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Revision

Effect of high intensity interval training on body fat indicators in adults with overweight or obesity: systematic review and meta-analysis of randomized studies

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ABSTRACT

Objective: To examine the effects of high-intensity interval training on body fat indicators in overweight and obese adults.
Methods: Randomized trials were included in the systematic review. Direct measures (e.g. whole-body fat) and indirect measures (e.g. waist circumference) were examined.
Results: From 1156 articles initially screened, 24 were included. The majority of studies were conducted, at least, for 10 weeks. High-intensity interval training elicited reductions in whole- body fat indicators. The meta-analytic models showed significant differences after high-intensity interval training intervention among body weight, fat mass and fat percentage. On the other hand, body mass index and waist circumference did not present significant results.
Conclusions: High-intensity exercise training can induce body composition improvements in overweight and obese individuals. High-intensity interval training may be a time-efficient component of weight management programs.
Keywords: High-Intensity Interval Training, Body Weight, Obesity, Randomized Controlled Trials.

Efecto del entrenamiento interválico de alta intensidad en los indicadores de grasa corporal de adultos con sobrepeso u obesidad: revisión sistemática y metaanálisis de estudios aleatorizados

RESUMEN

Objetivo: Examinar los efectos del entrenamiento en interválico de alta intensidad (HIIT) sobre los indicadores de grasa corporal en adultos con sobrepeso u obesidad.
Métodos: Se incluyeron ensayos aleatorios en la revisión sistemática. Se examinaron medidas directas (p. Ej., Grasa corporal total) e indirectas (p. Ej., Circunferencia de la cintura).
Resultados: De 1156 artículos encontrados inicialmente, se incluyeron 24. La mayoría de los estudios se realizaron, al menos, durante 10 semanas. El entrenamiento en interválico de alta intensidad provocó reducciones en todos los indicadores de grasa corporal. Los modelos metaanalíticos mostraron diferencias significativas después de la intervención com entrenamiento en interválico de alta intensidad en el peso corporal, la masa grasa y el porcentaje de grasa. Por otro lado, el índice de masa corporal y la circunferencia de la cintura no presentaron cambios significativos.
Conclusiones: El entrenamiento físico de alta intensidad puede inducir mejoras en la composición corporal en personas con sobrepeso y obesidad. El entrenamiento en interválico de alta intensidad puede ser un componente tempo-eficiente en los programas de control de peso.
Palabras clave: Entrenamiento Interválico de alta intensidade, Peso Corporal, Obesidad, Ensayos Clínicos Randomizados.

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Efeito do treinamento intervalado de alta intensidade nos indicadores de gordura corporal em adultos com sobrepeso ou obesidade: revisão sistemática e meta-análise de estudos randomizados

RESUMO

Objetivo: Examinar os efeitos do treinamento intervalado de alta intensidade (HIIT) nos indicadores de gordura corporal em adultos com sobrepeso ou obesidade.
Métodos: Ensaios randomizados foram incluídos na revisão sistemática. Medidas diretas (por exemplo, gordura corporal) e medidas indiretas (por exemplo, circunferência da cintura) foram examinadas.
Resultados: Dos 1156 artigos selecionados inicialmente, 24 foram incluídos. A maioria dos estudos foi realizada, pelo menos, por 10 semanas. O treinamento intervalado de alta intensidade provocou reduções nos indicadores de gordura corporal. Os modelos meta-analíticos mostraram diferenças significativas após a intervenção com treinamento intervalado de alta intensidade entre peso corporal, massa gorda e porcentagem de gordura. Por outro lado, o índice de massa corporal e a circunferência da cintura não apresentaram resultados significativos.
Conclusões: O treinamento físico de alta intensidade pode induzir melhorias na composição corporal em indivíduos com sobrepeso e obesidade. O treinamento intervalado de alta intensidade pode ser um componente eficiente em termos de tempo dos programas de controle de peso.
Palavras-Chave: Treinamento Intervalado de alta Intensidade, Peso Corporal, Obesidade, Ensaios Clínicos Randomizados.

Introduction

Being overweight or obese is a major risk factor for cardiovascular and metabolic disorders and increases risk of all-cause mortality. In addition, central adiposity, which is specifically related to adipose tissue located in visceral fat around the central organs, induces a range of negative adaptations in cardiovascular structure and function, which magnifies risk of chronic illness.[1] And, it is estimated that by 2025 about 2.3 billion adults are overweight and over 700 million are obese.[2] Obesity represents a major pandemic; with a multifactorial origin (behavioral, environmental and genetic aspects). About 2 billion people are overweight and a third of them are obese.[3] Being overweight or obese is a major risk factor for cardiovascular and metabolic disorders and increases risk of all-cause mortality. In addition, central adiposity, which is specifically related to adipose tissue located in visceral fat around the central organs, induces a range of negative adaptations in cardiovascular structure and function, which magnifies risk of chronic illness.

In the last years, many studies have demonstrated that the high intensity interval training (HIIT) could induce favorable adaptations in the control of obesity, such as decreasing fat mass, body mass index (BMI) and waist hip ratio.[4-7] HIIT refers to alternating short bursts of high-intensity exercise and recovery periods. It has become a popular alternative because of its time efficiency, and lack of time is a commonly cited barrier to exercise adherence.[8] On the other hand, endurance training methods tended to focus on longer-duration sessions involving moderate intensity exercise performed continuously without rest.[9] There is growing evidence that HIIT may have superior benefits than endurance training across a range of health markers in both healthy and chronic illness populations. Recent meta-analyses have reported that HIIT induces greater improvements in cardiorespiratory fitness than continuous training in healthy, young to middle-aged adults and in patients with coronary artery disease.[10]

Recent studies have analyzed the comparative effectiveness of HIIT and continuous training on body fat loss in overweight populations with varying findings,[6,7,11-14] but only one systematic review focused on body fat as the main outcome[4]. The study conducted by Maillard and colleagues[4] aiming to assess the efficacy of HIIT in reducing body fat and overweight/obese adults, showed significant reduction in visceral fat mass, with no differences between sexes. Although the results of the study are relevant, an additional approach is necessary to overcome some methodological limitations, such as the use of only two databases and the lack of evaluation of study quality.

Among the different indicators of obesity, the percentage of fat, fat mass and waist circumference are the most commonly studied measures, the latter being the most relevant to indicate cardiometabolic problems,[15,16] and with the strongest relationship with visceral fat.[17] The percentage of fat distinguishes fat from lean body mass and is a better obesity indicator when compared to the total weight and BMI, resulting in a more consistent diagnosis.[18]

HIIT has been shown to be efficient in reducing body fat. Galedari, Azarbayjani and Peeri[19] found significant reductions in the percentage of fat, fat mass and abdominal fat in overweight and obese women using HIIT. However, other authors such as Barry et al.[20] and Kong et al.[21] found no significant differences in the percentage of fat and fat mass in obese women using HIIT. Thus, the objective of this meta-analysis was to investigate whether HIIT is an effective strategy for weight loss in overweight or obese adults, using the following indicators: body weight, body mass index, waist circumference, percentage of fat and fat mass.

Methods

This systematic review was done according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyzes (PRISMA) guidelines.[22] The following databases were used: PubMed, Cochrane, Scielo, Web of Science and Scopus. In order to find studies that included HIIT and different indicators of weight loss (fat percentage, waist circumference, fat mass, body weight, BMI) including overweight or obesity participants, the PICOS strategy was adopted. According to the acronym PICOS strategy[22] (patient, intervention, comparison, outcome and study), the following words were used preliminarily: “Obesity”, “High intensity interval training”, “body composition”, “randomized controlled clinical study”. Although HIIT is not included in the *Medical Subject Headings (MESH)*, the words included in the search were those related to HIIT, which already exist in the literature. Therefore, the following terms was combined to each other and formed an equation: “high-intensity interval training”, “high-intensity interval trainings”, “interval training, high-intensity”, “interval trainings”, “high-intensity”, “training”, “high-intensity-interval”, “high-intensity intermittent exercise”, “exercise”, “high-intensity intermittent”, “exercises”, “high-intensity intermittent”, “high-intensity intermittent exercises”, “sprint interval training”, “sprint interval trainings”, “body weight”, “body weights”, “weights body”, “obesity”, “appetite depressants”, “reducing”, “skinfold thickeness”, “lipectomy”, “anti-obesity agents”, “randomized controlled trials”, “trials”, “randomized clinical”, “controlled clinical trials”, “randomized”, “clinical trials”. The searches were made without temporal restriction. A narrative synthesis and meta-analysis were undertaken as detailed in the protocol registered with PROSPERO (CRD42019130996).

Inclusion and exclusion criteria

The inclusion criteria for this systematic review were full length research articles published in peer-reviewed academic journals with no limits set on language, date of publication, or sex. In addition, the following criterions were considered: (a) 'overweight or obesity adults' (individuals aged ≥ 18) participants; (b) at least one standard obesity indicator (i.e. body weight, BMI, fat percentage, fat mass, waist circumference); (c) Randomized clinical trial; (d) any HIIT intervention. Firstly, titles and abstracts were read to exclude any references not meeting the inclusion criteria.

Exclusion criteria: studies were excluded if participants were diagnosed with severe illness (i.e. cancer, mental disorders, fibromyalgia) and if HIIT was combined with other interventions (i.e. aerobic training, resistance training). Besides, studies in which no body composition evaluation was presented after HIIT intervention or including diet supplementation were also excluded.

Study quality

Two reviewers (AJO and WSV) performed the quality assessment of all studies independently. The Testex scale,[23] a tool designed specifically for use in physical exercise studies, was used to verify the methodological quality of the studies. The scale has 15 points, 5 points for methodology quality and 10 points for reporting information that involves results. It does not have a scoring criterion for the exclusion of articles that have low methodological quality.

Meta-analyses

All analyses were conducted using the package META from R version 3.5.2.[24] Meta-analyses were conducted for the individual effects of HIIT on body weight, body fat percentage and BMI. Pre-means and post-means and standard deviations for HIIT group were collected. Within-group effect size was calculated to estimate change from baseline to the end of intervention. Weighted unstandardized and 95% confidence interval (95% CI) were calculated using random-effect meta-analysis. Heterogeneity was calculated by I^2 statistics, which indicates the proportion of variability between studies that cannot be attributable to chance alone. Studies that had insufficient information to be inserted in the meta-analysis were included in the narrative synthesis.

Results

This systematic review gathered and synthetized studies from ten countries, published between the years 2012 and 2018. Figure 1 presents the study selection flowchart, in which all studies included in the qualitative synthesis and in the meta-analysis were accessed in full. Most of the sample consisted of overweight/obese inactive people. The period ranged from 2 to 16 weeks with 3 to 5 sessions per week. Nineteen out of selected studies found decreases in obesity indicators. Further details of each study can be observed in Table 1.

Body weight

Eighteen studies[6,7, 9,11,13,17,21,25-35] evaluated the impact of HIIT on body weight. Only three studies did not observed reduction after intervention.[11,21,30] The random effects model of the meta-analyses showed a significant mean difference (-0.41; -0.14) evidencing a decrease of the body weight (-0.28 Kg) after intervention. On the other hand, prediction interval showed no significant results (-0.57; 0.02). More details can be seen in Figure 2-A.

Body Mass Index (BMI)

Seven studies investigated the effect of HIIT intervention on BMI.[20,21,28,29,32,35,36] Four did not observed a reduction.[20,21,32,36] However, the random effects model of the meta-analyses (n= 9) showed no significant mean difference (-0.66; 0.10) although Figure 2-B shows a decrease of the BMI (-0.28 Kg) after intervention, the result was not significant (P>0.05).

Fat percentage

Sixteen studies[2,6,7,9,17,19,21,27,30-37] investigated fat percentage as an outcome, twelve were included in the meta-analysis[6,7,9,17,20,21,27,30-33,36] which provide evidence of a significant mean difference (-0.72; -0.15). Figure 3-A presents more details about the model.

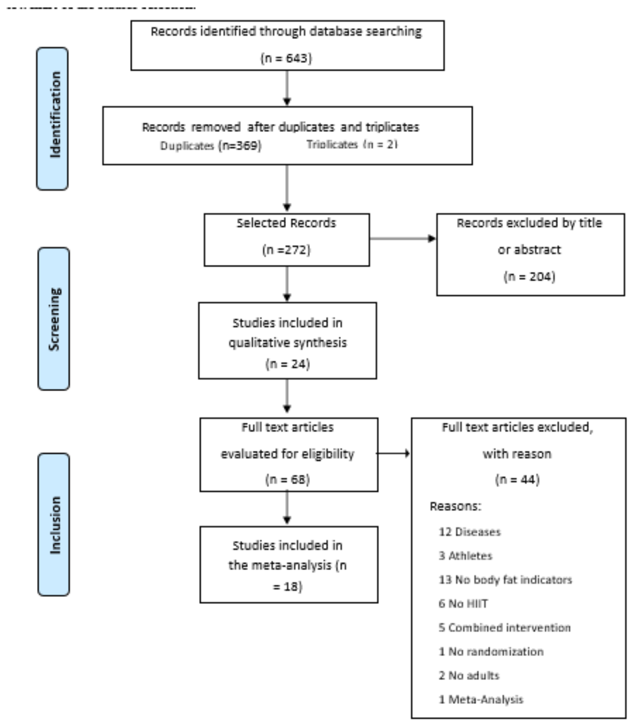

Figure 1. Flowchart of the studies selection

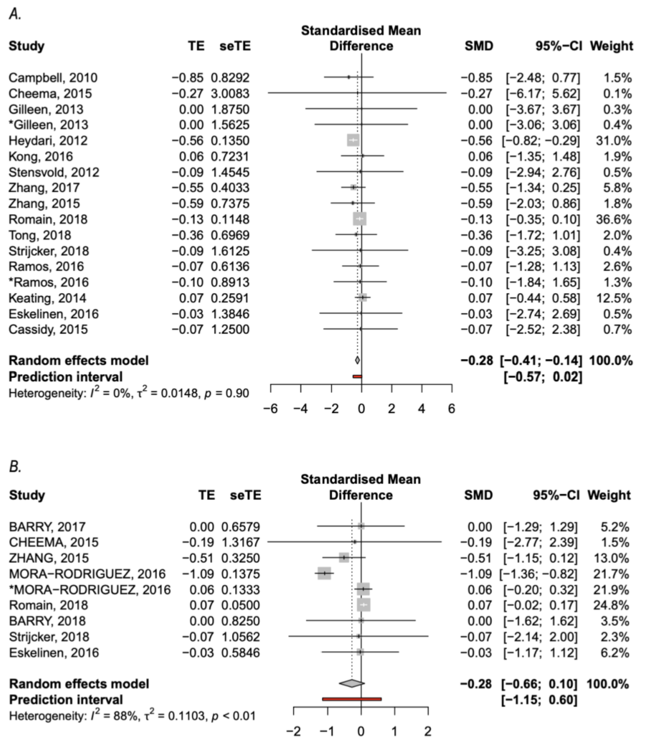

Figure 2. Forest plots for pooled standard mean differences in Body Weight (A) and Body Mass Index (B) using random-effects meta-analysis. TE: Effect Size; seTE: Standar Error; CI: Confidence Interval; SD: Standar Deviation; SMD: Means Differences.

Table 1. Characteristics of selected studies in the systematic review.

Author (year)	Country	Sample	Diet	Modality	HIIT	Resting	Time (min)	Weeks	Outcomes
Barry (2018)[36]	USA	Men and women/ obese/ 30-65 years	No	Cycle ergometer	5x without progressive/ ~90% HR peak	Active	13-20	2	BMI/ Fat percentage/ Fat mass
Romain (2018)[32]	Canada	Men and women/ Adults/ Diagnosis of psychotic disorder/ Overweight	No	Treadmill	2x without progressive/80% HR max	Active	30	6	BMI/ Fat percentage/ Body weight
Strijcker (2018)[28]	Germany	Men/ Risk of developing diabetes type II/ Overweight/ adults/ Inactive	No	Cycle ergometer	2x without progressive/85% HR max	Active	40	10	BMI/ Body weight
Tong (2018)[9]	China	Women/18-23 years/% body fat ≥30	No	Cycle ergometer	90% VO2 max	Passive	~28-47	12	Body weigh/ Fat percentage
Winn (2018)[35]	USA	Men and women / Obese /18-60 years	No	Treadmill	80% VO2 peak	Active	~55	4	BMI/ Fat percentage/ Body weight
Barry (2017)[20]	Canada	Men and women/ obese/ adults	No	Run/cycle ergometer/ treadmill or elliptical	5x without progressive/ 90% HR peak	Active	8-20	2	Fat percentage/ BMI/ Fat mass
Galedari (2017)[19]	Iran	Men/ overweight/ adults	Yes	Run in treadmill	Without progressive/ 90-95% HR max	Active	12-24	12	Fat percentage
Zhang (2017)[7]	China	Men and women/ obese/ sedentary/ adults	Yes	Cycle ergometer	3x-4x without progressive/ 90% VO2 max	Passive	26-38	12	Fat percentage/ Fat mass/ Body weight
Eskelinen (2016)[29]	Finland	Healthy Men/ 40-55 years old/ Inactive/ Overweight	No	Cycle ergometer	4–6×30s of all-out cycling efforts with 4 min of recovery between bouts	Active	27	2	Body weight / BMI
Martins (2016)[13]	Norway	Men and women/ obese/ sedentary/ adults	No	Cycle ergometer	3x without progressive 85-90% HR max	Active	10-20	12	Waist Circumference/ Body weight
Ramos (2016)[31]	Australia	Men and women diagnosed with metabolic syndrome	Yes	Treadmill or cycle ergometer	85-95% HR peak	Active	38	16	Waist Circumference/ Body weight/ Fat percentage
Thogersen N (2016)[41]	Australia	Men and women/obese/ sedentary/ adults	No	Cycle ergometer	3x without progressive / >90% VO2 max	Active	18-25	10	Fat mass
Zhaowei Kong (2016)[21]	China	Women/ sedentary/ obese/ 18-30 years	No	Cycle ergometer	4x without progressive/ 73-87% V02 peak	Passive	20	5	Fat percentage/ Fat mass/ Body weight/ BMI
Cassidy (2015)[26]	England	Men and women/ Obese or overweight/ ≥18 years /diabetes type II / Inactive	No	Cycle ergometer	Borg scale 6-20/ 16–17 Borg scale	Passive	18	12	Body weight/ Fat mass
Cheema (2015)[27]	Australia	Men and women/ overweight or obese/ adults	No	Box – Hiit	4x without progressive/ 86-89% HR max	Active	45	12	Fat percentage/ Waist Circumference/ Body weight
Mora-Rodrigues (2015)[38]	Spain	Men and women/ obese /adults/ Metabolic syndrome	Yes	Cycle ergometer	3x without progressive/ 90% HR max	Active	28	16	Fat mass/ Waist Circumference
Smith-Ryan (2015)[37]	USA	Men/ overweight /obese/ 18-50 years	No	Cycle ergometer	3x without progressive/ 90% HR max/ 3x without progressive/ 80-90% HR max	Passive-Active	15-20	3	Fat percentage
Zhang (2015)[6]	China	Overweight women	No	Treadmill	4x without progressive 85-95 % HR peak	Active	20	12	Fat percentage/ Waist Circumference/ Body weight/ Fat mass
Keating (2014)[11]	Australia	Adult men and women/18-55 years/ Inactive/ Overweight	No	Cycle ergometer	120% VO2 peak	Active	20-24	12	Waist Circumference/ Body weight
Gillen (2013)[30]	Canada	Women/ sedentary/ overweight or obese/ adults	Yes	Cycle ergometer	3x without progressive/ 90% HR max	Active	25	6	Fat percentage/ Fat mass/ Body weight
Tjonna (2013)[34]	Norway	Men/ overweight/ sedentary/ 35-45 years	No	Treadmill	3x without progressive/ 90% HR max/ 3x without progressive/ 70% HR max	Passive-Active	19-40	10	Fat percentage/ Fat mass/ Body weight
Heydari (2012)[17]	Australia	Men/ sedentary/ overweight/ adults	No	Cycle ergometer	3x without progressive/ 80-90% HR peak	Active	20	12	Fat percentage/ Fat mass/ Body weight/ Waist Circumference
Stensvold (2012)[33]	Norway	Men and women/ obese/ adults/ sedentary/ metabolic syndrome	No	Treadmill	3x without progressive/ 90% HR max	Active	28	12	Fat percentage/ Fat mass/ Body weight
Campbell (2010)[25]	Australia	Men and women/ sedentary/ obese/ 18-65 years	Yes	Walking	5x without/ progressive/ 70-75% V02 peak	Active	30	12	Body weight/ Fat mass

HIIT: high intensity interval training; min: minutes; BMI: body mass index; HR max: Maximum heart rate; VO2 max: maximal O2 consumption; [1]: number corresponding to the cited reference.

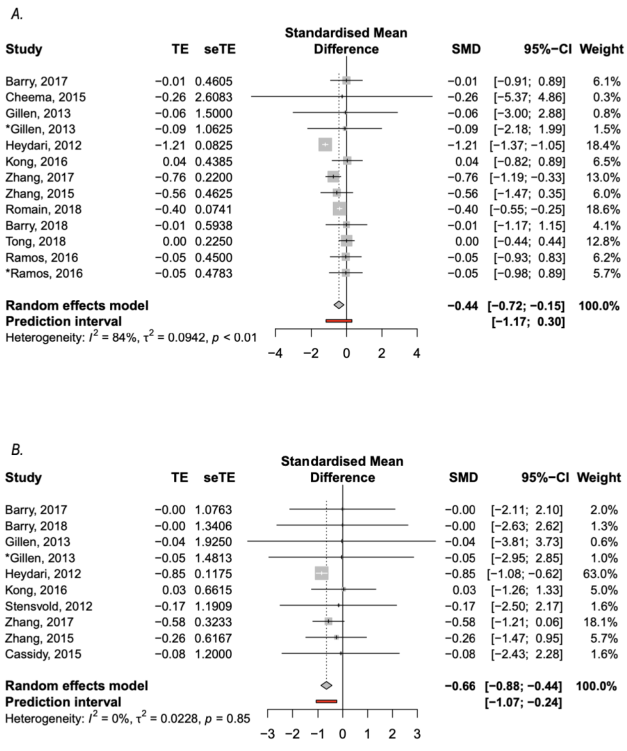

Figure 3. Forest plots for pooled standard mean differences in Fat Percentage (A) and Fat Mass (B) using random-effects meta-analysis. TE: Effect Size; seTE: Standar Error; CI: Confidence Interval; SD: Standar Deviation; SMD: Means Differences.

Fat mass

Twelve studies[6,7,17,20,21,25,26,30,33,34,36,38] investigated fat mass as an outcome, eight found a reduction after HIIT intervention studies. In the meta-analysis which showed the random effects model showed a significant mean difference (-0.88; -0.44) evidencing a decrease of the fat mass (-0.66 Kg) after intervention. In the same direction, the prediction interval which also showed significant results (-1.07; -0.24). More details can be seen in Figure 3-B.

Waist Circumference (WC)

Seven studies.[6,11,13,17,27,31,38] investigated waist circumference as an outcome. All of them were included in the meta-analysis which provide evidence of a non-significant mean difference (-1.88; 0.08). Figure 4 presents more details about the model. Four studies used 12 weeks of intervention, only one used 16 weeks.

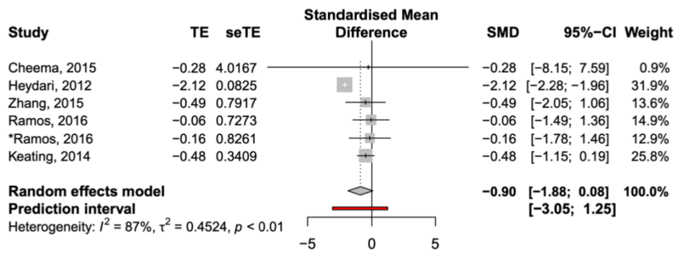

Figure 4. Forest plots for pooled standard mean differences in Waist Circumference using random-effects meta-analysis.TE: Effect Size; seTE: Standar Error; CI: Confidence Interval; SD: Standar Deviation; SMD: Means Differences.

Quality assessment

A Testex[23] assessment determined that the quality of studies in this analysis was moderate (mean score= 9.4 ± 1.5; range from 7 to 13). All studies randomly allocated subjects to intervention groups. No study blinded subjects, but the authors acknowledge the difficulty of applying this in training studies. Details related to methodological aspects of each study can be seen in Table 2.

Table 2. Tested scale for evaluation of study quality.

Studies	Criteria											
	1	2	3	4	5	6	7	8	9	10	11	12
Barry, Julianne C (2018)[36]	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No	No	Yes
Barry, Julianne C (2017)[20]	Yes	Yes	Yes	No	No	No	No	Yes	Yes	No	Yes	Yes
Birinder S Cheema(2015)[27]	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes	Yes
Campbell (2010)[25]	Yes	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes
Catia Martins (2016)[13]	Yes	No	No	Yes	No	No	No	Yes	Yes	No	Yes	Yes
Cassidy (2015)[26]	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes	Yes
Eskelinen (2016)[29]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes
Galedari M (2017)[19]	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes	Yes
Herfeng Zhang (2015)[6]	Yes	No	No	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes
Herfeng Zhang (2017)[7]	Yes	No	No	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes
Heydari M (2012)[17]	Yes	No	No	Yes	No	No	No	Yes	Yes	No	Yes	Yes
Jenna B. Gillen (2013)[30]	Yes	No	No	Yes	No	Yes	No	Yes	Yes	No	Yes	Yes
Keating (2014)[11]	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mora-Rodrigues (2015)[38]	Yes	No	No	No	No	Yes	No	Yes	Yes	No	Yes	Yes
Ramos (2016)[31]	Yes	Yes	No	Yes	No	Yes	No	Yes	Yes	No	No	Yes
Romain, Ahmed Jérôme (2018)[32]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes
Smith-Ryan AE (2015)[37]	Yes	Yes	No	No	No	Yes	No	Yes	Yes	No	Yes	Yes
Stensvold (2012)[33]	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes	Yes
Strijcker, Dorien De (2018)[28]	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes	Yes
Thogersen N (2016)[41]	Yes	No	No	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes
Tjonna (2013)[34]	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Tong, Tomas K (2018)[9]	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes	Yes
Winn, Nathan C (2017)[35]	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes	No
Zhaowei Kong (2016)[21]	Yes	No	No	Yes	No	No	No	Yes	Yes	No	Yes	Yes

1: Specified eligibility criteria; 2: Specified randomization; 3: Allocation concealment; 4: Similar groups at the baseline; 5: Evaluator blinding; 6: Outcome measures assessed at 85% of participants (3 points); 7: Intent to treat analysis; 8: Statistics between groups Comparisons reported (2 points); 9: Point of measures and measures of variability for all measures of reported results; 10: Monitoring of activity in control groups; 11; Relative intensity of the exercise remained constant; 12: Exercise volume and energy expenditure; [£]Studies in the gray lines were not included in meta-analysis.

Discussion

The aim our approach was to investigate if HIIT is an effective strategy for weight loss among overweight/obese individuals, using the following indicators: body weight, BMI, waist circumference, fat percentage and fat mass. Most studies consolidated positive responses on these indicators. An explanation for weight loss provided by HIIT is a higher excess post-exercise oxygen consumption (EPOC), resulting in elevated energy expenditure for the reestablishment of homeostasis. Phosphate resynthesis, lactate removal and synthesis of tissue are examples of metabolic changes contributing to higher EPOC.[39,40] The suppression of appetite through the increase of the hormone PYY3-36 justifies another relevant factor induced by HIIT, and may contribute to the energy balance.[14]

Most of the studies used fat mass and percentage of fat as indicators to be observed and meta-analytic results provide evidences of HIIT efficiency on reduction of obesity indicators. Cheema et al.[27] and Galedari et al.[19] stood out with reductions of four percent, but demonstrated some differences in their training protocols. The time of the training sessions was the most significant difference: forty-five minutes vs. twenty-four minutes respectively, with similar intensities. Thus, the possible explanation for the same result was the use of diet in the study by Galedari et al.[19], with a shorter training session. Tjonna et al.[34], Zhang et al.[6] and Zhang et al.[7] showed reductions in three percent. The rest of the studies had reductions around two to one percent of fat percentage, showing differences in intervention time. The fat mass was highlighted in two studies. Possibly the contribution of the diet and the greater training volume of Zhang's study[7] differed in the amount of lost kilograms. Other studies showed reductions of two kilograms,[6,17] reductions equivalent to or less than one kilogram[30,41] differing in intervention time.

All the studies that included the waist circumference as measurement showed significant reductions. The study that presented the greatest reduction was that of Cheema et al.[27] with almost seven centimeters, differing from the others by the superior volume of training. Zhang et al.[6] and Martins et al.[13] demonstrated the same reduction in their studies (almost five centimeters), using the same intervention time and similar intensities. We found that the sample characteristics, training session time and protocol volume did not have different repercussions in WC. The study, which had a smaller reduction in WC (less than two centimeters), was conducted by Martins et al.[13], who used short Sprint protocols (eight seconds) with obese patients. Heydari et al.[17] with the same intervention protocol and similar intensities, obtained almost the double of the reduction of WC in overweight men, showing that possibly obese individuals do not respond as well to short stimuli when compared to overweight subjects. In summary, the method showed its efficiency among overweight and obese people of both sexes. A possible explanation for the significant reduction of this indicator is that the visceral fat found in this region has a greater response to the exercise-induced catecholamines, because this tissue has more receptors, contributing to greater lipolysis in the region.[42]

Most studies reporting 12 weeks of intervention with three to four sessions per week have found improvements in obesity indicators, with the exception of the study by Campbell et al.[25] that presented a different methodology using moderate intensity walking and training fragmentation (two sessions of fifteen minutes per day). Probably the intensity was the determining factor of failure, since, Cheema et al.[27] found reduction in waist circumference and percentage of fat with the same stimulus (2:1), a similar sample (men and women with overweight or obesity), using less training sessions, but with greater intensity confirming the importance of strength in the method to obtain results in weight loss.

Authors who used up to 12 weeks of intervention[20,21,37] did not find reductions in obesity indicators, showing that in addition to intensity, intervention time is also important. These authors used in their studies, stimuli with low and high volumes, high intensities and times of sessions shorter or equal to 20 minutes. The same characteristics were used by other authors such as Heydari et al.[17], Zhang et al.[6] and Martins et al.[13] showing an inverse relationship, reporting reductions in obesity parameters with the use of more weeks. A clearer evidence on the importance of the intervention time is the comparison of the study by Martins et al.[13] with Kong et al.[21], who using the same training stimulus, modality, similar volume and sample, found reductions in markers of obesity, using seven more weeks.

Studies with only few weeks of intervention or low intensities did not present significant results. For instance, Smith-Ryan et al.[37] and Barry et al.[20] used time of similar interventions (three and two weeks respectively) representing less than half of the interventions that had a response in weight loss. Billat,[43] used a 12-week intervention, equivalent to many studies that had decrease in obesity indicators, but used low intensities, which may have determined their failure. Heydari et al.[17], used the same protocol, but with more weeks of intervention, obtained a response in the direction of weight loss. The intensity and the intervention time were the most important variables in studies that showed reductions on obesity indicators.[17]

Most of the studies used cycle ergometers and treadmill, but Cheema et al.[27] verified superior results using exercises with body weight, exercises commonly used in the box, showing that it is possible to lose weight without technological resources. Mcrae et al.[44] also used body weight exercises in their HIIT protocol, verifying benefits for weight loss.

The use of diet was found in few studies. Only the study by Campbell et al.[25] did not present reductions in the indicators of obesity using diet and HIIT. This may be justified by the lower intensity, showing that the intensity can also interfere in the response of conjugated strategies (diet + HIIT). Most of the studies that did not include diet, had beneficial results in weight loss, showing that the isolated method is efficient. The few studies that had no results used a few weeks of intervention, the largest of which, five weeks of intervention. The shortest intervention time with benefits was ten weeks of HIIT.[34,41] That would be the minimum intervention time for results in weight loss.

There are some limitations to this meta-analysis. The substantial heterogeneity found in several meta-analyzed obesity indicators (WC, VO2 max, Heart rate - HR, systolic blood pressure - SBP and diastolic blood pressure - DBP) suggests differences in sample as possible sources. Due to insufficient information some studies were not included in meta-analysis, which could bias our findings. Further studies conducted in larger and more diverse samples are required to address these limitations of primary studies. Most studies (13 studies) used a dual-energy X-ray absorptiometry (DXA), the 'gold standard' method to determine obesity indicators. Others used less accurate methods (8 studies), such as impedance which was recognized as the least reliable.

In conclusion, our systematic review and meta-analysis showed HIIT as efficient strategy for reducing body fat taking into account some indicators (i.e. fat mass, fat percentage), and may be another tool to reduce obesity. The method allows you to experience high intensity with successive rest intervals, favoring a slower rate of accumulation of metabolites and reducing fatigue and subjecting the body to greater stresses. This, in turn, promotes significant adaptations to oxidative metabolism. The demand for time imposed by HIIT is reduced, in most of its execution protocols, and this may justify a greater adherence to physical exercise, counterbalancing the rates of increase in obesity.

With a view to assessing the quality of the selected studies, we suggest that the next ones monitor the physical activities performed by the control group. Because individuals tend to change their behavior when they are aware that they will be subjected to measurements, especially in the field of body composition. In addition, the "blinding" of the evaluators is also recommended, in order to avoid measurement bias. More studies are needed to evaluate the adherence of HIIT and to configure it as a standard suggestion of physical activity for health promotion. Considering the use of exercise as a prophylactic and therapeutic measure, it is relevant that the scientific production demands more studies in other pathological areas, investigating the causalities imposed by the method.

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