

Is the combination of interval and resistance training more effective on physical fitness? A systematic review and Meta-analysis

Será a combinação dos treinamentos intervalado e resistido mais efetiva sobre a aptidão física em adultos? Uma revisão sistemática e meta-análise

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Abstract – Interval training (HIIT / SIT) combined with resistance training (RT) has been highlighted as a strategy for the improvement of health-related physical fitness markers (HRPF) in adults. Thus, the aim of this meta-analysis was to compare the efficacy of combined training (HIIT / SIT + RT) with other exercise protocols on HRPF markers in adults. A systematic search was performed in MEDLINE via PubMed, Cochrane-CENTRAL, SPORTDiscus, LILACS, SCIELO and Scopus databases between January and March 2017, using the following keywords in English and Portuguese: physical fitness, high-intensity interval training, sprint interval training, resistance training and adults. The quality of studies was evaluated using the PEDro scale. After applying both inclusion and exclusion criteria, nine articles were selected (n = 231). The extraction of means and standard deviations from studies was performed independently by two authors and the RevMan software was used to perform the meta-analysis. Combined training interventions lasted from 6 to 12 weeks and generated greater increase in maximal oxygen uptake than other forms of exercise. The combination of interval training and strength training may be considered more effective to improve aerobic capacity levels in adults.

Key words: Adults; High-intensity interval training; Physical fitness; Resistance training; Sprint interval training.

Resumo – O treinamento intervalado (HIIT/SIT) combinado com o treinamento de resistência (TR) tem se destacado como estratégia para a melhora de indicadores de aptidão física relacionados à saúde (AFRS) em adultos. Assim, o objetivo desta meta-análise foi comparar a efetividade do treinamento combinado (HIIT/SIT + TR) com outros protocolos de exercício sobre os indicadores de AFRS em adultos. Foi realizado a busca sistemática nas bases de dados eletrônicas MEDLINE via PubMed, Cochrane-CENTRAL, SPORTDiscus, LILACS, SCIELO e Scopus, entre janeiro e março de 2017, com a utilização dos seguintes descritores, em inglês e português: *physical fitness, high-intensity interval training, sprint interval training, resistance training and adults*. A qualidade dos estudos foi avaliada por meio da escala PEDro. Após a aplicação dos critérios de inclusão e exclusão, nove artigos foram selecionados (n= 231). A extração das médias e desvios padrões dos estudos foi realizada de forma independente por dois autores e utilizou-se o programa RevMan na condução da meta-análise. As intervenções com treinamento combinado (HIIT/SIT + TR) tiveram duração de 6 a 12 semanas e produziram maiores aumentos de absorção máxima de oxigênio que outras formas de exercício. A combinação do treinamento intervalado e treinamento de força pode ser considerada mais eficaz para a melhora dos níveis de capacidade aeróbica em adultos.

Palavras-chave: *Adultos; Aptidão física; Treinamento de resistência; Treinamento intervalado de alta intensidade.*

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INTRODUCTION

Western lifestyle is characterized by changes in dietary intake, increases in dietary energy supply, reductions in levels of physical activity and increases in time spent in sedentary behaviors¹, and the adult population, due to its social and economic relevance, deserves greater attention and policies aimed at the maintenance and / or recovery of its physical and mental well-being².

The maintenance of minimum performance indexes is necessary to maintain adequate functional (strength / resistance and flexibility), motor (cardiorespiratory fitness) and morphological levels (body composition) of adequate health-related physical fitness (HRPF)³. In addition, regular physical activity at all ages is essential to minimize the risk of incubation and early development of chronic-degenerative diseases, thus enabling longevity with higher quality of life, reduction of risk factors, health promotion and performance of daily tasks and leisure activities^{4,5}. Thus, different intervention protocols with physical exercises have been used to promote improvements in HRPF indicators, mainly in the reduction of visceral fat and cardiovascular risk factors⁶.

Among the various exercise protocols proposed for obesity management today, interval training has been highlighted as an efficient strategy to achieve innumerable health benefits^{7,8}. This method is characterized by intense loads of exercise separated by a period of interval between series⁹, with adaptive benefits superior to other types of training such as continuous aerobic exercise, but with less training volume¹⁰. In addition, this training protocol has helped to achieve greater adherence to exercise programs, precisely because it presents an efficient dose of time and reduces the health risks associated with obesity¹¹.

Among the methodologies observed in the various studies that use the principles of interval training, sprint interval training (SIT) is defined as sprints of short duration (8 to 30 seconds), with intensity greater than 100% of VO_{2max} and interspersed with recovery periods⁸, while high-intensity interval training (HIIT) is characterized by exercise sessions with intensities between 80% and 100% of maximum heart rate or aerobic capacity, with duration between 60 and 240 seconds, which are within the aerobic capacity of the individual (sub-maximum), but extremely intense⁹.

Another protocol widely used in literature is resistance training, since it is an important component for weight loss by promoting body fat reduction increased lean mass and muscle strength^{7,12}. In addition, this protocol produces the EPOC effect (excessive post-exercise oxygen consumption), and through this system, brings long-term benefits to individuals by increasing basal metabolic rate and caloric expenditure and improves lipid oxidation¹⁴.

Although there is consensus in literature about the benefits of interval and resistance training alone, it is important to analyze the effectiveness of the combination of these two protocols, since the sum of benefits brought by both seems to be an interesting strategy to improve the physical fitness indicators, weight management and health enrichment in adults^{11,7}.

Therefore, the aim of this meta-analysis is to compare the effectiveness of combined training (HIIT / SIT + RT) with other exercise protocols on HRRPF indicators in adults.

METHODOLOGICAL PROCEDURES

The systematic review was conducted between January and March 2017, following the recommendations of the Preferred Reporting Items for Systematic Review and Meta-analyses: The PRISMA Statement¹⁵, developed in a methodical, explicit and reproducible manner with a clear question, search strategy and well-defined inclusion and exclusion criteria, is aimed at guiding future research and systematizing the knowledge produced¹⁶.

The selection of descriptors used in the review process was done through consultation with DECS (BIREME health sciences subject descriptors) and MESH (Medical Subject Headings - controlled vocabulary used for indexing articles for PubMed). The search was performed in six electronic databases: MEDLINE (Medical Literature Analysis and Retrieval System online) via PubMed, Cochrane-CENTRAL, SPORTDiscus, LILACS, SCIELO (Scientific Electronic Library Online) and Scopus, using the following language descriptors in English and Portuguese, respectively: physical fitness (aptidão física), high-intensity interval training (treinamento intervalado de alta intensidade), sprint interval training (treinamento intervalado de Sprint), strength training (treinamento de força), resistance training (treinamento de resistência) and adults (adultos) using Boolean operators AND and OR to combine descriptors. Searches were carried out by two researchers (F.J.M.J) and (I.C.J), independently, who started reading the titles and abstracts, following for analysis of the articles in full. Disagreements among reviewers were resolved by consensus.

Initially, 685 articles were identified, to which the inclusion and exclusion criteria specified in Figure 1 were applied. The following inclusion criteria were adopted: 1) only original articles; it was decided not to include chapters of books, theses, dissertations and monographs, since the performance of a systematic search of these is logistically infeasible; 2) only studies that presented abstract, which were initially read; 3) studies carried out over the last 10 years (2007-2017); 4) studies using only human samples; 5) studies with minimum intervention of six weeks; 6) studies with combined HIIT / SIT and resistance training intervention. After applying the inclusion criteria, 43 articles were selected. The following exclusion criteria were applied: 7) repeated articles; 8) studies with population of athletes or aiming at sports performance; 9) articles without control group; 10) studies that did not evaluate health-related physical fitness variables; 11) articles that include samples of adolescents and / or elderly, resulting in the selection of nine articles.

Then, the selected articles were analyzed for their methodological quality, following the evaluation protocol based on the adapted PEDro¹⁷ scale, composed of nine criteria judged to be important and susceptible of

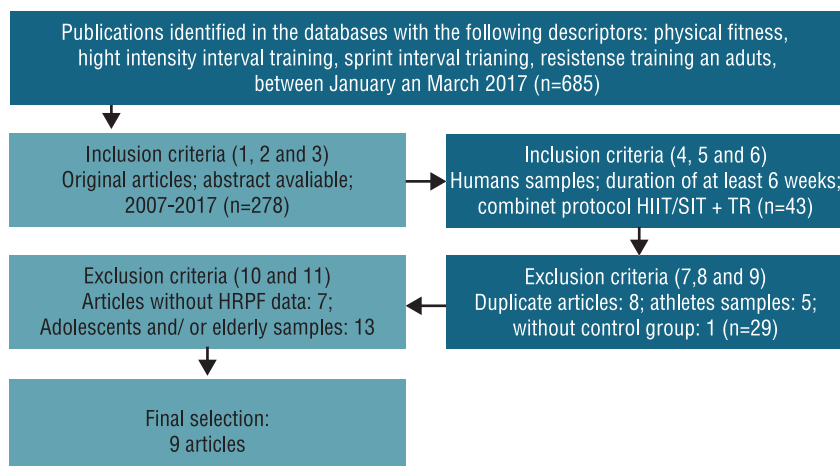


Figure 1. Application of the inclusion and exclusion criteria.

being scored in the selected articles. The quality score was performed by two investigators independently and the doubts were analyzed and decided by a third evaluator for final decision.

Thus, the following aspects were evaluated: 1) Specified eligibility criteria; 2) Randomization or random designation; 3) Secret allocation; 4) Similar groups at the beginning; 5) Blind assessors; 6) Evaluations made in at least 85% of the sample; 7) All evaluated subjects received intervention according to allocation; 8) Results of intergroup comparisons were described; 9) Study presents precision and variability measures for the results. The better the score, the better the quality of the article. Articles that reached less than 6 points were considered of low methodological quality, between 6 and 7, average quality and above 7, high methodological quality.

Data extraction was performed individually by two independent evaluators, in which means and standard deviations (baseline) and post-interventions of health-related physical fitness indicators were obtained: body composition (fat percentage), cardiorespiratory fitness (Relative VO_{2max} in $kg / ml / min$) and force (leg press and bench press, in kg). The RevMan version 5.3 software was used to conduct the meta-analysis, for which the standardized mean difference (SMD) and standard error (SE) of variables to be analyzed between groups were calculated (combined HIIT / SIT + RT training versus other training protocols): interval training (HIIT or SIT), resistance training (RT) and continuous training combined with resistance (CT + RT). In each study, the random effects model (DerSimonian-Approach Laird)¹⁸ was calculated and combined, since samples were taken from populations under various pre-intervention conditions.

To analyze the effects of the combined protocol (HIIT / SIT + RT) versus other protocols, significance level of 5% and 95% confidence interval (CI) were considered. The evaluation of the heterogeneity of the total variations in studies was analyzed by means of the Cochran Q statistic, where I^2 value of <25%, 25-50% and > 50% were considered small, medium and large quantities of inconsistency¹⁹.

Finally, sensitivity analysis¹⁸ was performed, excluding studies that

presented high risk of bias, following the procedure in two moments in order to verify changes in the results of the meta-analysis: 1) including only studies that performed the concurrent training in the same session; 2) excluding studies classified with low methodological quality.

RESULTS

The final selection had nine articles, totaling 231 adults. Among the selected studies, four performed interventions in samples with eutrophic nutritional status²⁰⁻²³ and five in overweight populations²⁴⁻²⁸. Regarding the origin of studies, we have identified researches carried out in Chile²⁷, Brazil²³, Norway²⁸, United States^{20,26}, Denmark²⁵, France²⁴, Canada²² and Greece²¹. Regarding the sex of subjects, there were studies with male samples^{21,24-26}, female^{20,22,23,27} and both sexes²⁸.

Among the HRPF indicators analyzed, six studies evaluated body composition, specifically fat percentage^{21,24,25,27,28}, seven muscle strength of lower limbs (leg press) and / or upper limbs (bench press)²⁰⁻²⁶ and seven cardiorespiratory fitness, specifically VO_{2max} in kg / ml / min.^{20,22,24-28}

In studies that used interval training, five used the combination of the HIIT protocol with strength training^{21,23-25,28}, while four adopted the SIT principles for combined training^{20,22,26,27}.

Regarding the methodological quality of studies, one was classified as with low methodological quality²⁰, six with medium quality^{21,23,24,26-28} and two with high quality^{22,25}.

Among the interventions used in the comparison with the combined protocol (HIIT / SIT) + RT, three studies adopted HIIT / SIT^{22,27,28} seven RT^{20,21,23,24,26-28} and two CT + RT^{24,25}. The HIIT / SIT + RT protocols used in the studies showed significant variation among themselves, including combined training interventions in the same week, but not in the same session²⁶⁻²⁸, and the training frequency ranged from 2 to 5 times per week. In relation to HIIT / SIT programs, exercises with running in the terrestrial environment^{23,26,27}, in treadmill^{20,24,25,28}, in cycle ergometer²¹ or during aerobic rowing exercises²² are observed.

The majority of interventions lasted 12 weeks, with the exception of studies with six weeks^{21,22} and eight weeks^{20,23}. The intensities of the interval exercise among studies ranged from 70 to 100% HR_{max} ^{25,27,28}, 110 to 120% VO_{2max} , 9-10 points of the subjective effort perception (Borg scale 0-10)²² and 120 to 150% of the lactate threshold²⁴. Regarding muscle strength training, the load ranged from 9-10 points in the scale of subjective effort perception of Borg²² and from 40 to 87% of 1RM. Details of groups and training protocols are highlighted in Table 1.

In the intergroup analysis, the standardized mean difference (SMD) for the fat mass variable did not reach statistical significance, corresponding to 0.03 and with [95% CI: (-18 to 0.23) $p = 0.79$; $I^2 = 0\%$] respectively (Figure 2A). The SMD in the relative VO_{2max} parameter was 0.24 ml / kg / min [95% CI: (0.04 to 0.45) $p = 0.02$; $I^2 = 0\%$] in favor of the combined group

(HIIT / SIT + RT) compared to the other training protocols (Figure 2B). For muscle strength, both in the Leg Press and in the Bench Press, SMD was not statistically significant (-0.57 [95% CI: (-1.71 to 0.57) p = 0.33, I² = 95%: (-0.29 to 0.27) p = 0.96, I² = 0%]) (Figure 3AB).

Table 1. Main features of selected studies

References	Sample data	Groups (n)	Volume - Frequency	Intensity - Load	Duration (weeks)
Álvarez et al. ²⁷	♀ 40.1 ± 11.4 years	ITb + RT (n=10)	(HIIT) 7x20sx2min, 3x/week + (RT) 5 exercises, 3x1minx2min, 2x/week: total 5x/week	>85% HRmax, MF, PR	12
		ITb (n=12)	7x20sx2min, 3x/week	>85% HRmax, PR	
		RT (n=8)	5 exercises, 3x1minx2min, 2x/week	MF	
Buckley et al. ²²	♀ 24.7 ± 5.4 years	ITb + RTf (n=14)	6x1minx3min (20s of HIIT + 40s of RT) 3 exercises, 4-10rep: 3x/week	9-10/10 EPR, PR	6
		ITb (n=14)	6x1minx3min, 3x/week	9-10 EPR; PR	
Cantrell et al. ²⁶	♂ 25.6 ± 6.1 years	ITb + RT (n=7)	(HIIT) 4-6x20sx4min + (RT) 6 exercises, 3x4-6repx2min: 2x/week each (total 4x/week)	85% 1RM, ME	12
		RT (n=7)	6 exercises, 3x4-6repx2min, 2x/week	85% 1RM	
Fyfe et al. ²⁴	♂ 29.6 ± 5.5 years	ITa + RT (n=8)	(HIIT) 6-11x2minx1min + (RT) 5 exercises, 3-5x4-14rmx2-3min: 3x/week	120-150% LL, MF, PR	12
		RT (n=8)	5 exercises, 3-5x4-14rmx2-3min, 3x/week	MF	
		CT+RT (n=7)	15-33min, 5 exercises, 3-5x4-14rmx2-3min, 3x/week	80-100% LL	
Laird et al. ²⁰	♀ 20.3 ± 1.7 years	ITbT + RT (n=13)	(HIIT) 8x20sx10s + (RT) AB, 4 exercises: 3-5x3-10rep: 3x/week	110-120% VO2max, MF, 70-87%1RM	8
		RT (n=13)	4 exercises, AB; 3-5x3-10rep, 3x/week.	MF; 70-87%1RM	
Silva et al. ²³	♀ 22.9 ± 14.1 years	ITa + RT (n=11)	(HIIT) 20-30minx1minx1min + (RT) 7 exercises, 2-3x8-18x2min: 2x/week	DP, VO2max	8
		RT (n=12)	7 exercises, 2-3x8-18x2min, 2x/week,	MF	
		CT+RT (n=10)	20-30min	95% vVO2max	
Stensvold et al. ²⁸	♀ ♂ 50.9 ± 7.6 years	IT + RTa (n=10)	(HIIT) 4x4minx3min, 2x/week + RT AB, 7 exercises, 2-3x8-20rep x *min, 1x/week: total 3x/week	70-95% HRmax, AR, 40-80% 1RM	12
		RT (n=11)	AB, 7 exercises, 2-3x8-20repx *min, 3x/week.	40-80%1RM	
		ITa (n=11)	4x4minx3min, 3x/week.	70-95% HRmax, AR	
Tsitkanou et al. ²¹	♂ 21.8 ± 0.6 years	ITa + RT (n=11)	(HIIT) 10x1minx1min + (RT) 4 exercises: 4x 6rep x 3-5min: 2x/week.	85%RM, 100%MAP, PR	6
		RT (n=11)	4 exercises; 4x6repx3-5min; 2x/week.	85% RM	
Wens et al. ²⁵	♂ 47 ± 3 years	ITa + RT (n=12)	(HIIT) 5x1-2minx1min + (RT) 6 exercises, 1-2 x 10-20 rep x *min: 2x/week	80-100% HRmax, ME	12
		CT+RT (n=11)	6-20min, 6 exercises, 1-2x10-20repx *min; 2x/week	80-90% HRmax, ME	

IT - interval training; RT - resistance training; ^a - high intensity interval training (HIIT); ^b - sprint intense training (SIT); CT - continuous aerobic training; MF - muscle fatigue; PR - passive rest; AR - active rest; ME - maximum effort; MAP - maximum aerobic power; LL - lactate threshold; HRmax - maximum heart rate; vVO2max - maximum oxygen uptake speed; RPE - Rating of Perceived Exertion (Borg scale); * - not specified by the authors; AB = two training divisions.

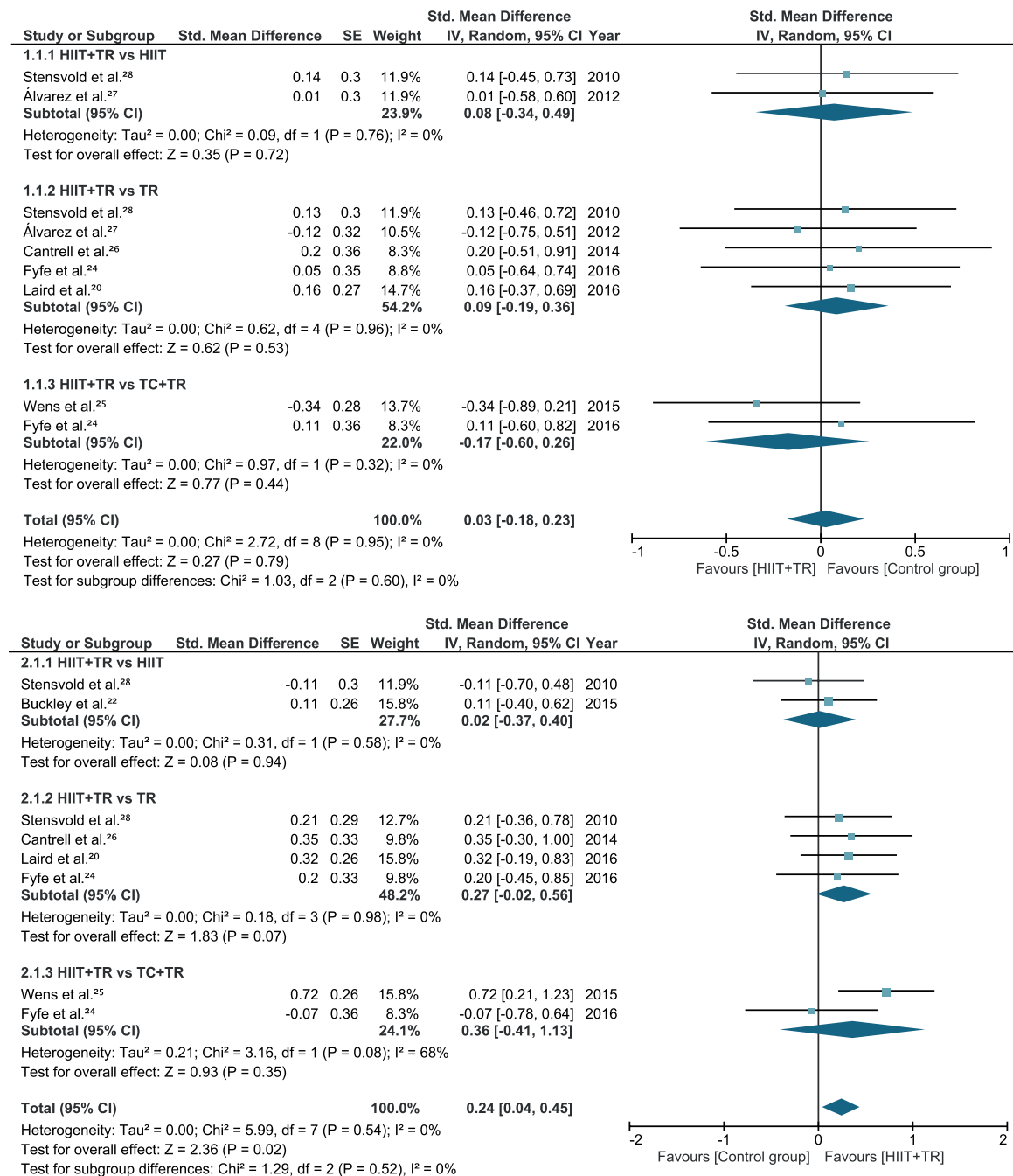


Figure 2. Meta-analysis of the results of combined protocol (HIIT / SIT + RT) versus other exercise protocols in parameters fat mass (A) and cardiorespiratory fitness (B), respectively. CI - confidence interval, HIIT / SIT + RT - high intensity interval training or sprint interval training combined with resistance training, IV - inverse variance, SD - standard deviation, total - number of participants in each study group.

DISCUSSION

The aim of this meta-analysis was to analyze the effectiveness of combined training (HIIT / SIT + RT) compared to other exercise protocols on the HRPF indicators of adults. Our search indicates that interventions using this combined training demonstrate more effective adaptations related to

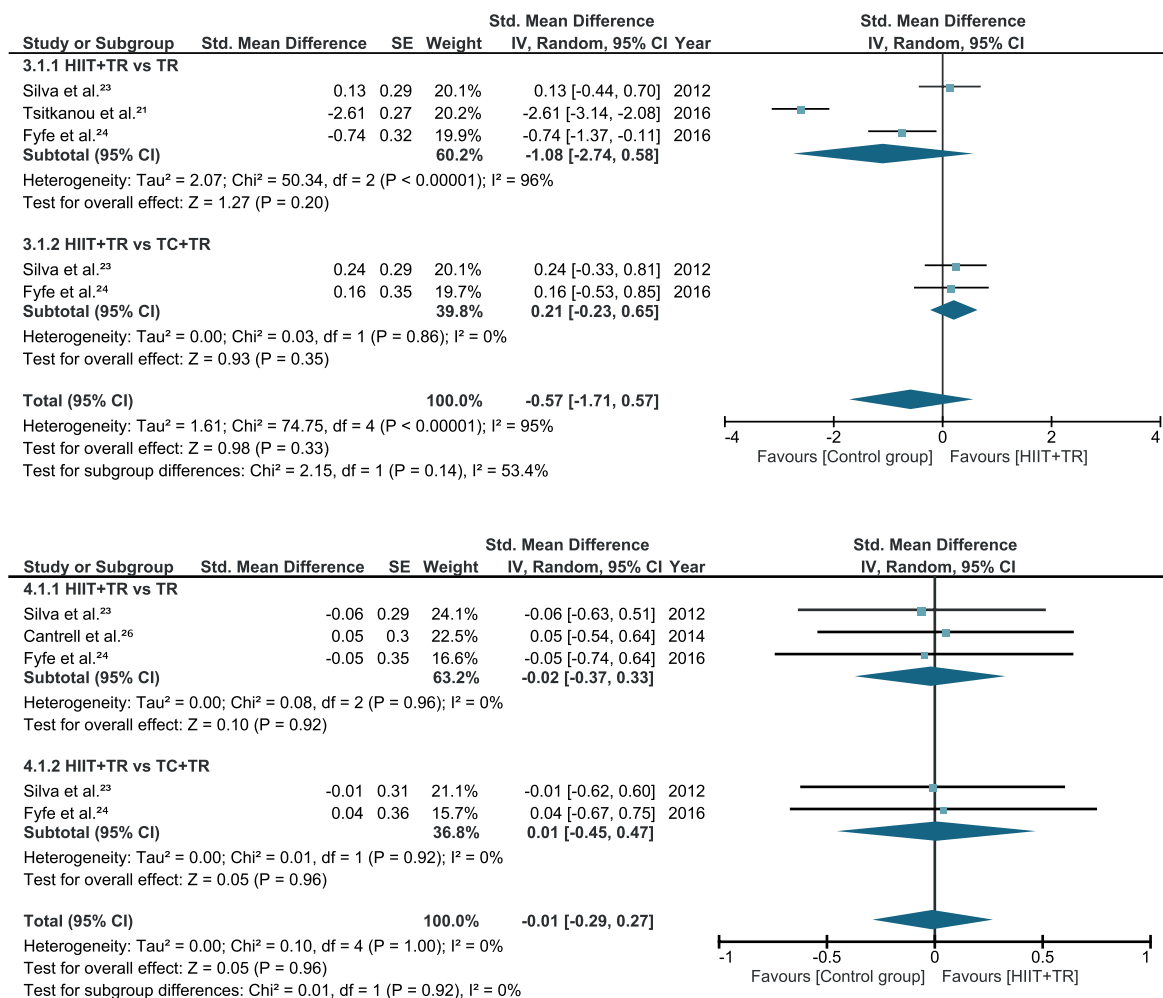


Figure 3. Meta-analysis of the results of combined protocol (HIIT / SIT + RT) versus other exercise protocols in parameter strength, leg press, in kg (A) and bench press, in kg (B), respectively. CI - confidence interval, HIIT / SIT + RT - high intensity interval training or sprint interval training combined with resistance training, IV - inverse variance, SD - standard deviation, total - number of participants in each study group

cardiorespiratory fitness when compared to other intervention protocols. Our findings are similar to those that reported increased maximal oxygen uptake in patients with hypertension²⁹, overweight and obese adolescents¹⁰ and in patients with chronic heart failure³⁰.

The present data suggest that combined training (HIIT / SIT + RT) may promote higher VO_{2max} benefits when compared to other training methods, specifically when compared with the RT method, although HIIT / SIT training as well as combined CT + RT training may also promote benefits in VO_{2max} ^{24,28}. Our results corroborate with the findings of a meta-analysis conducted in 2013 comparing interval training with other exercise protocols, including HIIT / SIT + RT on cardiorespiratory fitness in elderly patients with chronic heart failure, in which the authors pointed out a greater effectiveness in results in protocols that combine interval training and resistance training in cardiorespiratory fitness, provided that with similar energy expenditure³⁰.

In this sense, combining these two types of training, adaptations are

expected in skeletal muscle mass, peripheral nervous tissue and other tissues directly involved during training³¹. However, significant changes related to muscle strength in the bench press and leg press exercises were not observed, suggesting that the gains in these physical fitness variables are similar between training methods. However, it is important to note that few studies have equated volumes and / or weekly frequency between HIIT / SIT + RT intervention and the other comparison groups, which may underestimate the results of the other control groups, especially those who performed HIIT and RT alone. On the other hand, intervention protocols combining interval training and resistance training have some distinct characteristics in the prescription characteristics, which can contribute to the inconsistency in the improvement of these variables in favor of this exercise method.

In addition, combining strength training with interval training has been recommended for the maintenance of physical fitness and functional capacity throughout adulthood³², indicating increases in ribosomal activity, mitochondrial function and gene expression of skeletal muscles, culminating in increases in cardiorespiratory fitness, strength, resistance and muscle mass³³. It is worth emphasizing the importance of maintaining physical fitness throughout adult life as a relevant factor for the reduction of the development of risk factors, which favor the development of chronic cardiometabolic diseases³⁴; however, our results did not indicate a decrease in the fat percentage in adults who performed the HIIT / SIT + RT training.

However, an important bias risk was the fact that only one study controlled the diet variable²⁴. Diet is a factor that has great influence in manipulating morphological factors such as body composition. One study showed that increased protein intake associated with caloric reduction may provide greater fat mass decrease and lean mass increase when compared to low protein intake in trained individuals³⁵.

The findings in literature are widely controversial regarding the combination of exercises of distinct metabolic pathways in a single session, suggesting that they exert a metabolic dispute called concurrent training³¹. It is assumed that in this method, residues from one exercise can influence the metabolic adaptations of the other³⁶. Although data are still unclear, based on the results presented this assumption may not apply, because both concurrent or combined HIIT / SIT + RT training in the same week can bring significant results in physical fitness, as well as HIIT and RT alone.

The implementation of the combined program (HIIT / SIT + RT) can minimize training time, a factor that has been predominant in the choice of interventions³⁷. These results may help in the elaboration of new researches and identify the limitations in the studies to conduct new interventions using this type of protocol in populations of varied ages. In addition, the characteristics of this combined training protocol have reinforced the growing interest in this type of exercise in recent years, becoming an interesting strategy in increasing VO_{2max} and in maintaining other health-related physical fitness indicators.

In this sense, it was observed that the HIIT / SIT + RT protocol can be used in adults with different nutritional status, reinforcing the applicability and versatility of this type of training. In addition, the HIIT / SIT + RT method has been applied in different age groups, for example in elderly patients with heart failure³⁸, in adolescents³⁴, as well as in athletes to improve physical fitness indicators related to sports performance³⁹.

The present study has limitations that deserve to be pointed out. The small number of individuals in each study selected as well as samples in different health conditions are factors that may interfere with the analyses, because although training with athletes has been excluded, the subjects' initial condition may be a relevant bias. Due to the great variety of weekly frequency, load and duration among HIIT / SIT + RT protocols studied, future studies should focus on analyzing which protocols make better control of total volume and caloric expenditure of training sessions, as well as diet control, so that distortions can be minimized and satisfactory results can be better elucidated and disseminated to the general population.

CONCLUSION

In conclusion, the studies found suggest that the use of interval training (HIIT / SIT) combined with strength training in adults may be more efficient for improving cardiorespiratory fitness when compared to other exercise protocols. However, our results are insufficient and new analyses should be conducted for a better understanding of the optimization of effects and greater knowledge of metabolic adaptations of this protocol in adults.

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