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Effectiveness of high-intensity interval training versus moderate-intensity continuous training on peak oxygen uptake (vo_{2peak}) a cardiorespiratory parameter for individuals aged 40 and above: a systematic literature review and meta-analysis

Eficacia del entrenamiento interválico de alta intensidad frente al entrenamiento continuo de intensidad moderada en el consumo máximo de oxígeno (vo_{2peak}), un parámetro cardiorrespiratorio para personas de 40 años y más: una revisión sistemática de la literatura y meta-análisis

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Abstract. Cardiorespiratory fitness (CRF) is a crucial indicator for assessing an individual's maximal oxygen uptake capacity. Although numerous studies have investigated the effects of exercise on CRF, comparisons between high-intensity interval training (HIIT) and moderate-intensity continuous training (MICT) in individuals aged 40 and above remain limited and fragmented. This research employs a Systematic Literature Review (SLR) and meta-analysis to evaluate the effectiveness of HIIT and MICT in improving VO_2peak in individuals aged 40 and above. Data were collected from Scopus and WoS databases using the PRISMA method. Articles that met the inclusion criteria were analyzed using RevMan 5.4 and JASP 0.18.3. The analysis revealed that HIIT has a greater advantage in enhancing VO_{2peak} compared to MICT in individuals aged 40 and above. Overall, HIIT increased VO_{2peak} with a z-value of 5.59 (p-value < 0.00001) and a 95% confidence interval of 0.35 [0.23, 0.48]. Conversely, MICT showed a z-value of 1.84 (p-value = 0.07) and a 95% confidence interval of 0.11 [-0.01, 0.23]. Inter-study heterogeneity was low to moderate, with an I^2 value of 25% and τ^2 of 0.03 for HIIT, and an I^2 value of 0% for MICT. HIIT tends to be more effective than MICT in improving cardiorespiratory fitness in individuals aged 40 and above. However, the difference between the two methods is not statistically significant. Further research with more homogeneous designs and longer intervention durations is needed to confirm these findings and understand the underlying mechanisms of the differences in effectiveness between HIIT and MICT.
Keywords: HIIT, MICT, VO_{2peak}, CRF, exercise

Resumen. La aptitud cardiorrespiratoria (ACR) es un indicador crucial para evaluar la capacidad máxima de consumo de oxígeno de un individuo. Aunque numerosos estudios han investigado los efectos del ejercicio en la ACR, las comparaciones entre el entrenamiento interválico de alta intensidad (HIIT) y el entrenamiento continuo de intensidad moderada (MICT) en individuos de 40 años o más siguen siendo limitadas y fragmentadas. Esta investigación emplea una revisión sistemática de la literatura (SLR) y un meta-análisis para evaluar la eficacia del HIIT y el MICT en la mejora del VO2máx en individuos de 40 años o más. Los datos se recopilaron de las bases de datos Scopus y WoS utilizando el método PRISMA. Los artículos que cumplieron con los criterios de inclusión fueron analizados utilizando RevMan 5.4 y JASP 0.18.3. El análisis reveló que el HIIT tiene una mayor ventaja en la mejora del VO2peak en comparación con el MICT en individuos de 40 años o más. En general, el HIIT aumentó el VO2peak con un valor z de 5.59 (valor p < 0.00001) y un intervalo de confianza del 95% de 0.35 [0.23, 0.48]. Por el contrario, el MICT mostró un valor z de 1.84 (valor p = 0.07) y un intervalo de confianza del 95% de 0.11 [-0.01, 0.23]. La heterogeneidad entre estudios fue de baja a moderada, con un valor de I^2 del 25% y τ^2 de 0.03 para HIIT, y un valor de I^2 del 0% para MICT. El HIIT tiende a ser más efectivo que el MICT en la mejora de la aptitud cardiorrespiratoria en individuos de 40 años o más. Sin embargo, la diferencia entre los dos métodos no es estadísticamente significativa. Se necesita más investigación con diseños más homogéneos y duraciones de intervención más largas para confirmar estos hallazgos y comprender los mecanismos subyacentes de las diferencias en la eficacia entre HIIT y MICT.
Palabras clave: HIIT, MICT, VO2máx, ACR, ejercicio

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Introduction

A sedentary lifestyle is associated with a decline in cardiorespiratory fitness (CRF), which can negatively impact functional capacity (Prince et al., 2024). The World Health Organization (WHO) acknowledges the significant effects of exercise-based cardiac rehabilitation on patients, highlighting that such programs can influence their physical, emotional, and social well-being. Cardiac rehabilitation has the potential to improve overall quality of life and reduce the risk of complications that may arise (Go et al., 2013)

While many observational studies on physical activity have been conducted over several decades focusing on long-term cognitive decline in older adults, intervention studies typically last from a few weeks to 2 years (Ngandu et al., 2015; Chaeroni et al., 2024; Gusril et al., 2022; Gusril et al., 2024; Maidawilis et al., 2022; Chaeroni et al., 2023). In recent years, there has been an increase in the literature on the prevalence and popularity of high-intensity interval training (HIIT) among young adults, suggesting it is an attractive exercise modality and health promotion intervention with greater health benefits (Cunningham et al., 2020; Germano et al., 2015; Lu et al., 2022; Welis et al., 2022).

HIIT has the potential to significantly improve the aerobic capacity of individuals with heart failure (HF) and coronary artery disease (Spee et al., 2020; Van De Heyning et al., 2018). However, among the various training methods used for individuals with cardiovascular diseases, moderate-intensity continuous training (MICT) is the most commonly used, with an intensity of 50%–60% peak oxygen uptake (VO_{2peak}) or 50%–75% peak heart rate (HR peak) (Ito et al., 2016). MICT is characterized by lower intensity, longer duration, and higher safety levels (Wu et al., 2023). Several randomized clinical trials (RCTs) have been conducted to explore whether HIIT is a better form of exercise than MICT for fat reduction and improvement in CRF (Berge et al., 2021; Dias et al., 2018; Zhang et al., 2017; Chaeroni et al., 2024). HIIT has shown similar or better effects on VO_2peak (mL.min-1.kg-1) (Morales-Palomo et al., 2020).

HIIT and MICT have different characteristics and effects as two types of exercise, but there is not enough published data to conclude which is more effective (Grace et al., 2017). HIIT training shows greater positive effects on CRF fitness compared to MICT training (Calverley et al., 2020; Saniah et al., 2024). Previous research reported that HIIT using specialized equipment (e.g., running treadmills and cycle ergometers) produced similar or superior training effects compared to MICT, including improvements in cardiorespiratory fitness, body fitness, body composition, and increased insulin sensitivity (Batacan et al., 2017; Poon et al., 2020, 2021; Sawyer et al., 2016). In healthy adults, from young to middle age, HIIT resulted in greater improvements in cardiorespiratory fitness compared to MICT (Bacon et al., 2013; Milanović et al., 2015).

Although several systematic reviews suggest that the effects of HIIT on CRF are better than those of MICT (García-Hermoso et al., 2016; Thivel et al., 2019), they focus on child and adolescent populations (Cao et al., 2019) and young to middle-aged adults (Guo et al., 2023). The age group of 40 and above is still fragmented and often combined with much younger age groups. This study aims to investigate and compare the effectiveness of the two types of exercise, namely HIIT and MICT, in improving VO_2peak ($mL.min^{-1}.kg^{-1}$) in individuals aged 40 and above. Through a Systematic Literature Review (SLR) and meta-analysis approach, this study will evaluate the available data to determine which exercise is more effective in enhancing cardiorespiratory fitness in this population.

The results of this study are expected to make a significant contribution to the science of fitness and health and serve as a guide for practitioners and individuals aged 40 and above in choosing the optimal type of exercise to improve their cardiorespiratory fitness. Through the SLR and meta-analysis approach, this research will filter, evaluate, and synthesize the results of relevant studies to provide scientifically accountable conclusions. Thus, the results of this study are expected to form the basis for more accurate and effective exercise recommendations to improve cardiorespiratory fitness in individuals aged 40 and above, as well as contribute to the enhancement of their quality of life.

Materials and Methods

This study employs the Systematic Literature Review (SLR) method, an approach designed to find, assess, and interpret all available and relevant information in the literature to comprehensively answer research questions (Snyder, 2019; Xiao & Watson, 2019). SLR helps provide a summary of current knowledge or topics related to the research question (Kurniati et al., 2022). It is a valuable source of information where authors need to summarize and evaluate credible scientific literature using a structured method based on predetermined objectives, making it useful for other researchers (Gopalakrishnan & Ganeshkumar, 2013).

The data sources for this study were obtained from searches in the Scopus and WoS databases. The literature review method chosen utilizes the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach (Page et al., 2021). Introduced in 2009 (Moher et al., 2009), the PRISMA method is one of the best methods to help authors conduct systematic reviews and meta-analyses correctly, and it also assists authors in reviewing structures like a roadmap. The PRISMA method is also the most frequently used in literature review articles (Hutton et al., 2016; Moher et al., 2016; Shamseer et al., 2015; Stewart et al., 2015).

Table 1.
The inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Participant age ≥40 years	Age below 40 years
Years 2019-2024	Before the year 2019
Document type: RCT studies from Scopus and WoS	Types of documents: books, book chapters, theses, short reports, conference papers, literature reviews, and those not indexed in Scopus and WoS
Outcome includes cardiorespiratory (VO_2peak) with consistent unit ($mL.Kg^{-1}.min^{-1}$)	No cardiorespiratory outcome (VO_2peak) with consistent unit ($mL.Kg^{-1}.min^{-1}$)

The search strategy used the query (cardiorespiratory AND "HIIT" AND "MICT"), with article selection limited to new publications within the last 5 years (Paul et al., 2021), specifically those published from 2019 to 2024. Eligibility criteria were necessary to select appropriate articles (Ahmadi et al., 2018). Articles were then screened based on inclusion and exclusion criteria as described in Table 1.

The mean differences (MD) and standard deviations from baseline to final results were extracted and entered into a database for analysis of each group. Mean differences (MD) and 95% confidence intervals (95% CIs) were used to compare results. Analyses were performed using RevMan 5.4 and JASP 0.18.3. Given the significant variation in some experimental endpoints, we used a random-effects model for all results. The heterogeneity among the included studies was measured using the Q test and the I^2 inconsistency test. I^2 values of 25%, 50%, and 75% indicated low, moderate, and high heterogeneity, respectively (Higgins et al., 2003). Statistical significance was determined at $p < 0.05$, and effect sizes and 95% confidence intervals were graphically displayed using forest plots. Additionally, Funnel plots, Rank Correlation Test, and Egger's Test were used to evaluate the potential for publication bias. Funnel plots help visualize the distribution of effect sizes among studies, and asymmetry in these plots may indicate publication bias. The Rank Correlation Test is used to detect asymmetry in funnel plots by calculating the correlation between effect sizes and standard errors. Egger's Test provides additional statistical testing for asymmetry in funnel plots, which may indicate publication bias.

Results

The literature search was completed on June 27, 2024, with an initial identification of 492 records in the Scopus database and 141 records in the WoS database (see Figure 1). During the initial screening stage, 409 records from Scopus and WoS were removed because the search query did not appear in the title or abstract.

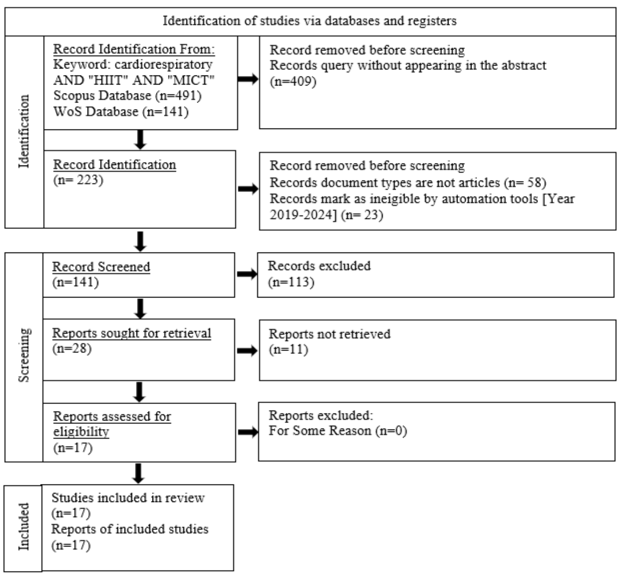

Figure 1. PRISMA flow diagram showing the study identification and selection process.

After further filtering, 223 records met the inclusion criteria. In the advanced screening stage, 58 records were removed because they were not empirical research articles, and 23 records were deemed ineligible by automation tools for the years 2019-2024. Thus, out of the total 632 initial records identified, only 141 records were eligible for further analysis. This screening process is crucial to ensure that only relevant and high-quality studies are analyzed, specifically focusing on the differences between HIIT and MICT training on cardiorespiratory parameter changes for individuals aged 40 and above.

Monitoring of articles was conducted by examining titles, and abstracts, and ensuring they were not review articles, based on the relevance of the articles to the current topic. This process identified 109 articles as irrelevant, placing them in the exclusion category. Consequently, a total of 32 articles met the inclusion criteria and were relevant to the aim of this literature review. These articles were analyzed, and relevant information was organized considering several classifications and criteria aligned with the information needs (Table 1).

Data extraction was structured to categorize, evaluate, and summarize the articles that met the predetermined criteria. Through the process of analyzing the collected data, we could achieve recommendations and results pertinent to the topic. The analysis of articles that met the inclusion criteria revealed key findings, indicating that there were no changes in the number of inclusion criteria. At least 17 articles were found to be suitable based on the analysis.

Study characteristics

Various studies, as summarized in Table 2, have compared high-intensity interval training (HIIT) with moderate-intensity continuous training (MICT) across diverse populations with a wide age range, from approximately 39 to 77 years old, and intervention durations ranging from 2 months to 5 years. These studies indicate that HIIT, typically performed 2-3 times per week with session durations varying from 4 to 50 minutes, involves high intensity (85-100% of VO2peak or HRmax, or 100% of PPO) and utilizes various types of exercise such as treadmill, ergo cycle, fast walking, and running.

Conversely, MICT is usually performed with higher frequency, 3-5 times per week, and session durations between 30 to 60 minutes at moderate intensity (50-70% of VO2peak or HRmax). MICT exercise types include walking, running, cycling, and circuit training. The general findings from these studies indicate that HIIT offers higher intensity but shorter training durations, whereas MICT tends to have longer session durations and more frequent training sessions.

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Table 2.
Characteristics of included studies

Study	M/F or T	Age (Year)	Duration	HIIT					MICT				
				Sample size	Duration/ session	Frequency	Intensity	Type of Exercise	Sample size	Duration /session	Frequency	Intensity	Type of Exercise
(Sokołowski et al., 2021)	54/52	70-77	5 years	87	30-40 min	Twice a week	85-95% HRmax	Treadmill	87	50 min	Twice a week	70% HRmax	Treadmill
(Lapointe et al., 2023)	33/19	69.2 ± 10.7	6 months	19	20-40 min	2 sessions/ month up to 6 months	95% PPO & 40% PPO	Ergocycle	16	20-40 min	Three times a week	50% of PPO	Ergocycle and home exercise
(Isanejad et al., 2023)	30	45.13 ± 6.86	12 weeks	10	Total 33 min	3 times/ week	Primarily 90% VO_2peak and 60% VO_2peak	Walking or running	10	Total 41 min	3 times/ week	Primarily 60% VO_2peak and 50%-60% VO_2peak	Walking or running
(Pani et al., 2021)	53/52	70-77	5 years	33	Total ±38 min	2 times/ week	85-95% HRmax	Fast walking or running	24	Total 50 min	2 times/ week	70% HRmax	Fast walking, light jogging, or cycling
(Ramos et al., 2020)	36	±54	16 weeks	13 (4HIIT), 16 (1HIIT)	38 min/ session (4HIIT), 17 min/ session (1HIIT)	3 times/ week (4HIIT), 3 times/week (1HIIT)	85-95% HRpeak	Running or cycling	10	30 min	5 times/ week	60-70% HR peak	Walking, running, cycling
(Marzolini et al., 2023)	47	62 ± 11	24 weeks	24	20-22 min/ session + 5 min warm-up and cool-down	3 days/ week + 2 days/ week MICT	60-80% VO_2peak	Treadmill + overhead system	23	60 min/ session	5 days/ week	60-80% VO_2peak	Treadmill
(Pani et al., 2022)	105	70-77	5 years	33	4x4 min + 3 min active rest/interval	2 times/week	90% HRmax	Fast walking, cycling, running, and aerobics	24	50 min	2 times/ week	70% HRmax	Fast walking, cycling, running, and aerobics
(Mendelson et al., 2022)	41/19	54 ± 11	2 months	20 baseline	45 min	3 times/ week for 2 months	100% PPO	Cycling	20 baseline	45 min	3 times/ week for 2 months	50% PPO	Cycling
(Ramos et al., 2021)	99	55-58	16 weeks	34 (4HIIT), 31 (1HIIT)	38 min/ session (1HIIT), 17 min/ session (1HIIT)	3 sessions/ week	85-95% HRpeak	Bicycle ergometer or treadmill	34	30 min/ session	5 sessions/ week	60-70% HRpeak	Bicycle ergometer or treadmill
(Arild et al., 2022)	777/ 790	70-76	5 years	400	38 min	2.8-3.3 sessions/ week	85-95% HRmax	Cycling, swimming, fitness center	387	50 min	2.8-3.3 sessions/ week	70% HRmax	Walking, cycling, fitness center
(Ballesta-García et al., 2020)	0/54	67.8 ± 6.2	18 weeks	18	1 hour/ session	2 days/ week	12-18 Borg scale points	Circuit training	18	1 hour/ session	2 days/ week	6-14 Borg scale points	Circuit training
(Marillier et al., 2022)	14/6	48 ± 8	8 weeks	10	16 min (first week) - 22 min (last week)	3 sessions/ week for 8 weeks	100% WRpeak	Cycling on an ergometer bike	10	32 min (first week) - 44 min (last week)	3 sessions/ week	50% WRpeak	Cycling on an ergometer bike
(Rohmansyah et al., 2023)	0/24	50-60	16 weeks	12	Total 38 min	3 times/ week for 16 weeks	90-95% HRmax	Ergometer bike	12	Total 47 min	3 times/ week for 16 weeks	70-75% HRmax	Ergometer bike
(Gripp et al., 2021)	22	39 ± 5	8 weeks	11	25-30 min	3 times/ week	85-100% Vshuttle	20-meter shuttle run protocol	11	40-50 min	3 times/ week	60-75% Vshuttle	20-meter shuttle run protocol
(Besnier et al., 2019)	31	59 ± 13	±3.5 weeks	16	Total 16 min	5 days/ week	100% PPO	Cycling	15	30 min/ session	5 days/ week	60% PPO	Cycling
(Sabag et al., 2020)	19/17	54.6 ± 1.4	12 weeks	12	4 min/ session	3 days/ week	90% VO_2peak	Cycling	12	45 min/ session	3 days/ week	60% VO_2peak	Cycling
(Gentil et al., 2023)	22/22	>40	8 weeks	15 each SHIIT and LHIIT	30 sec/ interval for 20 intervals (SHIIT), 2 min/inter	2 times/ week	100% vVO_2max	Walking/running long intervals on treadmill	14	14 min	2 times/ week	70% vVO_2max	Continuous walking/running on treadmill

Table 2.
Characteristics of included studies

Study	M/F or T	Age (Year)	Duration	HIIT Sample size	HIIT Duration/session	HIIT Frequency	HIIT Intensity	HIIT Type of Exercise	MICT Sample size	MICT Duration/session	MICT Frequency	MICT Intensity	MICT Type of Exercise
					val for 5 intervals (LHIIT)								

M/F, Male/Female; T, Total; HIIT, High-Intensity Interval Training; MICT, Moderate-Intensity Continuous Training; HRmax, Maximum Heart Rate; PPO, Peak Power Output; VO2peak, Peak Oxygen Uptake; HRpeak, Peak Heart Rate; WRpeak, Peak Work Rate; Vshuttle, Shuttle Velocity; vVO2max, Velocity at VO2max; Borg scale, Borg Rating of Perceived Exertion Scale.

Longer studies, such as those by Sokołowski et al. (2021) and Pani et al. (2021, 2022), highlight the long-term commitment to exercise programs, while shorter studies, like those by Lapointe et al. (2023) and Marillier et al. (2022), demonstrate rapid adaptations and changes in health parameters. With variations in sample sizes, study designs, and methods used to measure exercise intensity, conclusions drawn must consider consistent comparative standards. This data shows that both HIIT and MICT have specific advantages that can be tailored to individual needs and can provide significant health benefits, forming the basis for publication in reputable international journals with a focus on methodology, results, and practical applications of these exercise interventions.

Table 3.
Meta-Analysis for Fixed and Random Effects

category	Fixed and Random Effects: Residual Q^2	df	p	Coefficients (intercept): Estimate	Std. Error	z	p	95% CI Lower	95% CI Upper	Residual Heterogeneity Estimates: I^2 (%)	τ
HIIT vs control/baseline	43.71	33	0.10	0.369	0.065	5.59	< 0.001	0.23	0.48	25	0.039
MICT vs control/baseline	24.26	27	0.62	0.118	0.061	1.84	0.07	-0.01	0.238	0	0.000
(HIIT vs MICT)[a]	12.14	15	0.67	-0.084	0.078	-1,04	0,282	-0.237	0.069	0	0.000
(HIIT vs MICT)[b]	39.96	24	0.02	0.148	0.093	1.595	0.111	-0.034	0.329	40	0.087

a) baseline condition; b) post-intervention condition

data presented in Table 3 show several comparisons between HIIT (High-Intensity Interval Training) and MICT (Moderate-Intensity Continuous Training) against control/baseline conditions and between HIIT and MICT under two different conditions (a and b). The comparison of HIIT with control/baseline shows significant results with strong effects, as indicated by statistically significant estimate values (p-value < 0.001). In contrast, the comparison of MICT with control/baseline does not show significant results (p-value = 0.07), indicating that MICT does not have a meaningful effect compared to the control condition. In the comparison between HIIT and MICT, both in condition a and condition b, no statistically significant differences were found. However, in condition b, there is an indication of a moderate effect with a moderate level of heterogeneity (I^2 = 40%, τ = 0.087), though it remains non-significant (p-value = 0.111).

This data provides an overview of the variation in effectiveness between the two different exercise methods, HIIT and MICT. These findings are important for the development of exercise and health programs and can serve as a basis for further research. Additionally, this data is worthy of consideration for publication in reputable international journals, given the methodology used and the relevance of the findings to the field of health and fitness.

HIIT vs control and baseline

The forest plot presented in Figure 2 compares the effects of High-Intensity Interval Training (HIIT) with the control group (including baseline), using data from multiple studies analyzed to provide an aggregate view of the Standard Mean Difference (SMD) between the HIIT and control groups. The heterogeneity among the studies is low to moderate, with a τ^2 value of 0.03 and an I^2 value of 25%, indicating minimal variation between studies. A significant overall effect is indicated by a z-value of 5.59 (p-value < 0.00001) and a 95% CI for the SMD of 0.35 [0.23, 0.48], suggesting that HIIT is significantly more effective in improving VO_2peak compared to the control.

	HIIT			Control and baseline				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Arild et al. 2022a	30.4	6.9	33	30.3	6.5	48	4.8%	0.01 [-0.43, 0.46]
Arild et al. 2022b	30.5	6.1	33	30.1	7.6	48	4.8%	0.06 [-0.39, 0.50]
Ballesta-García et al. 2020a	26.1	5.63	18	26.8	5.17	18	2.8%	-0.13 [-0.78, 0.53]
Ballesta-García et al. 2020b	29.5	5.75	17	26	4.86	12	2.2%	0.63 [-0.13, 1.39]
Ballesta-García et al. 2020c	29.5	5.75	17	26.1	5.63	18	2.6%	0.58 [-0.09, 1.26]
Besnier et al. 2019	20.2	5.8	16	17.2	4.5	16	2.5%	0.56 [-0.15, 1.27]
Gentil et al. 2023a	25.6	6.3	15	22.4	5.6	15	2.3%	0.52 [-0.21, 1.25]
Gentil et al. 2023b	23.1	3.7	15	19.7	3.1	15	2.2%	0.97 [0.21, 1.73]
Isanejad et al. 2023a	20.65	3.87	10	17.04	2.99	10	1.5%	1.00 [0.06, 1.94]
Isanejad et al. 2023b	20.65	3.87	10	16.72	1.96	10	1.4%	1.23 [0.25, 2.20]
Lapointe et al. 2023a	19.5	5.3	19	19.3	7.3	17	2.8%	0.03 [-0.62, 0.69]
Lapointe et al. 2023b	20.6	5.6	19	18	7.6	17	2.7%	0.38 [-0.28, 1.05]
Lapointe et al. 2023c	21.9	6.1	19	18.7	8	17	2.7%	0.44 [-0.22, 1.11]
Lapointe et al. 2023d	20.6	5.6	19	18.9	5.5	19	2.9%	0.30 [-0.34, 0.94]
Lapointe et al. 2023e	21.9	6.1	19	18.9	5.5	19	2.8%	0.51 [-0.14, 1.15]
Marillier et al. 2022	26.7	5.8	10	23.2	5.4	10	1.6%	0.60 [-0.30, 1.50]
Marzolini et al. 2023	24	8.1	24	18.3	5	24	3.2%	0.83 [0.24, 1.42]
Mendelson et al. 2022a	24.9	5.4	20	23.3	3.1	20	3.0%	0.36 [-0.27, 0.98]
Mendelson et al. 2022b	26.4	4	20	23.3	3.1	20	2.8%	0.85 [0.20, 1.50]
Mendelson et al. 2022c	24.9	5.1	20	23.8	5.6	20	3.0%	0.20 [-0.42, 0.82]
Mendelson et al. 2022d	26.5	5.5	20	23.8	5.6	20	3.0%	0.48 [-0.15, 1.11]
Pani et al. 2021	30.4	6.9	33	30.3	6.6	48	4.8%	0.01 [-0.43, 0.46]
Pani et al. 2022a	28.71	4.92	33	29.31	6.84	48	4.8%	-0.10 [-0.54, 0.35]
Pani et al. 2022b	29.81	5.8	29	28.48	6.88	35	4.2%	0.20 [-0.29, 0.70]
Ramos et al. 2020a	5.7	4.7	13	2.3	0.2	13	1.9%	0.99 [0.17, 1.81]
Ramos et al. 2020b	2.9	2.2	16	2.3	0.2	16	2.5%	0.37 [-0.33, 1.07]
Ramos et al. 2021a	27.8	6.2	14	24.4	4.1	14	2.2%	0.63 [-0.13, 1.39]
Ramos et al. 2021b	27.9	6.9	14	25.7	6.1	14	2.3%	0.33 [-0.42, 1.07]
Ramos et al. 2021c	28.1	6.8	25	28.1	6.8	25	3.6%	0.00 [-0.55, 0.55]
Ramos et al. 2021d	28.8	6.7	26	26.5	6.3	26	3.6%	0.35 [-0.20, 0.90]
Rohmansyah et al. 2023	27.5	6.8	12	19.7	11.1	12	1.9%	0.82 [-0.02, 1.66]
Sabag et al. 2020	22	0.7	12	20.9	0.7	12	1.6%	1.52 [0.59, 2.44]
Sokołowski et al. 2021a	30.1	6.8	34	30.3	6.6	48	4.8%	-0.03 [-0.47, 0.41]
Sokołowski et al. 2021b	30.5	6.1	29	30.1	7.6	37	4.3%	0.06 [-0.43, 0.54]
Total (95% CI)			**683**			**761**	**100.0%**	**0.35 [0.23, 0.48]**

Heterogeneity: Tau² = 0.03; Chi² = 43.71, df = 33 (P = 0.10); I² = 25%
Test for overall effect: Z = 5.59 (P < 0.00001)

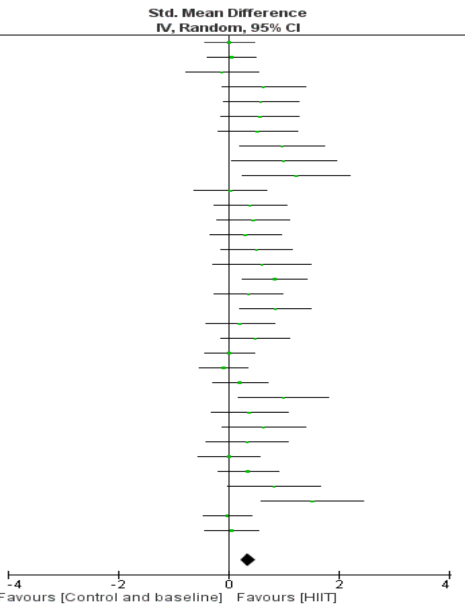

Figure 2. HIIT vs Control and Baseline

Baseline characteristics (Arild et al., 2022[a]); follow-up characteristics after five years (Arild et al., 2022[b]); baseline characteristics (Ballesta-García et al., 2020[a]); post-training and control conditions (Ballesta-García et al., 2020[b]); post-training and pre-training conditions (Ballesta-García et al., 2020[c]); L-HIIT (Gentil et al., 2023[a]); S-HIIT (Gentil et al., 2023[a]); post-training and pre-training conditions (Isanejad et al., 2023[a]); post-training and control conditions (Isanejad et al., 2023[b]); baseline characteristics (Lapointe et al., 2023[a]); intervention T12 vs control conditions (Lapointe et al., 2023[b]); intervention T6 vs control conditions (Lapointe et al., 2023[c]); intervention T12 vs T0 conditions (Lapointe et al., 2023[d]); intervention T6 vs T0 conditions (Lapointe et al., 2023[d]); HIIT-RM T6 vs T0 conditions (Mendelson et al., 2022[a]); HIIT-RM T2 vs T0 conditions (Mendelson et al., 2022[b]); HIIT T6 vs T0 conditions (Mendelson et al., 2022[c]); HIIT T2 vs T0 conditions (Mendelson et al., 2022[d]); baseline characteristics (Pani et al., 2022[a]); follow-up characteristics after five years (Pani et al., 2022[b]); treatment 4HIIT conditions (Ramos et al., 2020[a]); treatment 1HIIT conditions (Ramos et al., 2020[b]); non-T2D participants treatment 4HIIT conditions (Ramos et al., 2021[a]); non-T2D participants treatment 1HIIT conditions (Ramos et al., 2021[b]); all participants—changes treatment 4HIIT conditions (Ramos et al., 2021[c]); all participants—changes treatment 1HIIT conditions (Ramos et al., 2021[d]).

Several studies show statistically significant results for the SMD of HIIT, with 95% confidence intervals (CI) not crossing the zero line (Lapoite et al. 2023[d]; Lapoite et al. 2023[e]; Mendolson et al. 2022[a]; Pani et al. 2021; and Pani et al. 2022[a]). On the other hand, other studies show statistically non-significant results, with 95% CIs crossing the zero line (Arild et al. 2022[a]; Ballesta-Garcia et al. 2020[a]; Ballesta-Garcia et al. 2020[c]; Isanejad et al. 2023[a]; Mendolson et al. 2022[c]; Ramos et al. 2020[a]; Ramos et al. 2020[b]; and Ramos et al. 2020[c]). Overall, this forest plot indicates that HIIT is more effective in improving VO_2peak compared to the control. However, the presence of several studies with non-significant or negative results suggests variability in outcomes among the studies. Therefore, although the general trend supports HIIT as an effective intervention, factors contributing to the variability of results should be considered.

MICT vs control and baseline

Based on the data presented with the baseline sample characteristics, a comparative analysis between the HIIT and MICT methods on cardiorespiratory parameters (VO_2peak) was conducted using a Forest Plot (see Figure 4). The forest plot presented in Figure 3 shows the results of a meta-analysis comparing the effects of Moderate-Intensity Continuous Training (MICT) with the control or baseline group across various studies. This analysis includes multiple studies, each presenting the mean, standard deviation, and the number of participants in both the MICT and control groups. The average standard deviations and 95% confidence intervals (CI) of each study are used to measure the differences between the MICT and control groups.

Based on the results of the meta-analysis, there is no significant heterogeneity among the studies included in this analysis, with a τ^2 value of 0.00, Q^2 value of 24.26, df of 27 (p-value = 0.62), and I^2 of 0%. This indicates that the variation among these studies is quite consistent. The overall results show that the effect of MICT compared to the control or baseline is not statistically significant at the 0.05 significance level, with a z-value of 1.84 (p-value = 0.07). The overall effect shown by the diamond plot is 0.11 [-0.01, 0.23], meaning the

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standardized mean difference is 0.11 with a 95% confidence interval from -0.01 to 0.23, indicating a very small effect that tends to be insignificant.

Furthermore, the results of each study were analyzed to assess their statistical significance. The significant studies are those whose confidence intervals did not cross zero (Ballesta-Garcia et al. 2020[a]; Gentil et al. 2023 with 0.74 (0.14, 1.34); Lapointe et al. 2023[a]; Lapointe et al. 2023[b]; Lapointe et al. 2023[c]; Marzolini et al. 2023; Ramos et al. 2020). These studies indicate a significant positive effect of MICT.

On the other hand, the majority of the studies show non-significant results, where their confidence intervals crossed zero (Arild et al. 2022[a], Arild et al. 2022[b], Ballesta-Garcia et al. 2020[b], Ballesta-Garcia et al. 2021[c], Besnier et al. 2019, Isanejad et al. 2023[a], Isanejad et al. 2023[b], Lapointe et al. 2023[e], Marillier et al. 2022, Mendelson et al. 2022[a], Mendelson et al. 2022[b], Pani et al. 2021, Pani et al. 2022[a], Pani et al. 2022[b], Ramos et al. 2021[a], Ramos et al. 2021[b], Rohmansyah et al. 2023, Sabag et al. 2020, Sokokowski et al. 2021[a], and Sokokowski et al. 2021[b]). In conclusion, while some studies show significant results and positive effects of MICT, the majority of the studies show non-significant results. The overall effect from this meta-analysis indicates a very small and statistically non-significant standardized mean difference.

	MICT			Control and baseline				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Arild et al. 2022a	30	5.7	24	30.3	6.5	48	6.0%	-0.05 [-0.54, 0.44]
Arild et al. 2022b	28.6	5.3	24	30.1	7.6	48	6.0%	-0.21 [-0.71, 0.28]
Ballesta-García et al. 2020a	25	5.57	18	26.8	5.17	18	3.3%	-0.33 [-0.99, 0.33]
Ballesta-García et al. 2020b	26.9	4.72	17	26	4.86	12	2.6%	0.18 [-0.56, 0.92]
Ballesta-García et al. 2021c	26.9	4.72	12	25	5.57	18	2.7%	0.35 [-0.38, 1.09]
Besnier et al. 2019	15.7	5.1	15	15	4.6	15	2.8%	0.14 [-0.58, 0.86]
Gentil et al. 2023	23.4	10.7	14	22.6	8.9	14	2.6%	0.08 [-0.66, 0.82]
Isanejad et al. 2023a	17.37	3.95	10	16.62	3	10	1.9%	0.20 [-0.67, 1.08]
Isanejad et al. 2023b	17.37	3.95	10	16.72	1.96	10	1.9%	0.20 [-0.68, 1.08]
Lapointe et al. 2023a	20.4	4.7	16	19.3	7.3	17	3.1%	0.17 [-0.51, 0.86]
Lapointe et al. 2023b	19.3	7.3	16	18	7.6	17	3.1%	0.17 [-0.51, 0.85]
Lapointe et al. 2023c	24.1	4.9	16	18.7	8	17	2.9%	0.79 [0.08, 1.50]
Lapointe et al. 2023d	22.5	5.3	16	21.1	4.5	16	3.0%	0.28 [-0.42, 0.97]
Lapointe et al. 2023e	24.1	4.9	16	21.1	4.5	16	2.9%	0.62 [-0.09, 1.33]
Marillier et al. 2022	24.7	7.9	10	22.6	8.2	10	1.9%	0.25 [-0.63, 1.13]
Marzolini et al. 2023	19.8	6.9	23	17.4	4.2	23	4.2%	0.41 [-0.17, 1.00]
Mendelson et al. 2022a	24	6	20	23.2	6.1	20	3.8%	0.13 [-0.49, 0.75]
Mendelson et al. 2022b	24.4	5.8	20	23.2	6.1	20	3.8%	0.20 [-0.42, 0.82]
Pani et al. 2021	30	5.7	24	30.3	6.6	48	6.0%	-0.05 [-0.54, 0.44]
Pani et al. 2022a	27.21	5.89	21	29.31	6.84	48	5.5%	-0.32 [-0.83, 0.20]
Pani et al. 2022b	29.07	6.82	21	28.48	6.88	35	5.0%	0.08 [-0.46, 0.63]
Ramos et al. 2020	2.7	1.9	10	2.3	0.2	10	1.9%	0.28 [-0.60, 1.17]
Ramos et al. 2021a	30.5	8.3	17	29	7.8	17	3.2%	0.18 [-0.49, 0.86]
Ramos et al. 2021b	28.9	8	26	27.6	7.9	26	4.9%	0.16 [-0.38, 0.71]
Rohmansyah et al. 2023	24.4	7.6	12	21.6	11.4	12	2.2%	0.28 [-0.53, 1.08]
Sabag et al. 2020	23.9	1.5	12	21.6	1.7	12	1.8%	1.39 [0.48, 2.29]
Sokołowski et al. 2021a	29.8	5.8	24	30.3	6.6	48	6.0%	-0.08 [-0.57, 0.41]
Sokołowski et al. 2021b	28.6	5.3	21	30.1	7.6	37	5.0%	-0.22 [-0.75, 0.32]
Total (95% CI)			**485**			**642**	**100.0%**	**0.11 [-0.01, 0.23]**

Heterogeneity: Tau² = 0.00; Chi² = 24.26, df = 27 (P = 0.62); I² = 0%
Test for overall effect: Z = 1.84 (P = 0.07)

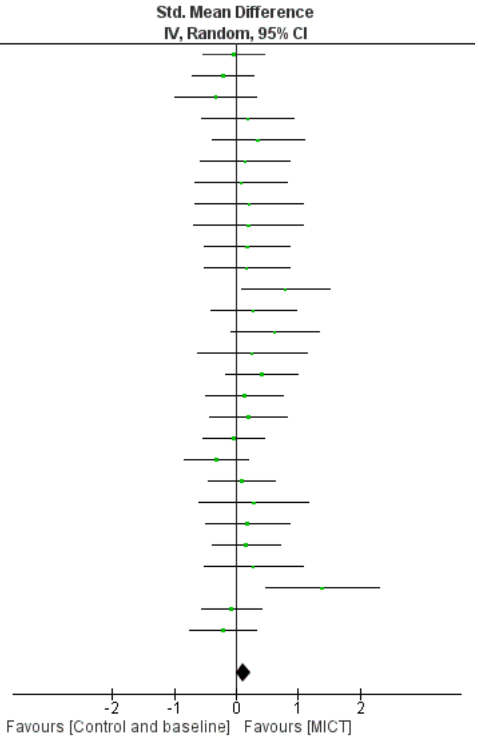

Figure 3. MICT vs Control and Baseline

In the condition Baseline characteristics (Arild et al., 2022[a]); Karakteristik tindak lanjut setelah lima tahun (Arild et al., 2022[b]); in the condition Baseline characteristics (Ballesta-García et al., 2020[a]); after intervention Fraksionalisasi condition post training and control (Ballesta-García et al., 2020[b]); after intervention Fraksionalisasi condition post training and pre training (Ballesta-García et al., 2020[c]); condition post training and pre training (Isanejad et al., 2023[a]); condition post training and control (Isanejad et al., 2023[b]); Baseline characteristics (Lapointe et al., 2023[a]); intervention condition T12 vs control (Lapointe et al., 2023[b]); intervention condition T6 vs control (Lapointe et al., 2023[c]); intervention condition T12 vs T0 (Lapointe et al., 2023[d]); intervention condition T6 vs T0 (Lapointe et al., 2023[e]); condition T6 vs T0 (Mendelson et al., 2022[a]); condition T2 vs T0 (Mendelson et al., 2022[b]); Baseline characteristics (Pani et al., 2022[a]); Karakteristik tindak lanjut setelah lima tahun (Pani et al., 2022[b]); condition Non-T2D participants (Ramos et al., 2021[a]); condition All participants—changes (Ramos et al., 2021[b]);

HIIT vs MICT (baseline characteristics)

The analysis results show (see figure 5) a total Standard Mean Difference (SMD) of -0.08 with a 95% confidence interval (CI) from -0.23 to 0.07, and a z-value of 1.04 (p-value 0.30). The p-value greater than 0.05 indicates that there is no significant difference between HIIT and MICT in improving VO_2peak. Additionally, the heterogeneity analysis using a Q^2 value of 12.14 (p-value 0.67) with df = 15 shows that there is no significant heterogeneity among the studies (I^2 = 0%). This indicates that the variation among studies can be considered homogeneous, allowing the results to be generalized.

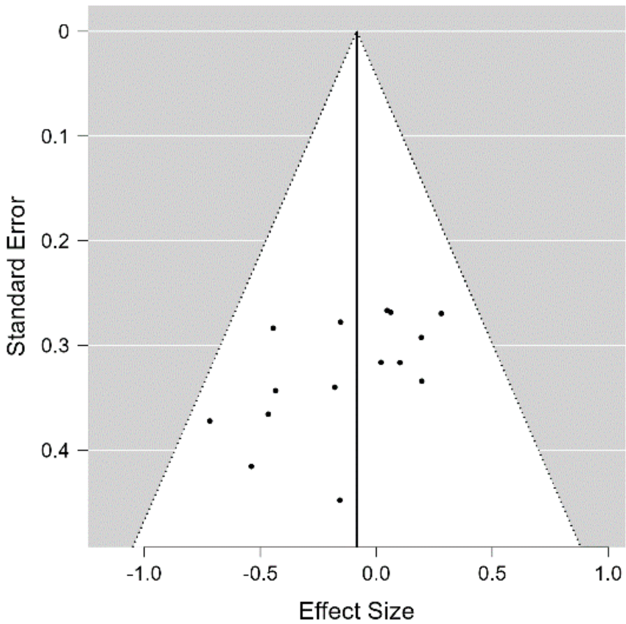

Figure 4. Funnel Plot HIIT vs. MICT (Baseline)

The Funnel Plot analysis in Figure 4, used to evaluate publication bias, does not show significant asymmetry, indicating a low likelihood of publication bias. However, in Table 4, the results of the Rank Correlation Test with Kendall's τ of -0.378 (p-value 0.042) and Egger's Test with a z-value of -1.971 (p-value 0.049) suggest a slight indication of publication bias. Nevertheless, the asymmetry indicated is not significant enough to influence the overall conclusions.

Therefore, the results for HIIT vs. MICT baseline sample characteristics show no significant difference in improving VO_2peak, which is expected as these are baseline characteristics. The low heterogeneity strengthens the consistency of these results across the various studies analyzed. Although there is an indication of publication bias based on Egger's Test, the overall analysis shows that this bias is not strong enough to affect the final conclusion.

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Study or Subgroup	HIIT Mean	HIIT SD	HIIT Total	MICT Mean	MICT SD	MICT Total	Weight	Std. Mean Difference IV, Random, 95% CI
Arild et al. 2022	30.4	6.9	33	30	5.7	24	8.5%	0.06 [-0.46, 0.59]
Ballesta-García et al. 2020	26.1	5.63	18	25	5.57	18	5.5%	0.19 [-0.46, 0.85]
Isanejad et al. 2023	2.32	0.49	10	2.4	0.53	10	3.0%	-0.15 [-1.03, 0.73]
Lapointe et al. 2023a	18.9	5.5	19	21.1	4.5	16	5.2%	-0.42 [-1.10, 0.25]
Lapointe et al. 2023b	19.5	5.3	19	20.4	4.7	16	5.3%	-0.17 [-0.84, 0.49]
Marzolini et al. 2023	18.3	5	24	17.4	4.2	23	7.1%	0.19 [-0.38, 0.76]
Mendelson et al. 2022a	23.3	3.1	20	23.2	6.1	20	6.1%	0.02 [-0.60, 0.64]
Mendelson et al. 2022b	23.8	5.6	20	23.2	6.1	20	6.1%	0.10 [-0.52, 0.72]
Pani et al. 2021	30.4	6.9	33	30	5.7	24	8.5%	0.06 [-0.46, 0.59]
Pani et al. 2022	28.71	4.92	33	27.21	5.89	24	8.4%	0.28 [-0.25, 0.81]
Ramos et al. 2021a	24.6	5.3	25	27.6	7.9	26	7.6%	-0.44 [-0.99, 0.12]
Ramos et al. 2021b	26.5	6.3	26	27.6	7.9	26	7.9%	-0.15 [-0.70, 0.39]
Ramos et al. 2021c	24.4	4.1	14	29	7.8	17	4.4%	-0.70 [-1.43, 0.03]
Ramos et al. 2021d	25.7	6.1	14	29	7.8	17	4.5%	-0.45 [-1.17, 0.26]
Sabag et al. 2020	20.9	0.7	12	21.6	1.7	12	3.5%	-0.52 [-1.34, 0.30]
Sokołowski et al. 2021	30.1	6.8	34	29.8	5.8	24	8.6%	0.05 [-0.48, 0.57]
Total (95% CI)			**354**			**317**	**100.0%**	**-0.08 [-0.23, 0.07]**

Heterogeneity: Tau² = 0.00; Chi² = 12.14, df = 15 (P = 0.67); I² = 0%
Test for overall effect: Z = 1.04 (P = 0.30)

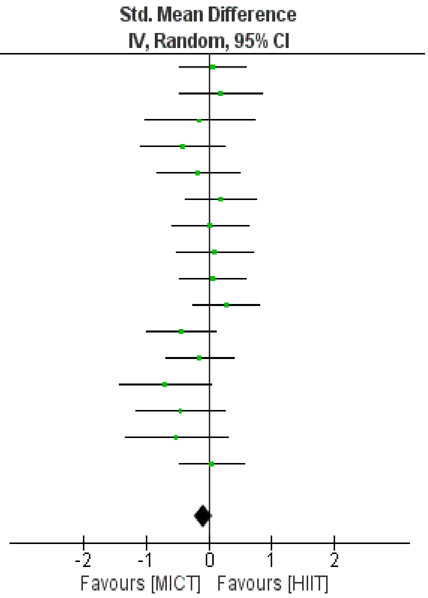

Figure 5. Forest Plot HIIT vs. MICT (Baseline)

Baseline characteristics (Lapointe et al., 2023[a]); intervention condition T0 (Lapointe et al., 2023[a]); condition HIIT-RM (T0) vs. MICT (T0) (Mendelson et al., 2022[a]); condition HIIT (T0) vs. MICT (T0) (Mendelson et al., 2022[b]); condition All participants—changes treatment MICT vs. 4HIIT (Ramos et al., 2021[a]); condition All participants—changes treatment MICT vs. 1HIIT (Ramos et al., 2021[b]); condition Non-T2D participants treatment MICT vs. 4HIIT (Ramos et al., 2021[c]); condition Non-T2D participants treatment MICT vs. 1HIIT (Ramos et al., 2021[d]).

HIIT vs. MICT post-intervention

The forest plot presented in Figure 7 illustrates the results of 27 individual studies comparing the effects of High-Intensity Interval Training (HIIT) and Moderate-Intensity Continuous Training (MICT) on the cardiorespiratory parameter, VO_2peak. Each study lists the mean values (Mean), standard deviations (SD), sample sizes (Total), and weights (Weight) for each group. The column "Std. Mean Difference" shows the standardized mean difference between HIIT and MICT with 95% confidence intervals (95% CI).

Overall, the total sample size included in the analysis is 445 for the HIIT group and 407 for the MICT group. The overall effect size is 0.15 with a confidence interval ranging from -0.03 to 0.32. The heterogeneity index indicates a τ^2 value of 0.08, a Q^2 value of 39.96 with degrees of freedom (df) of 24 (p-value 0.02), and an I^2 value of 40%, indicating a moderate level of heterogeneity among the studies.

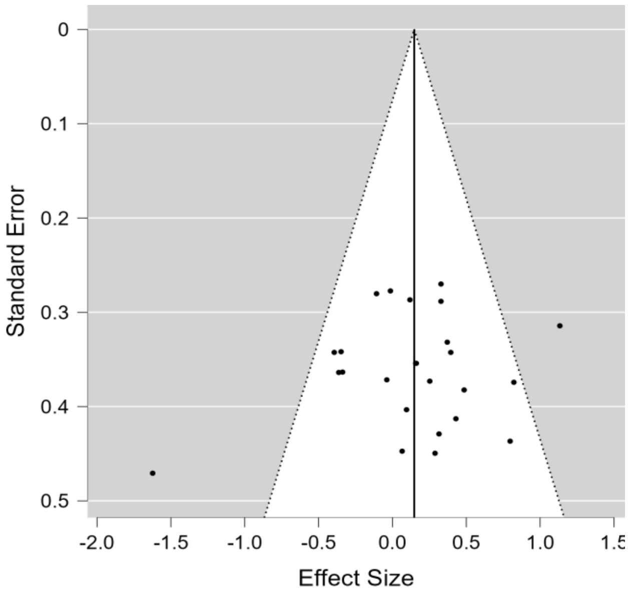

Figure 6. Funnel Plot of HIIT vs MICT (Post-Intervention)

These results indicate that HIIT tends to have a small advantage over MICT in improving VO_2peak; however, this difference is not statistically significant (z-value 1.59, p-value 0.11) at the 0.05 significance level because the confidence interval includes zero. Specifically, out of the 25 studies analyzed, only 2 studies showed significant results. The study by Marzolini et al. (2023) showed a statistically significant standardized mean difference of 1.11 [0.50, 1.73], while the study by Ramos et al. (2020c) showed a statistically significant standardized mean difference of -1.57 [-2.50, -0.63]. In contrast, 23 other studies (Arild et al. 2022; Ballesta-Garcia et al. 2020; Besnier et al. 2019; Gentil et al. 2023[a] and 2023[b]; Gripp et al. 2021; Isanejad et al. 2023; Lapointe et al. 2023[a] and 2023[b]; Marillier et al. 2022; Mendelson et al. 2022[a], 2022[b], and 2022[c]; Pani et al. 2022; Ramos et al.

2020[a], 2020[b], 2021[a], 2021[b], 2021[c], and 2021[d]; Rohmansyah et al. 2023; Sabag et al. 2020; and Sokokowski et al. 2021) mostly showed positive differences favoring HIIT, although some studies favored MICT or showed no significant difference.

The funnel plot displayed in Figure 7 is used to detect publication bias by showing the distribution of effect sizes from each study against their standard errors. This plot shows slight asymmetry, which could indicate the possibility of publication bias; however, these results are not statistically significant. In Table 4, the Rank Correlation Test produced a Kendall's τ value of 0.047 with a p-value of 0.764, indicating no strong correlation between effect size and standard error. The results of Egger's Test were also not significant (z-value -0.755, p-value 0.450), indicating no strong evidence of publication bias.

These findings imply that both HIIT and MICT are effective in improving cardiorespiratory capacity (VO2peak), with a tendency for HIIT to be slightly more advantageous. However, the non-significant difference suggests that the choice of training method can be tailored to individual preferences and health conditions without significant concern about the effectiveness of either method.

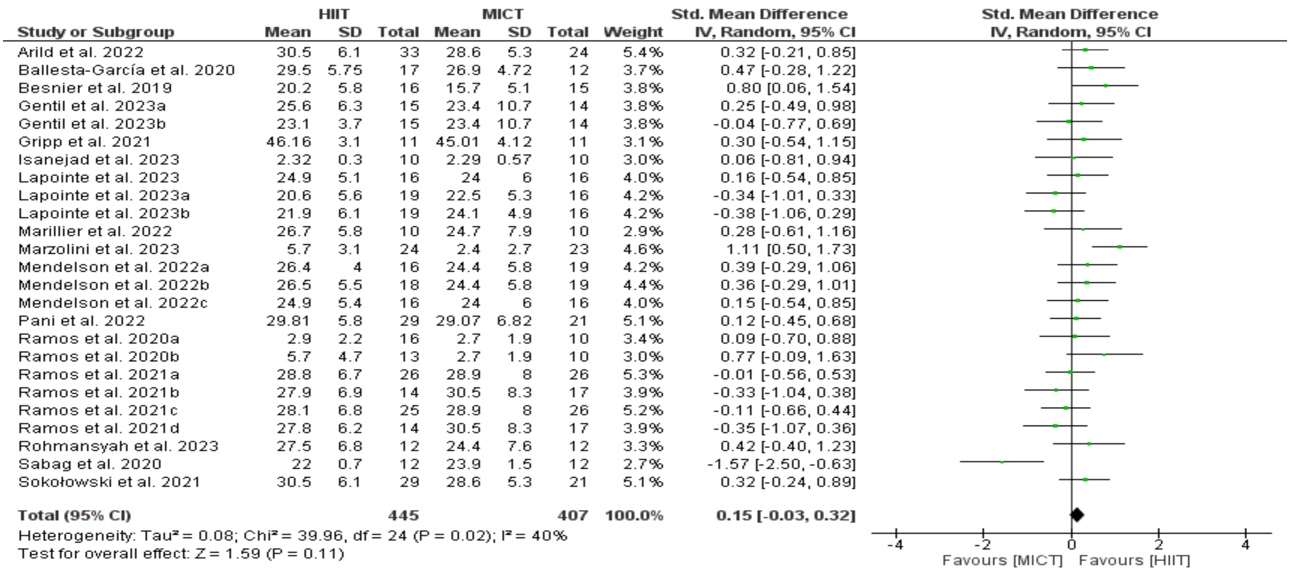

Figure 7. Forest Plot of HIIT vs MICT (Post-Intervention)

Table 4.
Rank Correlation Test for Funnel Plot Asymmetry and Regression Test for Funnel Plot Asymmetry

Category	Kendall's		Egger's test	
	τ	p	z	p
(HIIT vs MICT)[a]	-0.378	0.042	-1.971	0.049
(HIIT vs MICT)[b]	0.047	0.764	-0.755	0.450

L-HIIT (Gentil et al., 2023[a]); S-HIIT (Gentil et al., 2023[a]); intervention condition T12 (Lapointe et al., 2023[a]); intervention condition T6 (Lapointe et al., 2023[b]); condition T2 HIIT-RM vs MICT (Mendelson et al., 2022[a]); condition T2 HIIT vs MICT (Mendelson et al., 2022[b]); condition T6 HIIT-RM vs MICT (Mendelson et al., 2022[c]); treatment condition MICT vs 1HIIT (Ramos et al., 2020[a]); treatment condition MICT vs 4HIIT (Ramos et al., 2020[b]); condition All participants—changes treatment MICT vs 1HIIT (Ramos et al., 2021[a]); condition Non-T2D participants treatment MICT vs 1HIIT (Ramos et al., 2021[b]); condition All participants—changes treatment MICT vs 4HIIT (Ramos et al., 2021[c]); condition Non-T2D participants treatment MICT vs 4HIIT (Ramos et al., 2021[d]).

Discussion

The objective of this research is to investigate and compare the effectiveness of two types of exercise, High-Intensity Interval Training (HIIT) and Moderate-Intensity Continuous Training (MICT), in improving VO2peak in individuals aged 40 and above. Based on a systematic literature review and meta-analysis, we evaluated the available data to determine which exercise is more effective in enhancing cardiorespiratory fitness in this population. The analysis results indicate that HIIT has a greater advantage in improving VO2peak compared to MICT in individuals aged 40 and above. However, the difference between the two exercise methods is not statistically significant, both at baseline and after the intervention. These findings suggest that both exercise methods can be effective in improving cardiorespiratory capacity, with a tendency for HIIT to be slightly more advantageous. The low heterogeneity in this analysis reinforces the consistency of the results, indicating that the variation among studies can be considered homogeneous, and the results can be generalized. Although there are indications of publication bias, the overall analysis shows that this bias is not strong enough to affect the final conclusion.

The difference in effectiveness between HIIT and MICT on VO2peak can be observed from the obtained results, where HIIT shows a significant increase in VO2peak compared to the control group. A z-value of 5.59 (p-value < 0.00001) and a 95% confidence interval that does not include zero indicate that HIIT is consistently more effective in improving cardiorespiratory fitness compared to the control. Conversely, MICT does not show a significant difference compared to the control (z-value 1.84, p-value 0.07), indicating that MICT does not have a meaningful effect in this context.

These results align with several previous studies stating that the high intensity offered by HIIT is more effective in stimulating increases in aerobic capacity compared to the moderate intensity of MICT (Bacon et al., 2013; Milanović et al., 2015). The study by Grace et al. (2017) showed that HIIT has a greater effect on cardiorespiratory fitness compared to MICT in older populations. Another study by Calverley et al. (2020) confirmed these findings by demonstrating that HIIT significantly increases VO2peak more than MICT. Additionally, the research by Wu et al. (2023) found that while MICT is safer and has a longer duration, its effect on increasing VO2peak is not as strong as HIIT. Reviews by García-Hermoso et al. (2016) and Thivel et al. (2019) also support the superiority of HIIT in improving aerobic capacity compared to MICT across various age populations.

The results of this meta-analysis show that High-Intensity Interval Training (HIIT) is significantly more effective in improving VO2peak compared to the control group. This is evidenced by a z-value of 5.59 (p-value < 0.00001) and a 95% confidence interval that does not include zero, indicating that HIIT has a strong and consistent effect on increasing cardiorespiratory capacity. In contrast, Moderate-Intensity Continuous Training (MICT) does not show a significant difference compared to the control, with a z-value of 1.84 and a p-value of 0.07, indicating that MICT does not have a meaningful effect in the context of VO2peak improvement.

These findings are consistent with previous research suggesting that the high intensity of HIIT is more effective in stimulating aerobic capacity increases compared to the moderate intensity used in MICT (Bacon et al., 2013; Milanović et al., 2015; Calverley et al., 2020; Wu et al., 2023). For example, a study by Morales-Palomo et al. (2020) demonstrated that HIIT has a similar or better impact on VO2peak compared to MICT. Similarly, research by Grace et al. (2017) and Poon et al. (2020, 2021) found that HIIT is more effective in improving cardiorespiratory fitness and body composition compared to MICT.

After the intervention period, the results show that High-Intensity Interval Training (HIIT) tends to have a slight advantage over Moderate-Intensity Continuous Training (MICT) in improving VO2peak. However, this difference is not statistically significant, with a z-value of 1.59 and a p-value of 0.11. Nevertheless, some individual studies, such as those conducted by Marzolini et al. (2023) and Ramos et al. (2020[c]), show significant results, supporting HIIT as a more effective method for improving cardiorespiratory capacity. These findings are also consistent with previous research by Milanović et al. (2015) and Bacon et al. (2013), which state that HIIT is more effective than MICT in increasing VO2peak in adult populations. Additionally, studies by Batacan et al. (2017) and Sawyer et al. (2016) also support that HIIT has greater benefits for cardiorespiratory fitness compared to MICT. The moderate level of heterogeneity (I^2 of 40%) indicates variation in results among the studies, which may be due to differences in study design, sample populations, and intervention duration. This variation suggests that while overall HIIT is slightly superior, the relative effectiveness of these two training methods can be influenced by various contextual and individual factors. Further research is needed to confirm these findings and explore the underlying mechanisms behind the differences in effectiveness between HIIT and MICT.

The clinical and practical implications of this study provide evidence that both HIIT and MICT can be used to improve cardiorespiratory capacity in individuals aged 40 and above. HIIT tends to be more effective, especially in the short term, as the high intensity offered can provide a greater stimulus for increasing VO2peak. However, MICT remains a valid option for individuals who may not be able to perform high-intensity exercises due to various reasons, such as health conditions, personal preferences, or a lower risk of injury. These findings can guide health and fitness practitioners in designing exercise programs that meet the needs and conditions of individuals, considering the advantages and limitations of each training method. This personalized approach is essential for maximizing health and fitness benefits and ensuring sustainability and comfort in long-term exercise programs.

The limitations of this study include variations in study design, sample populations, and measurement methods used in the analyzed studies. The variations in study design encompass differences in intervention duration, exercise intensity, and tools and procedures used to measure VO2peak, which can influence the obtained results. Additionally, diverse sample populations, such as differences in age, gender, and baseline health conditions of the participants, can also affect the effectiveness of HIIT and MICT in improving cardiorespiratory fitness. The varying measurement methods, such as the use of different measurement tools or inconsistent procedures, can introduce bias into the research results.

Therefore, further research is needed to confirm these findings and explore the mechanisms underlying the differences in effectiveness between HIIT and MICT. Studies with more homogeneous designs, stricter controls, and longer intervention durations will help provide a clearer picture of the relative benefits of these two training methods. Future research should also consider using larger and more representative sample populations and standardized and consistent measurement methods to ensure the reliability and validity of the results. Additionally, in-depth analysis of individual factors such as genetics, physiological adaptations, and participant adherence to the exercise programs can provide deeper insights into how and why HIIT and MICT differently affect cardiorespiratory fitness. This will aid in designing more effective and specific interventions to improve cardiorespiratory health across various populations.

Conclusion

This study investigates and compares the effectiveness of High-Intensity Interval Training (HIIT) and Moderate-Intensity Continuous Training (MICT) in improving VO2peak in individuals aged 40 and above. Results from a systematic literature review and meta-analysis indicate that HIIT has an advantage in increasing VO2peak compared to MICT, although this difference is not statistically significant. Both exercise methods are effective in enhancing cardiorespiratory capacity, with HIIT showing a tendency for better outcomes. The heterogeneity of results among the studies is low to moderate, indicating good consistency. Although there is an indication of publication bias, it is not strong enough to affect the overall conclusions. The practical implications of this research suggest that both HIIT and MICT can be utilized according to individual preferences and conditions, with HIIT being a more effective choice in the short term. Further research with more homogeneous designs and longer intervention durations is needed to reinforce these findings and understand the mechanisms underlying the differences in effectiveness between HIIT and MICT.

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