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Effects of long-term resistance training on blood pressure: a systematic review

Efeitos de longo prazo do treinamento resistido na pressão arterial: uma revisão sistemática

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Abstract – Studies assessed the beneficial effects of aerobic exercise on blood pressure (BP); however, few studies have evaluated the effects of long-term resistance training on variations of this response. The aim of the study was to verify through a systematic review, the long-term effect of resistance training on BP. Searches were made on Medline through Pubmed, Science Direct, Scopus, Web of Science and Lilacs databases. Overall, 751 articles were found, of which 22 were further analyzed. The analysis followed the PRISMA checklist (Statement for Reporting Systematic Reviews and Meta-Analyses of Studies) and was divided according to two resistance training models: traditional resistance training (TRT), resistance training alone; or combined resistance training (CRT), resistance training associated with aerobic exercise. Greater BP reductions occurred for CRT compared to TRT. However, further studies are needed to better explicit the resistance training variables (number of exercises, repetitions, number of sets, intervals, speed of execution and load intensity), in order to identify the best training model and improve the methodological quality of experiments in an attempt to reduce the risk of bias.

Key words: Blood pressure; Exercise; Hypertension; Resistance training.

Resumo – *Estudos têm verificado os efeitos benéficos do exercício aeróbico na modificação da pressão arterial (PA), entretanto poucos estudos avaliaram os efeitos a longo prazo do treinamento resistido na variação desse desfecho. Assim, o objetivo do estudo foi verificar por meio de uma revisão sistemática a ação de longo prazo do treinamento resistido na PA. Realizaram-se buscas nas bases Medline via Pubmed, Science Direct, Scopus, Web Science e Lilacs. Foram encontrados 751 artigos dos quais 22 fizeram parte da análise. A análise seguiu o checklist PRISMA (Statement for Reporting Systematic Reviews and Meta-Analyses of Studies) e foi dividida em função da utilização de dois modelos para a aplicação do treinamento resistido: treinamento resistido tradicional (TRT), somente exercícios resistidos, e treinamento resistido combinado (TRC), exercícios resistidos mais exercícios aeróbicos. As maiores reduções na PA ocorreram quando da realização do treinamento resistido combinado em relação ao treinamento resistido tradicional. Entretanto, são necessários mais estudos para melhor explicitar as variáveis do treinamento resistido (número de exercícios, repetições, número de séries, intervalos, velocidade de execução e intensidade de carga), para que se possa identificar o melhor modelo de treinamento e aprimorar a qualidade metodológica dos experimentos na tentativa de diminuir os riscos de viés.*

Palavras-chave: *Exercício; Hipertensão; Pressão arterial; Treinamento de resistência.*

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INTRODUCTION

Physical inactivity is a risk factor for the development of arterial hypertension (AH) and cardiovascular problems. AH is a modifiable risk factor, causing mortality from cardiovascular disease and has been presented as a prevalent health problem in several countries[1].

According to the World Health Organization[2], 40% of the world's population over 25 years has high blood pressure (BP). In Brazil, the prevalence of high BP ranges from 12.9% to 29.8% of the population, according to the region studied, ranging from 12.9% to 23.9% and from 12.7% to 34.7% in men and women, respectively[3]. Because it is a strong risk factor for the development of cardiovascular diseases, lifestyle modifications such as the practice of physical exercise should be encouraged even when the disease is controlled by medications[4].

It is consensus that the regular practice of aerobic training produces a long-term effect on BP reduction, being the most studied and recommended approach. However, studies on the long-term effect of resistance exercises (RE) on BP reduction are less frequent[5,6].

RE are physical activities developed predominantly through analytical exercises, using progressive resistances provided by material resources such as dumbbells, bars, washers or the body's own weight[7]. For BP reduction, they provide greater muscle strength, thus reducing cardiovascular effort in performing activities[8].

Thus, the aim of this study was to verify, through a systematic review of clinical studies, the long-term effect of traditional resistance training (TRT) compared to combined resistance training (CRT) in BP reduction.

METHODOLOGICAL PROCEDURES

Searches were performed between June 17 and June 22, 2014 on Medline, Science Direct, Scopus, Web Science and Lilacs and manual search.

The inclusion criteria were: clinical studies with resistance training; sedentary individuals over 19 years of age, with a measure of the long-term effect of resistance training on BP. No publishing language or year of publication has been delimited. Long-term response, articles that observed at least eight weeks of training at minimum frequency of twice a week were considered, so that they could show an acceptable long-term effect.

In Medline via PubMed the following search strategy was used: Search (((((("hypertension"[MeSH Terms]) OR "hypertension"[Title/Abstract]) OR "high blood pressures"[Title/Abstract]) OR "blood pressure"[MeSH Terms]) OR "blood pressure"[Title/Abstract]))) AND (((((((((("resistance training"[Title/Abstract]) OR "resistance training"[MeSH Terms]) OR "training, resistance"[Title/Abstract]) OR "strength training"[Title/Abstract]) OR (("training strength"[Title/Abstract] OR "training strengthens"[Title/Abstract]))) OR (("weight lifting exercise program"[Title/Abstract] OR "weight lifting exercise programs"[Title/

Abstract] OR "weight lifting exercises"[Title/Abstract]))) OR (("weight bearing strengthening program"[Title/Abstract] OR "weight bearing strengthening programs"[Title/Abstract]))) OR (("weight bearing exercise program"[Title/Abstract] OR "weight bearing exercise programme"[Title/Abstract] OR "weight bearing exercise programmes"[Title/Abstract] OR "weight bearing exercise programs"[Title/Abstract] OR "weight bearing exercises"[Title/Abstract]))) OR (("weight bearing exercise programs"[Title/Abstract] OR "weight bearing exercises"[Title/Abstract]))) Filters: Clinical Trial; Humans; Adult: 19+ years.

The search and selection of studies were analyzed by two researchers independently and blindly and disagreements were resolved by consensus.

Initially, the selection of studies was made by reading the title and abstract and, afterwards, the complete reading of the article. After complete reading, bibliographic references were observed for manual search.

Systolic (SBP) and diastolic (DBP) blood pressure variation was considered as outcome for resistance training.

To compose tables, the main author, country of origin and year of publication were extracted from each article. In the analysis of articles, the PICOS strategy was taken into account, where a set of characteristics such as Populations, Intervention, Comparator, Outcomes and Study design is considered.

Physical characteristics such as mean age and standard deviation and number of subjects by sex were considered. Training variables such as the training/ study period, weekly training frequency, load percentage, number of exercises and series (number of times repetitions are performed), number of repetitions, interval between sets and the percentage of outcome variation.

To analyze the methodological quality of studies, the Cochrane Risk of Bias Tool was used[9].

RESULTS

Of the 751 articles identified, 675 were excluded because they had no relation to the topic based on the reading of titles and abstracts. Of the remaining 76 articles, 26 articles were repeated, nine were review articles and 21 did not meet the inclusion criteria, remaining 20 articles. At the end of the search, two articles were added by manual search, according to Figure 1.

Due to variations in the resistance training models, it was decided to present analyses according to the type of training: traditional resistance training (TRT) and CRT (resistance exercises plus aerobic exercise), being designated by experimental group in the tables. The control group (CG) consisted most of studies with individuals who did not exercise and there is a smaller number of studies with individuals who practiced aerobic exercise only.

The 16 studies that performed TRT involved from six to 64 volunteers, with mean age varying from 33.9 to 76 years, the majority (11 studies) including both sexes, three men only and two women only (Table 1).

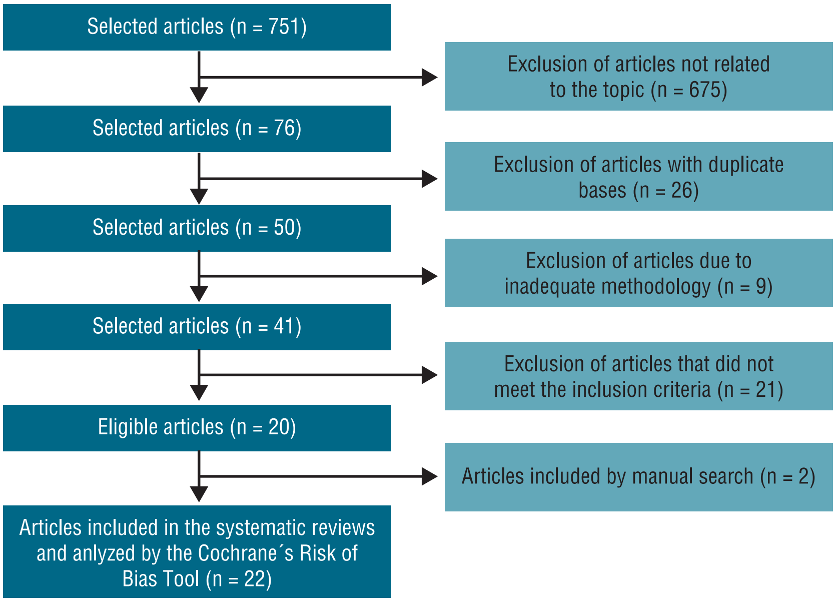

Figure 1: Flow diagram of article selection.

Table 1. Blood pressure (BP) behavior in sedentary subjects after the TRT and CRT period

Study	Age years Mean±SD	N (M/F)	EG (%)	CG (%)
TRT x CG Inactive				
Wanderley et al.[10] (Portugal)	68 (5.5)	11 (4 / 7)	SBP (-5.9%) DBP (-5.5%)	SBP (-3.6%) DBP (-2.8%)
Alvarez[11] (Chile)	33.9 (9.3)	8 (F)	SBP (-6.1%) DBP (-7.4%)	SBP (+0.8%) DBP (+1.3%)
Ho[12] (Australia)	52 [43-59]	16 (M) (F)	SBP (-1.3%) DBP (-1.4%)	SBP (-3.3%)* DBP (-3.3%)*
Souza[13] (Brazil)	48.7 (5.5)	9 (M)	SBP (-4.9%) DBP (-0.5%)	SBP (-3.5%) DBP (-3.2%)
Kanegusuku et al.[14] (Brazil)	63.9 (0.7)	13 (5 / 8)	BP (§)	BP (§)
Martins[15] (Portugal)	76 (8)	63 (25 / 38)	SBP (+0.5%) DBP (-4.0%)*	SBP (-2.5%) DBP (-1.0%)
Stensvold et al.[16] (Noruega)	50.9 (7.6)	11 (M) (F)	SBP (-1.9%) DBP (-2.0%)	SBP (+0.4%) DBP (-0.6%)
Hasley[17] (UK)	53 (9)	6 (3 / 3)	SBP (+3.7%) DBP (+2.7%)	SBP (+6.1%) DBP(+4.4%)
Sillanpää et al.[18] (Finland)	50.8 (7.9)	17 (F)	SBP (§) DBP (-1.4%)	SBP (-6.9%) DBP (-3.9%)
Terra et al.[19] (Brazil)	66.8 (5.6)	20 (F)	SBP (-9.2%)* DBP (-1.4%)	SBP (-1.1%) DBP (-1.2%)
Sigal et al.[20] (Canada)	54.7 (7.5)	64 (40 / 24)	SBP (-3.7%) DBP (- 2.5%)	SBP (-3.0%) DBP (-1.3%)
TRT x CG w/ Aerobic Training				
Bateman et al.[5] (USA)	45.8 (11.8)	31 (16 / 15)	SBP (+1.9%) DBP (-0.2%)	SBP (-0.5%) DBP (-1.1%)
Jakovljevic et al.[21] (UK)	63 (10)	10 (8 / 2)	SBP (-2.1%) DBP (-2.6%)	SBP (-3.1%) DBP (-4.9%)
Schjerve et al.[22] (Norway)	46.2 (2.9)	13 (2 / 11)	BP (§)	SBP (§) DBP (-9.0%)*

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Study	Age years Mean±SD	N (M/F)	EG (%)	CG (%)
Cauza et al.[23] (Austria)	56.4 (1.1)	22 (11 / 11)	SBP (-13.8%)* DBP (-9.5%)*	SBP (-14.2%)* DBP (-14.9%)*
Banz et al.[24] (USA)	48 (6)	12 (M)	SBP (-0.5%) DBP (+0.2%)	SBP (-0.3%) DBP (+1.3%)
CRT x CG Inactive				
Alvarez[11] (Chile)	(Ø)	10 (F)	SBP (-3.4%) DBP (-3.0%)	SBP (+0.8%) DBP (+1.3%)
Ho[12] (Australia)	52 [43 – 59]	17 (M) (F)	SBP (-4.2%)* DBP (-4.3%)	SBP (-3.3%)* DBP (-3.3%)*
Souza[13] (Brazil)	47.5 (5.1)	10 (M)	SBP (-7.8%)* DBP (-1.4%)	SBP (-3.5%) DBP (-3.2%)
Stensvold et al.[16] (Norway)	52.9 (10.4)	10 (M) (F)	SBP (-2.4%) DBP (+0.9%)	SBP (+0.4%) DBP (-0.6%)
Sillanpää et al.[18] (Finland)	48.9 (6.8)	18 (F)	SBP (+0.8%) DBP (+2.7%)	SBP (-6.9%) DBP (-3.9%)
Sigal et al.[20] (Canada)	53.5 (7.3)	64 (40 / 24)	SBP (-1.5%) DBP (§)	SBP (-3.0%) DBP (-1.3%)
Souza[25] (Portugal)	69.1 (5)	16 (M)	SBP (-16.2%)* DBP (-13.9%)*	SBP (-0.2%) DBP (-4.4%)
Rego[26] (Brazil)	68.7 (8.4)	26 (F)	SBP (-7.1%)* DBP (-2.1%)*	SBP (-0.9%) DBP (-1.6%)
Balducci et al.[27] (Italy)	58.8 (8.5)	288 (173 / 115)	SBP (-5.7%)* DBP (-4.8%)*	SBP (-2.8%)* DBP (-2.4%)*
Shaw[28] (South Africa)	26 (3.1)	13 (M)	SBP (-7.5%)* DBP (Ø)	SBP (+2.2%)* DBP (Ø)
Barone[29] (USA)	64.6 (5.7)	51 (25 / 26)	SBP (-3.8%) DBP (-4.8%)*	SBP (-3.1%) DBP (-1.9%)
Stewart et al.[30] (USA)	63 [61.5-64.5]	51 (25 / 26)	SBP (-3.8%) DBP (-4.8%)*	SBP (-3.1%) DBP (-1.9%)
TRC x CG w/ Aerobic Training				
Bateman[5] (USA)	45.8 (11.8)	25 13/12	SBP (-2.6%) DBP (-4.3%)*	SBP (-0.5%) DBP (-1.1%)

N: sample number; M: Male; F: Female; BP: Blood pressure; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; TRT: Traditional Resistance Training; CRT: Combined resisted training; EG: Experimental group; CG: Control group; SD: Standard Deviation; Ø: no information; §: without change; *: statistically significant variation.

The training period ranged from eight to 32 weeks, with predominance of 12 weeks of training (seven studies). The weekly training frequency ranged from two to five times a week, and most studies (11 studies) used frequency of three times a week. The number of exercises ranged from five to 10, and the number of sets varied from one to six, with the volume of three sets as the most used (six studies). The number of repetitions ranged from four to 20, and the interval of eight to 12 repetitions was the most used (six studies), but two studies [11,21] used time (one minute) to perform repetitions. The percentage of load used in eight studies ranged from 40% to 90% of repetition maximal (RM) and the interval between sets and exercises ranged from 30 seconds to three minutes (Table 2). Only two studies [14,19] reported the execution speed [(2 "X2": two seconds in the positive phase and two seconds in the negative phase of the exercise) (data not shown)].

Table 2: Characteristics of the application of TRT and CRT variables

Study	TP	TF	Load	QE	Sets	QR	RI
			%	N	N	N	
	†	Δ	†		†	†	†
TRT x CG Inactive							
Wanderley et al.[10] (Portugal)	32	3	80	9	2	12-15	120”
Alvarez[11] (Chile)	12	3	(Ȼ)	5	3	1’	120”
Ho[12] (Australia)	12	5	75	5	4	8-12	60”
Souza[13] (Brazil)	16	3	(Ȼ)	9	3	10 (1-8) 8 (9-16)	60” (1-8) 90” (9-16)
Kanegusuku et al.[14] (Brazil)	16	2	70-90	7	2	4-10	180”
Martins[15] (Portugal)	16	3	(Ȼ)	8	1 (1-4) 2 (5-12) 3 (13-16)	8-12 (1-4) 8-15 (5-12) 12-15 (13-16)	180”
Stensvold et al.[16] (Norway)	12	3	60 (1) 80 (2-12)	8	3	8-12	(Ȼ)
Hasley[17] (UK)	8	2	50 (1-4) 60 (5-8)	9	1 (1) 2 (2-8)	15	30”
Sillanpää et al.[18] (Finland)	21	2	40-60 (1-7) 60-80 (8-14) 70-90 (15-21)	9	3-4	15-20 10-12 6-8	(Ȼ)
Terra et al.[19] (Brazil)	12	3	60 (1-4) 70 (5-8) 80 (9-12)	10	3	12 (1-4) 10 (5-8) 8 (9-12)	60” (1-8) 90” (9-12)
Sigal et al.[20] (Canada)	22	3	(Ȼ)	7	2-3	7- 9	(Ȼ)
TRT x CG w/ Aerobic Training							
Bateman[5] (USA)	32	3	(Ȼ)	8	1 (1-2) 2 (3-4) 3 (5-32)	8-12	(Ȼ)
Jakovljevic et al.[21] (UK)	12	5	(Ȼ)	6	2	1’	60”
Schjerve et al.[22] (Norway)	12	3	90	(Ȼ)	4	5	(Ȼ)
Cauza et al.[23] (Austria)	12	3	(Ȼ)	10	3-6	10-15	(Ȼ)
Banz et al.[24] (USA)	10	3	(Ȼ)	8	3	10	(Ȼ)
CRT x CG Inactive							
Alvarez[11] (Chile)	12	5	(Ȼ)	5	3	1’	120”-150”
Ho[12] (Australia)	12	5	75	5	2	8 a 12	(Ȼ)
Souza[13] (Brazil)	16	3	(Ȼ)	6	3	10 (1-8) 8 (9-16)	60” (1-8) 90” (9-16)
Stensvold et al.[16] (Norway)	12	3	80	8	3	8-12	(Ȼ)
Sillanpää et al.[18] (Finland)	21	2	40-60 (1-7) 60-80 (8-14) 70-90 (15-21)	9	3-4	15-20 10-12 6-8	(Ȼ)
Sigal et al.[20] (Canada)	22	3	(Ȼ)	7	2-3	7-9	(Ȼ)
Souza[25] (Portugal)	36	3	65 (1-8) 75 (9-24) 70 (25-28) 65 (29-32)	9	3	12 8-10 8-10 10-12	30”
Rego[26] (Brazil)	18	2	(Ȼ)	10	2	10	40”

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Study	TP	TF	Load	QE	Sets	QR	RI
			%	N	N	N	
	†	Δ	†		†	†	†
Balducci et al.[27] (Italy)	48	2	(₡)	4	(₡)	(₡)	(₡)
Shaw[28] (South Africa)	16	3	60	8	2	15	(₡)
Barone[29] (USA)	24	3	50	7	2	12-15	(₡)
Stewart et al.[30] (USA)	24	3	50	7	2	10-15	(₡)
CRT x CG w/ Aerobic Training							
Bateman[5] (USA)	32	3	(₡)	8	3	8-12	(₡)

TP: Training Period; TF: Training Frequency; †: weeks; Δ: weekly times; QE: Number of Exercises; QR: Number of repetitions; RI: Recovery Interval; N: Number; %: Percentage; ₡: without citation.

In studies in which experimental group submitted to TRT was compared with the CG, which was inactive, it is observed that only two studies[15,19] of the 11 analyzed presented statistically significant changes in BP. One of them[15], the reported modification occurred only in DBP. Another study[19] showed modification only in SBP, although it presented no significant modification in DBP. Five other studies[10,11,13,16,20] showed greater changes in BP in relation to CG, but not statistically significant. Two studies[12,18] reported that BP had a greater reduction in CG. In one study[14], BP did not change as it did in CG, and in another study[17] that used the shortest intervention time (eight weeks), BP increased in both groups, with greater magnitude in the control group (Table 1).

In studies in which the experimental group was compared with the control group that performed aerobic exercises, one study[23] of the five analyzed had a significant variation in BP, although the magnitude was smaller than the control group. In two other studies[5,21], BP also varied with a smaller magnitude than the control group. In one study[24], BP had a greater magnitude variation compared to CG, and in another study[22], BP did not change, although in the control group, DBP decreased (Table 1).

In the analysis of the adherence of subjects to the intervention, of the 16 TRT studies analyzed, only in six[10,13,16,20,22,24], adherence was cited. In one study[13], adherence was fixed at 90%, in three[10,16,24], adherence was 80% and in two studies[20,22], adherence was 70% (data not shown).

As for the criteria of methodological quality of articles analyzed by the *Cochrane* Risk of *Bias* Tool[9], only articles of Stensvold et al.[16] and Sigal et al.[20] indicated low risk of bias in all the evaluation items. The generation of randomization sequence was adequate in five articles (31.3%), was not clear in 10 articles (62.5%) and was not mentioned in one article (6.2%). In five articles (31.3%) the allocation of subjects was not mentioned, in nine articles (56.2%), allocation was not clear and two articles (12.5%) did not mention allocation concealment. In nine articles (56.2%), data were not influenced by the lack of blinding, and seven articles (43.8%) did not make this item clear. Seven articles (43.8%) showed no incomplete data, six articles (37.5%) did not make clear the existence of incomplete data and three articles (18.7%) did not mention how incomplete data were analyzed. Bias by selective reports of outcome was present in one article (6.3%), absent in three articles (18.7%), and 12 articles (75%) did not contain elements for this analysis. High risk of other types of bias was evident in four articles (25%), none in six articles (37.5%), and six articles (37.5%) did not allow this analysis (Figure 2).

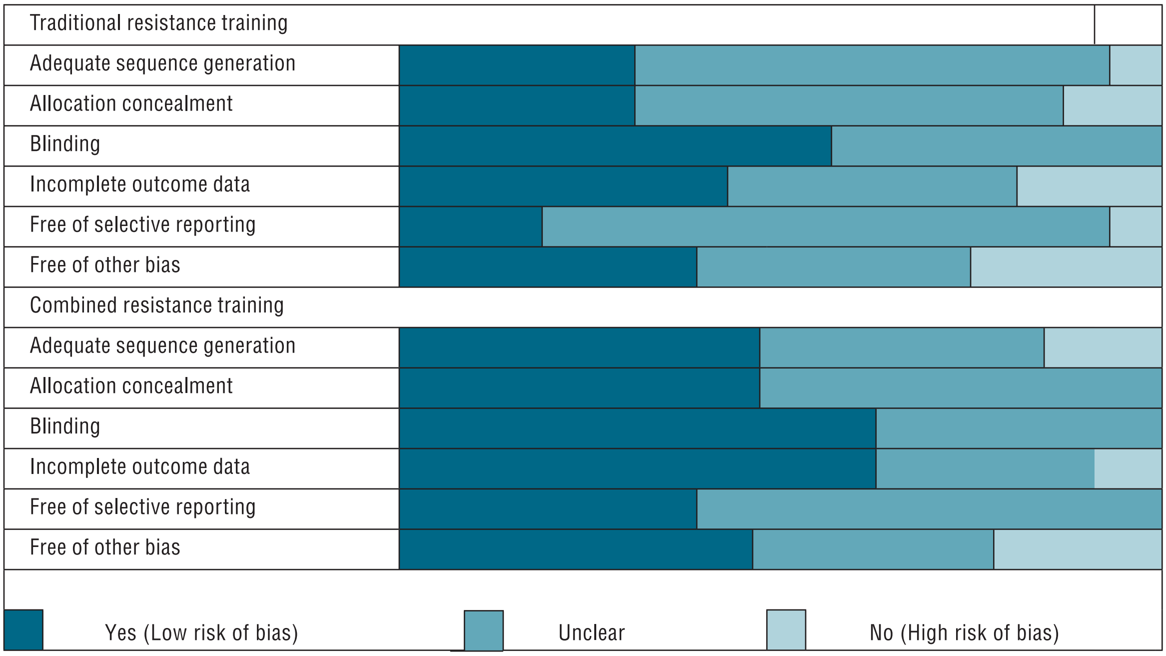

Figure 2. Analysis of the quality of articles involving TRT and CRT according to the *Cochrane* Risk of *Bias* Tool (percentage of the studies).

The 13 studies that performed CRT involved from nine to 606 volunteers with mean ages varying from 26 to 69.1 years. The majority (seven studies) included both sexes, three males only and three females only (Table 1).

The training period ranged from 12 to 36 weeks with no predominance of the number of weeks. The weekly frequency ranged from two to five times a week, and most studies (eight studies) used frequency of three times a week. The number of exercises used in articles ranged from four to 10, the number of sets ranged from two to four, with three series being the most used (seven studies). The interval of repetitions ranged from eight to 20, and the interval from eight to 12 repetitions was the most used (six articles), and one study[11] used time (one minute) to perform repetitions. The percentage of load used, cited by seven studies, varied from 40% to 90% of one RM, and the interval between sets and exercises, cited by only four studies, ranged from 30 seconds to two and a half minutes (Table 2). None of the articles cited execution speed.

In studies in which CRT of EG was compared to CG that did not perform physical activity, it is observed that three studies[25-27] of the 12 analyzed presented statistically significant changes in BP (SBP and DBP) in relation to CG. In three studies[12,13,28], SBP presented statistically significant changes in relation to CG. In other two[29,30], DBP presented statistically significant changes in relation to CG. In one, BP had higher magnitude variation in relation to CG. In two studies[18,20], BP of the CG had higher magnitude variation than in the EG. In one study[16], the SBP of EG varied with higher magnitude compared to CG; however, the DBP had greater variation compared to EG (Table 1).

In the only study[5] in which the CRT of EG was compared to CG that performed aerobic exercises, DBP had a statistically significant variation in relation to CG, and SBP had greater magnitude difference than in CG (Table 1). There is no real reason for this behavior. This variation may have been determined by the concomitant use of aerobic training in CRT or by the very instability of BP measurement throughout the day.

In the analysis of the adherence of subjects to the intervention, of the 13 CRT studies analyzed, in seven[13,16,20,25,26,29,30], adherence was cited. In one study[13], adherence was set at 90%, in four studies[16,25,29,30] adherence was 80%, and in two studies[20,26], it was 70% (data not shown).

Regarding the methodological quality criteria of CRT articles analyzed by the *Cochrane* Risk of *Bias* Tool[9], the studies by Stensvold et al.[16], Sigal et al.[20], Balducci et al.[27] and Shaw[28], had low risk of bias in all the evaluation items (not shown in the table). The generation of the randomization sequence was adequate in six articles (46.1%), was not clear in five articles (38.5%) and was not mentioned in two articles (15.4%). In six articles (46.1%), the allocation of subjects was concealed, in four articles (30.8%), how the allocation was performed was not clear and three articles (23.1%) did not mention allocation concealment. The impossibility of blinding subjects was not considered relevant for the results of eight articles (61.5%) and five articles (38.5%) did not analyze this aspect. Eight articles (61.5%) showed no incomplete results, four articles (30.8%) did not make clear the existence of incomplete data and one article (7.7%) did not mention how incomplete data was analyzed. No articles had high risk of bias due to selective reports of outcome, five articles (38.5%) were free of this bias, and eight articles (61.5%) did not make this analysis clear. High risk of other types of bias was evident in three articles (23.1%), non-existent in six other articles (46.1%), and four articles (30.8%) that did not allow this analysis had another bias (Figure 2).

DISCUSSION

When analyzing the results of BP variation, it can be observed that of the 13 studies in which CRT was applied, there was a significant decrease in BP in nine articles, three of them in SAP and DBP in other three only in SAP and in three other studies, only in DBP. In the TRT of the 16 articles analyzed, in only three BP decreased with one being in SBP and DBP, one in SBP and one in DBP.

In the TRT study[23] in which there was the highest BP variation, the authors used the largest set volume of all studies (six sets) and one of the largest number of repetitions (15), which may have contributed to this result.

In the CRT study[25] in which there was the highest BP variation, the authors used a long training time (36 weeks), used the circuit model and a low interval between recovery sets.

This variation in BP values in studies that applied CRT in relation to TRT can be explained in part by the aerobic component of CRT, providing an increase in peripheral blood flow and an increase in arterial compliance[31], decreasing peripheral resistance.

The sample size of studies analyzed may explain the scarcity of statistically significant results. Of the 29 studies analyzed in both groups (TRT and CRT), 18 studies (62.1%) were found with less than 20 subjects, which generates imprecise estimates.

Age did not appear to affect the differences in results because the mean age variations among studies were small and the mean age of TRT and CRT studies were similar.

Two studies, one of TRT[11] and one of CRT[28] that used younger subjects, did not obtain results of magnitude different from the other studies with older individuals.

Results according to sex were not analyzed, because in 11 studies (68.8%) of the 16 that performed TRT, and in seven studies (53.9%) of the 13 that performed CRT, the results were analyzed without distinction of sex, which provided a limiting factor in the analysis in relation to this important variable, since sex is an influencing factor in the prescription of exercises.

The 70% to 90% variation in the percentages of adherence to TRT and CRT did not seem to influence the results, since the amplitude of variation observed in the adherence to training was not enough to show a plausible influence on the effect of training on BP.

In addition to the variation of the training methods applied (TRT and CRT), other resistance training variables can influence the analysis of results, such as variation in load intensity[32], interval between sets performed, speed of exercise execution (almost all articles did not mention the speed used), number of sets, number of repetitions per exercise set and number of exercises applied in the training session. The quality of articles was also another item that influenced the analysis of results. Thus, the variation of methodologies used and the training variables, in addition to the limitations in the quality of studies, impaired the analysis and comparison of the results of studies.

CONCLUSION

Apparently, CRT provides, in the long term, larger BP reductions when compared to TRT. A larger number of CRT studies obtained higher magnitude results in BP change compared to TRT studies. Although analyzed only in one study, CRT also provided greater magnitude variations in both SBP and DBP when compared to the control group that performed aerobic exercise.

Age did not appear to affect the differences in results because the mean age variations among studies were small and the mean age of TRT and CRT studies was similar.

However, further studies are needed to identify how resistance training variables should be used in order to observe how these variables should be applied to reduce BP. Determining the proportion of load used (cited in half of the studies analyzed), the interval between repetitions of each exercise (cited in less than half of studies analyzed), the speed of exercise execution (variable that was only cited in 2 articles of the 22 analyzed), the number of exercises, the number of repetition groups, the number of repetitions and the training model used, in order to observe, how these variables should be applied to lower blood pressure. In addition, studies should have methodology that takes into account the norms of application of clinical studies, such as the creation of control group, so that the results found can be accepted as true.

Moreover, the improvement in the methodological quality of articles, such as the generation of adequate randomization sequence, concealment of subjects in the allocation and treatment of incomplete data do not allow us affirming that changes occurred in BP are effective due to the possibility of bias that may have interfered in the results found.

REFERENCES

1. Monteiro MDF, Sobral Filho DC. Exercício físico e o controle da pressão arterial. Rev Bras Med Esporte 2004;10(6):513-6.
2. World Health Organization. WHO Global InfoBase. 2008. Available at: <http://www.who.int/gho/ncd/risk_factors/obesity_text/en/> [2011 Dez 10].
3. Ministério da Saúde. Vigitel Brasil 2009. Vigilância de fatores de risco e proteção para doenças crônicas por inquérito telefônico. Brasília DF: Secretaria de Vigilância em Saúde; 2011.
4. Botelho LP, Vale RGS, Cader SA, Senna GW, Gomes MCV, Dantas EHM. Efeito da ginástica funcional sobre a pressão arterial, frequência cardíaca e duplo produto em mulheres. Acta Sci Health Sci 2011;33(2):119-25.
5. Bateman LA, Slentz CA, Willis LH, Shields AT, Piner LW, Bales CW, et al. Comparison of aerobic versus resistance exercise training effects on metabolic syndrome (from the Studies of a Targeted Risk Reduction Intervention Through Defined Exercise - STRRIDE-AT/RT). Am J Card 2011;108(6):838-44.
6. Church T. Exercise in obesity, metabolic syndrome, and diabetes. Prog Cardiovasc Dis 2011;53(6):412-8.
7. Godoy E. Musculação fitness. Rio de Janeiro: Sprint; 1994.
8. McCartney N, McKelvie RS, Martin J, Sale DG, MacDougall JD. Weight-training-induced attenuation of the circulatory response of older males to weight lifting. J Appl Physiol 1993;74(3):1056-60.
9. Cochrane Collaboration's Bias Methods Group (BMG). Critical appraisal and risk of bias tool. Canada. 2010; Available at: <http://bmg.cochrane.org/sites/bmg.cochrane.org/files/uploads/TTT%20June%202010.pdf> [2017 Out 20].
10. Wanderley FA, Moreira A, Sokhatska O, Palmares C, Moreira P, Sandercock G, et al. Differential responses of adiposity, inflammation and autonomic function to aerobic versus resistance training in older adults. Exp Gerontol 2013;48(3):326-33.

11. Álvarez C, Ramírez R, Flores M, Zúñiga C, Celis-Morales CA. Efectos del ejercicio físico de alta intensidad y sobrecarga en parámetros de salud metabólica en mujeres sedentarias, pre-diabéticas con sobrepeso u obesidad. Rev Méd Chile 2012;140(10):1289-96.
12. Ho SS, Radavelli-Bagatini S, Dhaliwal SS, Hills AP, Pal S. Resistance, aerobic, and combination training on vascular function in overweight and obese adults. J Clin Hypertens 2012;14(12):848-54.
13. Souza GV, Libardi CA, Rocha Jr J, Madruga VA, Chacon-Mikahil MPT. Efeito do treinamento concorrente nos componentes da síndrome metabólica de homens de meia-idade. Fisioter Mov 2012;25(3):649-58.
14. Kanegusuku H, Queiroz AC, Chehuen MR, Costa LA, Wallerstein LF, Mello MT, et al. Strength and power training did not modify cardiovascular responses to aerobic exercise in elderly subjects. Braz J Med Biol Res 2011;44(9):864-70.
15. Martins RA, Veríssimo MT, Silva MJC, Cumming SP, Teixeira AM. Effects of aerobic and strength-based training on metabolic health indicators in older adults. Lipids Health Dis 2010;76(9):1-6.
16. Stensvold D, Tjønna AE, Skaug EA, Aspenes S, Stølen T, Wisløff U, et al. Strength training versus aerobic interval training to modify risk factors of metabolic syndrome. J Appl Physiol 2010;108(4):804-10.
17. Hazley L, Ingle L, Tsakirides C, Carroll S, Nagi D. Impact of a short-term, moderate intensity, lower volume circuit resistance training programme on metabolic risk factors in overweight/obese type 2 diabetics. Res Sports Med 2010;18(4):251-62.
18. Sillanpää E, Laaksonen DE, Häkkinen A, Karavirta L, Jensen B, Kraemer WJ, et al. Body composition, fitness, and metabolic health during strength and endurance training and their combination in middle-aged and older women. Eur J Appl Physiol 2009;106(2):285-96.
19. Terra DF, Mota MR, Rabelo HT, Bezerra LMA, Lima RM, Ribeiro AG, et al. Redução da pressão arterial e do duplo produto de repouso após treinamento resistido em idosas hipertensas. Arq Bras Cardiol 2008;91(5):274-9.
20. Sigal RJ, Kenny GP, Boulé NG, Wells GA, Prud'homme D, Fortier M, et al. Effects of aerobic training, resistance training, or both on glycemic control in type 2 diabetes: a randomized trial. Ann Intern Med 2007;147(6):357-69.
21. Jakovljevic DG, Donovan G, Nunan D, McDonagh S, Trenell MI, Grocott-Mason R, et al. The effect of aerobic versus resistance exercise training on peak cardiac power output and physical functional capacity in patients with chronic heart failure. Int J Cardiol 2010;145(3):526-8.
22. Schjerve IE, Tyldum GA, Tjønna AE, Stølen T, Loennechen JP, Hansen HE, et al. Both aerobic endurance and strength training programmes improve cardiovascular health in obese adults. Clin Sci 2008;115(9):283-93.
23. Cauza E, Hanusch-Enserer U, Strasser B, Ludvik B, Metz-Schimmerl S, Pacini G, et al. The relative benefits of endurance and strength training on the metabolic factors and muscle function of people with type 2 diabetes mellitus. Arch Phys Med Rehabil 2005;86(8):1527-33.
24. Banz WJ, Maher MA, Thompson WG, Bassett DR, Moore W, Ashraf M, et al. Effects of resistance versus aerobic training on coronary artery disease risk factors. Exp Biol Med 2003;228(4):434-40.
25. Sousa N, Mendes R, Abrantes C, Sampaio J, Oliveira J. A randomized 9-month study of blood pressure and body fat responses to aerobic training versus combined aerobic and resistance training in older men. Exp Gerontol 2013;48(8):727-33.
26. Rêgo ARON, Gomes ALM, Veras RP, A. Júnior ED, Alkimin RMN, Dantas EHM. Pressão arterial após programa de exercício físico supervisionado em mulheres idosas hipertensas. Rev Bras Med Esporte 2011;17(5):300-4.
27. Balducci S, Zanuso S, Nicolucci A, De Feo P, Cavallo S, Cardelli P, et al. Effect of an intensive exercise intervention strategy on modifiable cardiovascular risk factors in subjects with type 2 diabetes mellitus: a randomized controlled trial: the Italian Diabetes and Exercise Study (IDES). Arch Intern Med 2010;170(20):1794-803.

28. Shaw I, Shaw BS, Cilliers JF, Brown GA. Concurrent resistance and aerobic training as protection against heart disease. Cardiovasc J Afr 2010;21(4):196-99.
29. Barone BB, Wang NY, Bacher AC, Stewart KJ. Decreased exercise blood pressure in older adults after exercise training: contributions of increased fitness and decreased fatness. Br J Sports Med 2009;43(1):52-6.
30. Stewart KJ, Bacher AC, Turner KL, Fleg JL, Hees PS, Shapiro EP, et al. Effect of exercise on blood pressure in older persons: a randomized controlled trial. Arch Intern Med 2005;165(7):756-62.
31. Umpierre D, Stein R. Efeitos hemodinâmicos e vasculares do treinamento resistido: implicações na doença cardiovascular. Arq Bras Cardil 2007;89(4):256-62.
32. Nery SS, Gomides RS, Silva GV, Forjaz CLM, Mion Jr D, Tinucci T. Intra-arterial blood pressure response in hypertensive subjects during low-and high-intensity resistance exercise. Clinics 2010;65(3):271-77.

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