interventions. The HIIT and MICT groups included 128 and 122 participants, respectively. A significant difference was observed in the variation of insulin sensitivity [WMD = −0.19 (95% CI: −0.35 to −0.03; $I^2 = 51\%$, p = 0.02)] in favor of HIIT over MICT. Subgroup analysis revealed that in studies that reported the level of risk for certain considerations, the variation in insulin sensitivity favored HIIT over MICT, whereas this variation was not observed in studies with a high risk of bias. Additionally, among the 11 studies included for this outcome, three demonstrated significantly higher insulin sensitivity in favor of HIIT [30,33,52], whereas the other eight studies did not demonstrate significant differences [34–38,40,49,51] (Fig. 7).

Publication Bias Assessment: A Funnel plot was used to assess potential publication bias in selected studies that evaluated individuals with overweight or obesity and compared the variation in weight, body mass index, abdominal waist, percentage of body fat, body fat, and insulin sensitivity. Modest differences in symmetrical distribution were observed in the funnel plot, suggesting no publication bias in weight (Fig. 8,a), BMI (Fig. 8,b), abdominal waist circumference (Fig. 8,c), body fat mass percentages (Fig. 8,d), body fat mass in kilograms (Fig. 8,e), and insulin sensitivity (Fig. 8,f).

Risk of Bias: Most of the selected studies presented a risk of bias with certain considerations for different outcomes. Nevertheless, the outcome related to abdominal waist circumference displayed a higher frequency of a high risk of bias. Furthermore, all studies in domain 2 had some risk of bias. A graphical representation of the risk of bias was observed for the respective effect measurements of the interventions.

Certainty Assessment of the Evidence: Six outcomes of the systematic review were analyzed using the GRADE methodology. Among these, a moderate level of certainty was achieved for outcomes related to weight, body mass index, insulin sensitivity, and percentage and kilogram of body fat mass. However, the level of certainty was rated low for abdominal waist circumference (Table 3).

4. Discussion

This study compared the effects of HIIT and MICT on weight, body mass index, waist circumference, and body fat in individuals

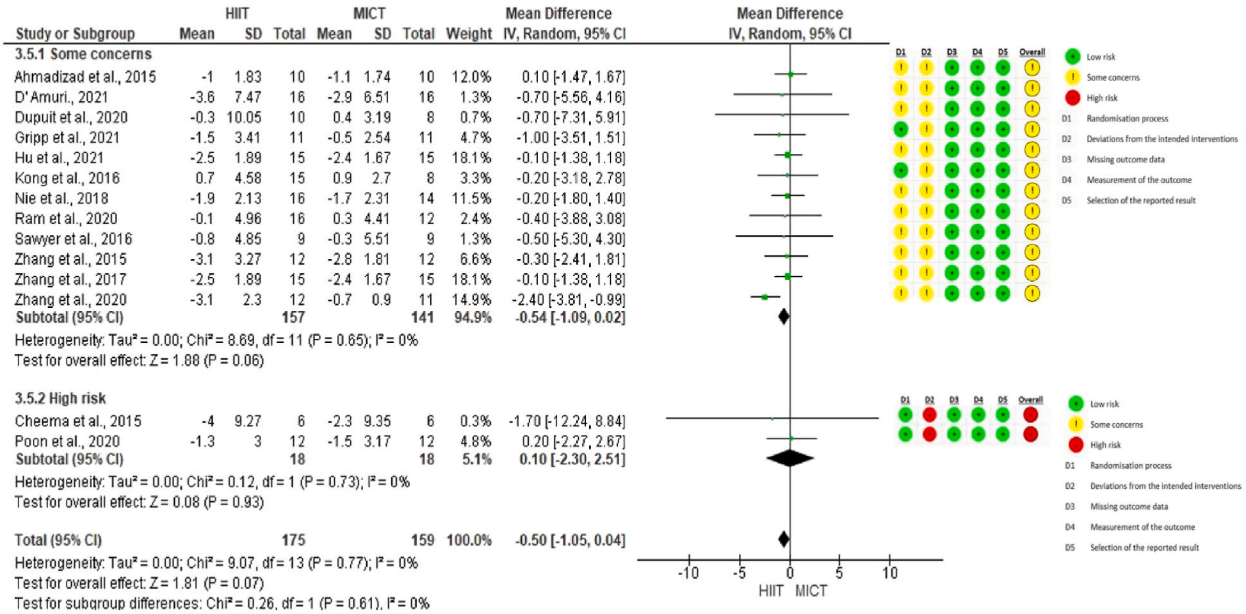

Fig. 5. Forest plot showing the results of percent change in body fat mass comparing the HIIT with the MICT.

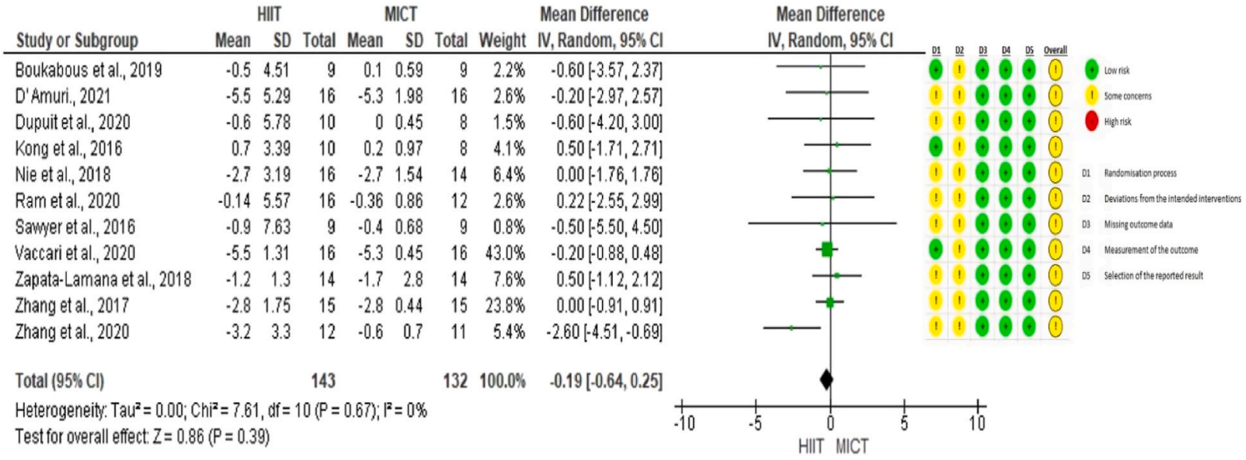

Fig. 6. Forest plot showing the results of change in body fat mass measured in kilograms comparing the HIIT with the MICT.

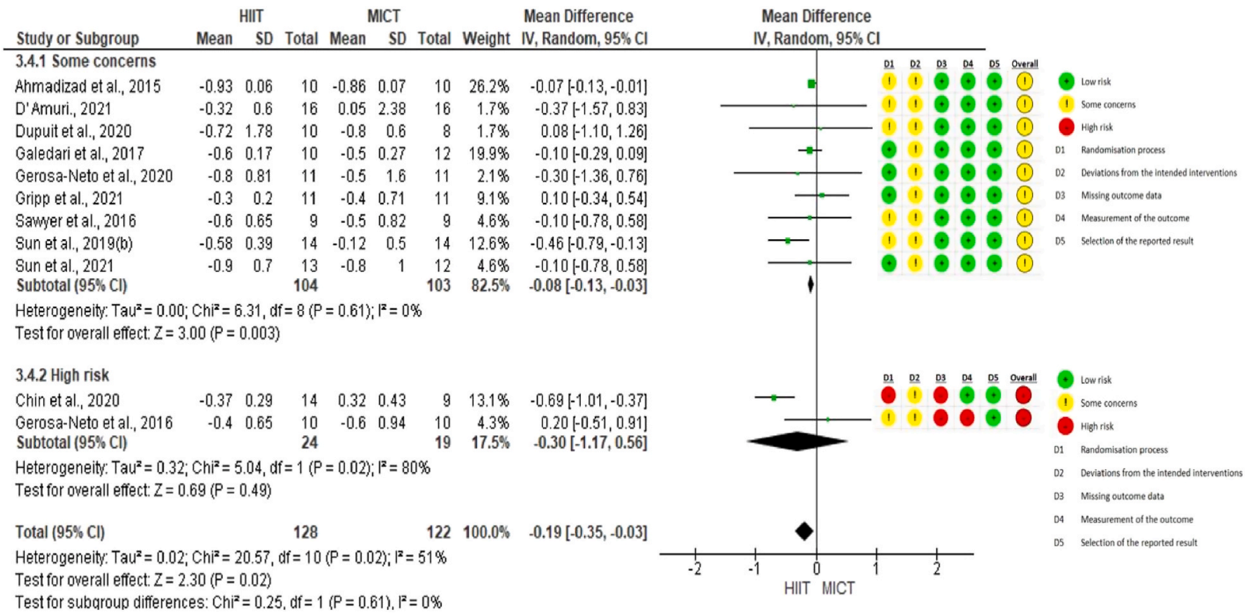

Fig. 7. Forest plot showing the results on insulin sensitivity variation comparing the HIIT with the MICT.

with overweight and obesity. The results revealed no significant differences between the two types of exercises in terms of weight, body mass index, waist circumference, and body fat in individuals with overweight and obesity. However, a difference was observed in insulin sensitivity, as measured by HOMA, where the effect of HIIT was significant compared with that of MICT.

In this systematic review, no significant differences were observed in weight reduction and body mass index reduction between HIIT and MICT. Individual studies also showed inconsistent significant differences in weight reduction between the two training methods, except for the studies conducted by Zapata-Lamana et al. [55] and Zhang et al. [57]. The first study [55] observed greater weight reduction in favor of MICT, whereas the second study [57] reported greater weight reduction in favor of HIIT. Additionally, other systematic reviews have reported that HIIT and MICT yield similar results for weight reduction and body mass index in adults with overweight and obesity [24,25].

In this systematic review, the differences in energy expenditure regulation, dietary control, and participant characteristics among the included studies may explain the lack of significant differences in weight reduction and body mass index outcomes between HIIT and MICT.

Similarly, in this systematic review, no significant differences were observed when comparing the variation in waist circumference between HIIT and MICT. However, four of the 13 included studies indicated a greater reduction in waist circumference favoring HIIT [32,34,35,53], whereas one favored MICT [54]. Previous studies with an average duration of 10 weeks have reported reductions in waist circumference for HIIT and MICT but no significant differences between the two training methods [25].

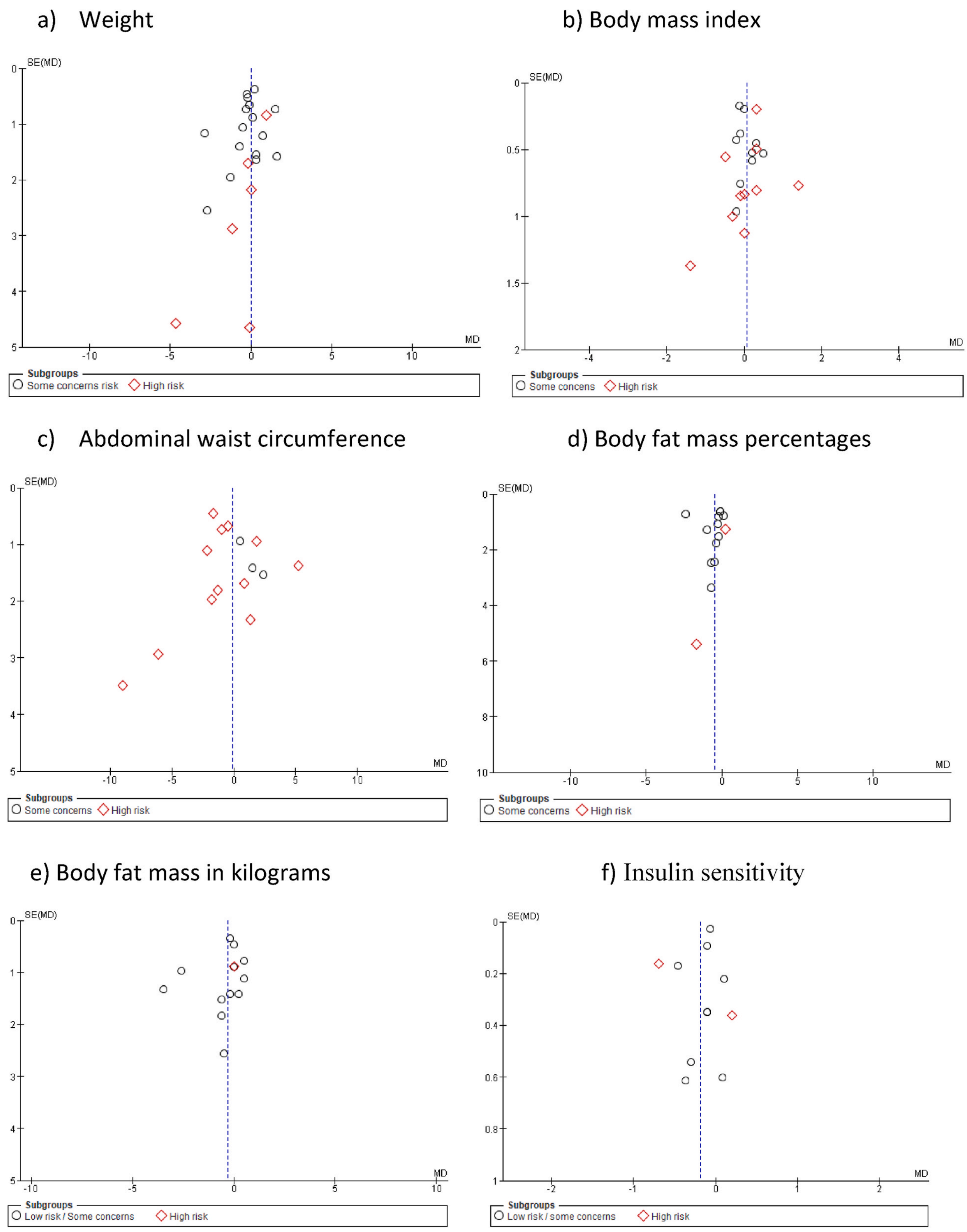

Fig. 8. Funnel plot to assess publication bias.

Table 3
GRADE assessment of the results of the systematic review.

Certainty assessment						
Participants (studies) follow-up	Risk of bias	Inconsistency	Indirect evidence	Inaccuracy	Publication bias	General certainty of the evidence
Weight (Kg)						
532 (22 Controlled experiments)	not serious	not serious	not serious	not serious	none	⨁⨁⨁◯ Moderate
Body mass index (kg/m^2)						
494 (20 Controlled experiments)	serious	not serious	not serious	not serious	none	⨁⨁⨁◯ Moderate
Abdominal waist (cm)						
322 (13 Controlled experiments)	Very serious	not serious	not serious	not serious	none	⨁⨁◯◯ Baja
Body fat mass (in percentage)						
334 (14 Controlled experiments)	serious	not serious	not serious	not serious	none	⨁⨁⨁◯ Moderate
Body fat mass (in kilograms)						
275 (11 Controlled experiments)	serious	not serious	not serious	not serious	none	⨁⨁⨁◯ Moderate
Insulin sensitivity (mmol. μU/mL)						
250 (11 Controlled experiments)	serious	not serious	not serious	not serious	none	⨁⨁⨁◯ Moderate

Furthermore, a study evaluating HIIT duration discovered that long-term training (>12 weeks) had a greater effect on reducing waist circumference than short-term HIIT [11]. In this review, the duration of training ranged from 3 to 12 weeks; thus, exposure duration to training and variations in protocols must be considered when interpreting the results. These variations in training protocols and individual study characteristics were evident as a high heterogeneity (75%) in the analysis of the waist circumference variation outcome.

This systematic review observed no significant differences in variation in body fat percentage between HIIT and MICT. However, one study by Zhang et al. [57] reported differences favoring HIIT over MICT. Nevertheless, the combined evidence in this meta-analysis did not show differences between HIIT and MICT with respect to variations in body fat percentage or body fat (in kilograms). These results are consistent with those of another review conducted on individuals who are overweight and obese, where HIIT and MICT resulted in significant reductions in total body fat. However, no significant differences were observed between the two types of training [25]. Another study that assessed fat distribution in the trunk and legs by comparing HIIT and MICT reported similar results [21].

Another study that assessed the long-term duration of HIIT (≥12 weeks) reported an increased reduction in total body fat among overweight and obese populations [10]. Thus, training duration may affect body weight and fat outcomes. In a pragmatic clinical trial, a comparison was made between 12 weeks of MICT and 12 weeks of HIIT, with the latter performed at home following prior instructions. The MICT group exhibited a significant reduction in body fat, whereas the HIIT group did not [59]. These differences may indicate the importance of supervision during training, the context in which training is performed, and appropriate follow-up protocols. In this systematic review, most studies were conducted under supervision in a training center for HIIT and MICT.

A minimum level of energy expenditure is required to achieve a positive modification and influence lipid reduction. Therefore, training programs should tailor the number, duration, and frequency of exercise sessions [60]. However, the studies in this systematic review exhibited variations in training variables, including the frequency, intensity, type, and duration of HIIT and MICT protocols. The diversity in the protocols could explain the absence of significant differences between the two types of training. Furthermore, the studies included in this systematic review demonstrated differences in energy expenditure during training sessions and varying degrees of dietary control.

Regarding the assessment of insulin sensitivity using the HOMA method, differences were observed in the pre- and post-intervention variations between the HIIT and MICT groups. However, when considering all the included studies, these differences moderately favored HIIT over MICT, and the effect diminished when focusing on the subgroup of studies that exhibited some risk of bias. Among the 11 studies included for this outcome, three demonstrated greater insulin sensitivity favoring HIIT [30,33,52], with the study by Chin et al. [33] showing the highest risk of bias and the most significant effect in favor of HIIT over MICT. In contrast, no significant differences were observed in the other eight studies with a risk of bias [30,52].

In contrast, another study conducted by Martins et al. [21] reported no differences in insulin sensitivity between isocaloric HIIT and MICT workouts. Similarly, Fisher et al. [61], using other tests such as QUICK and oral glucose tolerance, did not observe differences in the variation of insulin sensitivity when comparing HIIT and MICT in youths who are overweight and obese. Additionally, individuals at high altitudes exhibit better insulin sensitivity than those at sea level [62,63]. Exposure to high altitudes enhances glucose and lipid utilization [63]. These population-specific characteristics, among other factors, may explain the differences and heterogeneity of the results.

This study addresses obesity, a global health issue, by evaluating the effects of HIIT and MICT among adults who are overweight and obese. Unlike other studies, this study stands out for assessing various outcomes such as body weight, body mass index, body fat, waist circumference, and insulin sensitivity. Additionally, the study adhered to rigorous guidelines and utilized standardized methods to assess the quality of the evidence. Furthermore, it provides a detailed and applicable comparison of HIIT and MICT, making it relevant to healthcare professionals and individuals aiming to enhance their metabolic health.

However, this systematic review had some limitations owing to the inherent methodological designs of the included studies. Additionally, the references of the selected studies were not manually searched to identify additional sources, potentially leading to the omission of relevant references. Moreover, heterogeneity was observed in the intervention protocols, participant characteristics across the diverse range of included studies, and various instruments for measuring outcomes, such as weight, waist circumference, and body fat mass. Furthermore, discrepancies were noted in the frequency, intensity, and duration of HIIT and MICT training protocols.

5. Conclusions

In adults with overweight and obesity, HIIT and MICT did not result in significant differences in weight variation, body mass index, waist circumference, and body fat. However, a moderate variation in favor of HIIT was observed in terms of insulin sensitivity. Nonetheless, the findings of this study indicated a moderate level of evidence for most outcomes, except for waist circumference, which exhibited low certainty. Consequently, further research is warranted to establish a more comprehensive understanding of the effects of these training modalities on the studied outcomes.

We concluded that there were no significant differences in weight variation, body mass index, waist circumference, or body fat between HIIT and MICT in adults who are overweight and obese. Therefore, both types of training may be equally effective in achieving changes in body composition in this population. However, HIIT may offer additional benefits in terms of insulin sensitivity. The limitations of the included studies, such as the risk of bias related to blinding and variations in training protocols, should be considered when interpreting these results and designing future studies in this field.

Based on these findings, it is recommended that HIIT and MICT are effective in improving body composition in individuals who are overweight and obese. However, variations in training protocols should be considered when tailoring the exercise program to individual preferences and capacities. HIIT may be a valuable option to enhance insulin sensitivity for individuals at risk of insulin resistance.

Furthermore, we recommended that more rigorous and higher-quality research be conducted to assess the long-term effects of HIIT and MICT, considering the variability in protocol durations and specific population characteristics. In addition, considering combined interventions and evaluating implementation in community settings would be valuable. These future studies will strengthen the evidence base, provide relevant information to guide clinical practice, and promote effective interventions to improve body composition and insulin sensitivity.

Author contribution statement

SS: was involved in the conception and design of the study, protocol registration, literature search and reviewer, the acquisition of data, independent reviewer, risk of bias assessment, analyzed and interpreted the data, initial and final manuscript drafts, final approval of the version submitted. She is the guarantor of the review.

ME: literature search, the acquisition of data, independent reviewer, risk of bias assessment, analyzed and interpreted the data, and final manuscript draft, final approval of the version submitted.

JC: literature search, analyzed and interpreted the data, and critical review of final manuscript drafts, final approval of the version submitted.

CC: the conception and design of the study, third independent reviewer, analyzed and interpreted the data, critical review of final manuscript drafts, final approval of the version submitted.

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Data availability statement

Data included in article/tables/figures. Material/referenced in article. Any other information will be made available on request.

Additional information

No additional information is available for this paper.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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