ACUTE PHYSICAL EXERCISE AND HYPERTENSION IN THE ELDERLY: A SYSTEMATIC REVIEW

EXERCÍCIO FÍSICO AGUDO E HIPERTENSÃO ARTERIAL EM IDOSOS: REVISÃO SISTEMÁTICA

EJERCICIO FÍSICO AGUDO E HIPERTENSIÓN ARTERIAL EN ANCIANOS: REVISIÓN SISTEMÁTICA

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ABSTRACT

As the population ages, health conditions, including hypertension (HT), which is one of the most prevalent diseases in the elderly population, increase. Regular physical exercise has been recommended for hypertensive individuals; however, due to the variety of factors involved in exercise, different acute responses can be achieved. Accordingly, the purpose of this study was to perform a systematic review of the acute effect of physical exercise on blood pressure (BP) in elderly hypertensive patients and of its applicability to the treatment of HT. The search was performed in electronic databases available at Pubmed/Medline, Scopus and Bireme from 2008 to 2018, using the terms "acute physical exercise and hypertension and elderly". A total of 592 articles were found, and after applying the inclusion criteria, 9 articles were selected to form the analysis. All studies evaluated the acute effect of the exercise session and the acute effect of the session after a training period in male and female hypertensive individuals aged 60 years or over. The results indicate that in spite of the heterogeneity of training methods, all intervention protocols used in these studies were effective in promoting BP reduction post exercise when compared to the control group. However, there is still a gap in the reviewed literature regarding the maintenance time of post exercise hypotension (PEH) in the elderly. This information could suggest how long individuals undergoing physical exercise would be "protected" from high blood pressure values and their health risks, and help plan physical exercise sessions at the precise time the hypotensive effect ceases to be present. ***Level of evidence II; Therapeutic studies-Investigation of treatment results.***

Keywords: Aging; Arterial hypertension; Physical exercise; Post-exercise hypotension.

RESUMO

À medida que a população envelhece, aumentam os agravos de saúde, entre eles, a hipertensão arterial (HA) destaca-se como uma das doenças de maior prevalência na população idosa. O exercício físico regular tem sido recomendado para indivíduos hipertensos, entretanto devido à variedade com que o exercício pode ser realizado, diferentes respostas agudas podem ser obtidas. Sendo assim, o objetivo do presente estudo consistiu em realizar uma revisão sistemática sobre o efeito agudo do exercício físico na pressão arterial (PA) em idosos hipertensos e sua aplicabilidade para o tratamento da HA. A busca foi realizada a partir de bancos de dados eletrônicos disponíveis no Pubmed/Medline, Scopus e Bireme de 2008 a 2018, utilizando os termos "acute physical exercise and hypertension and elderly". Foram encontrados 592 artigos e, após aplicar os critérios de inclusão, foram selecionados nove artigos que fizeram parte da análise, os quais avaliaram o efeito agudo da sessão de exercício e o efeito agudo da sessão após um período de treinamento em indivíduos hipertensos, com idade a partir de 60 anos, de ambos os sexos. Os resultados apontam que apesar da heterogeneidade nos métodos de treinamento, todos os protocolos de intervenção utilizados nesses estudos foram eficazes na promoção da redução da PA pós-exercício quando comparados ao grupo controle. No entanto, ainda existe uma lacuna na literatura revisada em relação ao tempo de manutenção da hipotensão pós-exercício (HPE) em idosos. Essa informação poderia sugerir por quanto tempo os praticantes estariam "protegidos" dos elevados valores pressóricos e seus riscos para a saúde e auxiliar no planejamento das sessões de exercício físico, justamente quando o efeito hipotensor estivesse deixando de se manifestar. ***Nível de evidência II; Estudos terapêuticos–Investigação dos resultados do tratamento.***

Descritores: *Envelhecimento; Hipertensão arterial; Exercício físico; Hipotensão pós-exercício.*

RESUMEN

A medida que la población envejece, aumentan los agravios de salud, entre ellos, la hipertensión arterial (HA) se destaca como una de las enfermedades de mayor prevalencia en la población anciana. El ejercicio físico regular ha sido recomendado para individuos hipertensos, sin embargo, debido a la variedad con que el ejercicio puede ser realizado, diferentes respuestas agudas pueden ser obtenidas. Siendo así, el objetivo del presente estudio consistió en realizar una revisión sistemática sobre el efecto agudo del ejercicio físico en la presión arterial (PA) en ancianos hipertensos y su aplicabilidad para el tratamiento de la HA. La búsqueda fue realizada a partir de bancos de datos electrónicos disponibles en el Pubmed/Medline, Scopus y Bireme de 2008 a 2018, utilizando los términos "acute physical exercise and hypertension and elderly". Se encontraron 592 artículos y, después de aplicar los criterios de inclusión, se seleccionaron nueve artículos que formaron parte del análisis, los cuales evaluaron el efecto agudo de la sesión de ejercicio y efecto agudo de la sesión después de un período de entrenamiento en individuos hipertensos, con edad *a partir de 60 años, de ambos sexos. Los resultados apuntan que, a pesar de la heterogeneidad en los métodos de entrenamiento, todos los protocolos de intervención utilizados en estos estudios fueron eficaces en la promoción de la reducción de la PA postejercicio cuando comparados con el grupo control. Sin embargo, todavía existe un vacío en la literatura revisada con relación al tiempo de mantenimiento de la hipotensión postejercicio (HPE) en ancianos. Esta información podría sugerir por cuánto tiempo los practicantes estarían "protegidos" de los elevados valores presóricos y sus riesgos para la salud y auxiliar en la planificación de las sesiones de ejercicio físico, justamente cuando el efecto hipotensor estuviera dejando de manifestarse.* ***Nivel de evidencia II; Estudios terapéuticos-Investigación de los resultados del tratamiento.***

Descriptores: *Envejecimiento; Hipertensión arterial; Ejercicio físico; Hipotensión postejercicio.*

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INTRODUCTION

Aging is a universal phenomenon and longevity is currently identified as one of the most significant demographic transformations of the 21st century.[1] In developed and developing countries there has been a proportional reduction in the young population and an increase in the absolute number of older people. This process has multiple determinants, particularly the decline in birth rates, the increase in life expectancy and the reduction in mortality.[2]

Evidence of a progressively aging population has a direct impact on modern society, due to the significant demand for structural changes, especially those geared towards the public health area. As the number of older people grows, health problems also increase exponentially, with special emphasis on hypertension (HT) as one of the most prevalent diseases in the elderly population,[3,4] while vascular aging is the main aspect related to blood pressure (BP) elevation in the elderly.[5]

According to the World Health Organization (WHO), HT causes widespread concern among health professionals, as it is associated with cardiovascular and cerebrovascular diseases, identified as the leading causes of death in the world.[6] HT affects approximately 1 billion people worldwide, contributing to 9.4 million deaths from cardiovascular diseases per year. In Brazil, HT affects about 25% of the population, of which over 50% is acquired at an advanced age, emphasizing aging as an alarming factor for its occurrence.[7]

The development of HT is not due to an isolated cause, but to a set of factors that may increase the likelihood of its onset. Its etiology is multifactorial and involves social, environmental, psychological and genetic variables.[8]

To address this worrying public health problem, regular physical exercise is indicated as a non-pharmacological therapeutic tool for the treatment of HT. The VII Brazilian Guidelines on Hypertension pinpoint regular aerobic training as a preferential form of exercise, because it contributes both to the reduction of casual BP in pre-hypertensive and hypertensive individuals, and the reduction of awake BP in hypertensive individuals in situations of physical, mental and psychological stress. Due to its ability to produce an approximate systolic/diastolic blood pressure reduction of 2.1/1.7 in pre-hypertensive patients and 8.3/5.2 mmHg in hypertensive patients, respectively, physical exercise is of paramount importance for the prevention and treatment of HT.[5] Lifestyle changes as well as regular and continuous aerobic exercise is, according to the European Society of Cardiology, a Class I recommendation and level of evidence B, with an estimated reduction of approximately 6.9 mmHg in systolic blood pressure and 4.9 mmHg in diastolic blood pressure.[9] Reiterating this claim, the American College of Cardiology states that regular physical exercise is the best proven non-pharmacological intervention for the prevention and treatment of HT, and can cause a reduction of 5 to 8 mmHg in BP values.[10]

Although there is overwhelming evidence in the literature of the benefits of chronic adaptations resulting from regular physical exercise, the variety of factors involved in physical exercise is extensive (different exercise types, intensities, and durations), and it can thus elicit distinct acute responses, especially in elderly hypertensive individuals. Therefore, the purpose of this study was to conduct a systematic review of the last ten years on the acute effect of physical exercise on BP in hypertensive elderly individuals and its applicability to HT treatment.

MATERIALS AND METHODS

Study search and selection strategy

The search for articles on the effects of acute exercise on BP was performed from electronic databases available at Pubmed/Medline, Scopus and Bireme. The study was approved by the Institutional Review Board of the Universidade do Estado de São Paulo (IRB/FC-UNESP No. 2,422,919). The search was conducted using the terms "acute physical exercise and hypertension and elderly". This systematic review included only clinical trials published between January 2008 and December 2018, which investigated the acute effect of exercise on BP in elderly individuals (aged ≥60 years), diagnosed with HT. There were no restrictions imposed on the sex of the sample groups and the language of the studies. Reviews, meta-analyses, non-clinical trials, studies not involving physical exercise, animal studies, methodological or observational studies (descriptive only), and clinical trials that did not have the full text available were not included in the review. Due to the variability of the interventions, we only included articles with an analysis of the effect of an exercise session on BP. The literature search and evaluation of studies were carried out by two independent reviewers (TAR and AMGM). Articles were initially selected based on their title and abstract, and after both reviewers considered them eligible, studies were selected for full-text screening.

Data extraction and analysis

Data on study origin, sample size, participant characteristics (age, sex, baseline BP, physical activity level and comorbidities), method used to measure BP, intervention characteristics (type, frequency and duration of exercise), and results and limitations were extracted from studies included independently by two authors (TAR and AMGM). In the event of discordance between the reviewers, a third author (RFDS) was consulted. The methodological quality of the studies included was assessed using the PEDro scale (www.pedro.org.au). The results of the systematic review are presented descriptively (mean, standard deviations and minimum and maximum values).

RESULTS

The database search resulted in the selection of 592 articles, of which 449 were removed as they were not clinical trials. Of the 143 clinical trials, 84 were published before January 2008 and one was not available in the full text version. Of the 58 remaining clinical trials, 49 were removed because the population age was <60 years, the subjects were normotensive, or the trials did not involve exercise. Finally, after applying the eligibility criteria, we included nine articles in this review that evaluated only the acute effect of the exercise session (six studies) and acute effect of the session after a training period (three studies) on BP in hypertensive older people (Figure 1).

Study and characteristics of the subjects

The general description of each study is presented in Table 1. Nine articles were selected for the final analysis, six of which are considered crossover[11-16] and three parallel design.[17-19] As regards the trials, three are randomized and non-controlled.[12,15,16] Only one study presented samples of normotensive and hypertensive patients,[17] while the other articles only presented hypertensive patients. Seven articles were conducted with hypertensive women, one article considering both sexes[11] and another including only men,[13] while all the studies included participants aged between 60 and 80 years. Six studies assessed the acute effect of a single exercise session on BP with a sample size of 15-20 participants (totaling 106 participants), including only women, or only men or both sexes. Three studies assessed the acute effect of a single exercise session after a training period with a sample size of 20 to 64 participants (totaling 148 participants), including women only. In most studies, BP was measured by a digital or oscillometric device; only one study used the auscultatory method[11] and two studies used 24-hour ambulatory blood pressure monitoring (ABPM).[11,13] The methodological quality of the studies was assessed using the PEDro scale (Figure 2), with a mean PEDro score of 6.6 ranging from five to ten.

Effect of interventions on BP

The main results and conclusions of the different interventions are described in Table 2. It can be observed that there was a reduction in BP in all protocols when compared to the control intervention, but the results of this review showed some dissimilar effects on the different types of physical exercise, intensity and duration.

DISCUSSION

This systematic review evaluated the acute effect of physical exercise on BP in hypertensive elderly patients and its applicability to the treatment of HT. We found nine articles published in the last ten years.

The studies included in this article were found to contain a significant variety of training protocols, of which four used only muscle resistance exercises,[11,15,17,18] one used resistance exercises in combination with vascular occlusion,[14] another three combined resistance and aerobic exercises[12,13,19] and only one study used aerobic exercise alone, which was also associated with vascular occlusion.[16] Associated with the different types of exercises used, we also observed different intensities and durations of exercise sessions. Accordingly, it is important to emphasize that the physiological mechanisms involved in BP control and its relationship with the different ways in which physical exercise can be performed are not yet fully established, and may make a greater or lesser contribution to the reduction of BP values according to the training protocol used.

Among the studies included in this review, six analyzed only post--exercise BP reduction following an acute physical exercise session[11,13-17] while the other three repeated the analysis after a training period, assessing not only the acute effect alone, but also chronic adaptation and its effect on the magnitude of PEH.[12,18,19] The above observation shows that physiological and structural adaptations arising in the respective training periods of the studies, despite the use of different training protocols, may contribute to a better hypotensive effect both in chronic terms and in acute responses. A possible hypothesis is that under both conditions the shear stress stimulated by physical exercise (acute or chronic) acts on the endothelial cells which, through a cascade of events, lead to the production of the enzyme endothelial nitric oxide synthase, generating vasodilation and as a consequence the reduction of BP values.[20]

As indicated by the VII Brazilian Guidelines on Hypertension,[5] among other guidelines, aerobic treatment is recommended as a preferential option for the prevention and treatment of HT, a fact that draws attention when we observe that only one of the nine studies used aerobic exercise in its experimental protocol, in combination with vascular occlusion. Associated with this fact, there is a predominance of protocols using resistance and combined exercise, with only one investigation that combined resistance exercise with vascular occlusion. All protocols presented satisfactory post-exercise BP reduction results, demonstrating the search for innovative proposals in exercise planning for hypertensive patients, especially those with some limitation regarding overload, since the protocols that used vascular occlusion and lighter loads also had beneficial results in BP values.

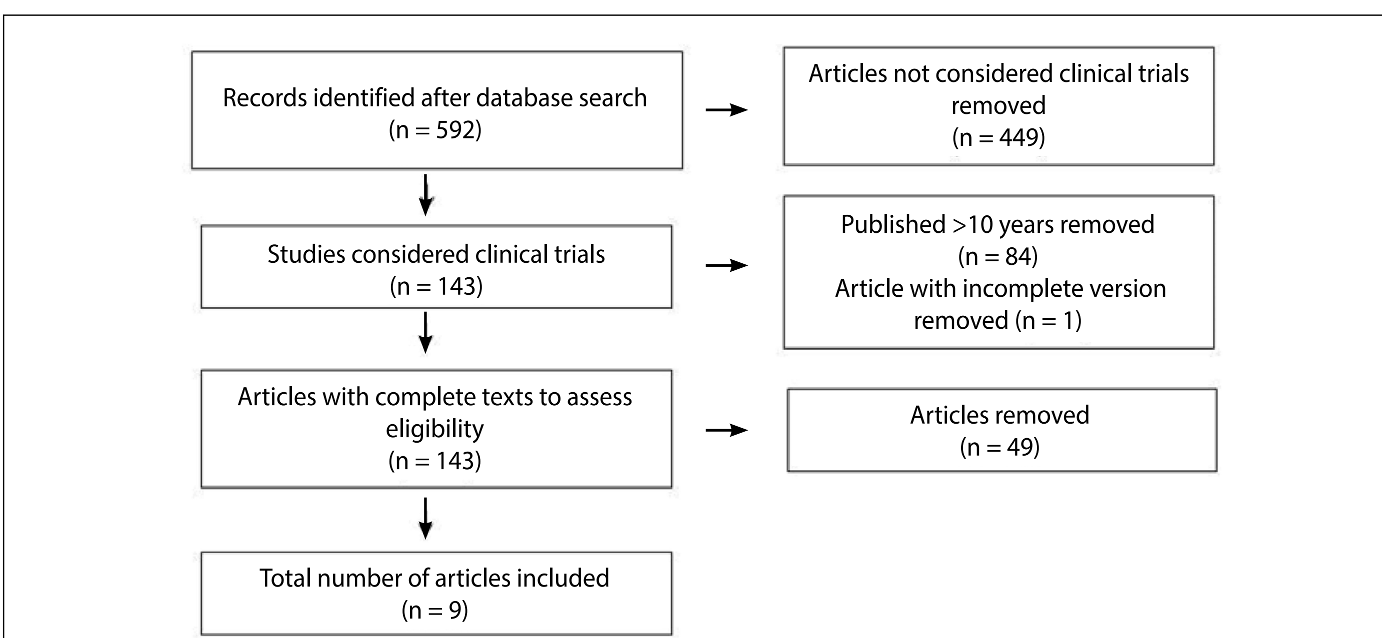

Figure 1. Study selection process.

Table 1. General characteristics of the studies.

Author(s) / Year/ Type of study	Sampling	Experimental intervention	Control intervention	Parameters measured
Scher et al., 2011[11]/ crossover	16 hypertensive participants (7 men/9 women, average age 67.6 ± 65.1) were randomized to exercise sessions 1 (E1), 2 (E2), and control.	E1: 20min of resistance exercises (1 lap around the circuit). E2: 40min of resistance exercises (2 laps around the circuit). Both sessions adopted intensity of 40% of 1RM.	40min of rest in the sitting position.	BP was measured every 5min using the auscultatory and oscillometric methods for 20min before the sessions. After each session, BP was measured every 5min for 60min. ABPM was installed and BP was automatically measured every 15min or 20min for 2h.
Mota et al., 2013[18]/ parallel	64 hypertensive women were randomized in the EG (n=32, average age 67.5 ± 7) and CG (n=32, average age 66.8± 5.4).	EG: Month 1: 3 weeks of adaptation; Month 2: 16 resistance exercise sessions at 60% of 1RM; Month 3: 16 resistance exercise sessions at 70%; Month 4: 16 resistance exercise sessions at 80%.	Did not perform any exercise.	BP was assessed with an automatic device and HR with a specific monitor. Variables were measured with participants sitting in all exercise and control sessions, every 5min for 20min at pre-exercise rest and after resistance exercise, and also every 15min during a 1h post-exercise recovery period.
Dos Santos et al., 2014[19]/ parallel	60 hypertensive women randomized in TRT (n=20, age 62.6±2.5), ERT (n=20, age 64.2±3.1) and CG (n= 20, age 63.1±2.3).	The protocols were combined with 20min of aerobic exercise, 3 times a week for 16 weeks. TRT Group: between 1 and 5 weeks at 70% of 10RMs, 6-11 at 80% and 12-16 at 90% of 10RMs, with an average duration to complete 1 repetition of 3-4 sec in both phases. ERT: between 1-5 weeks at 100% of 10RMs, 6-11 at 110% and 12-16 at 120% with an average duration of 1 repetition of 2-3s (eccentric phase and aid in the concentric phase).	Did not perform any exercise.	BP was measured by an oscillometric device and HR by a monitor after 10, 15, 30, 45 and 60min (time 1, 2, 3 and 4) of rest after control or exercise sessions. Post-exercise BP reduction was analyzed in the first training session after RT familiarization and strength testing, and chronic hypotension was measured after the last training session.
Moreira et al., 2016[12]/ crossover	20 hypertensive women (age 66.8±5.6) undergoing the acute physical exercise session and the chronic training.	The acute exercise session consisted of 10 resisted exercises on machines at 60% of 1RM. Participants then underwent progressive RE training for 12 weeks at 60-80% of 1RM.	Absent.	BP and HR were measured using a digital automatic device after 20min of rest in the pre-intervention period and for 60min after the RE session. These pre-exercise data from the acute session were also used to analyze chronic effects.
Pinto et al., 2018[14]/ crossover	18 hypertensive women (age 67±1.7) randomized in TVO, TWVO and CG.	TVO group performed 3 sets of 10 repetitions at 20% of 1RM with VO. The TWVO group performed 3 sets of 10 repetitions at 65% of 1RM without VO. Both exercise sessions were performed on the knee extension equipment with a 1min interval between sets.	Absence of exertion with VO.	BP was measured by a digital device after 10min of rest and was also obtained using continuous noninvasive digital photoplethysmography during the experimental and control sessions.
Coelho-Júnior et al., 2017[17]/ parallel	21 normotensive (n=11) and hypertensive (n=10) women randomized in ST (n=11, age 66.7±4.7), RT (n=10, age 67.5±4.4) and CG (n=10, age 66.8±5.4).	RT: 3 sets of 8 to 10 repetitions of each exercise at 70% of 1RM; ST: 3 sets of 8 to 10 repetitions of each exercise at 50% of 1RM. In the ST each repetition should be performed at the highest possible speed.	Did not perform any exercise.	BP was measured 20min before the experimental sessions and for 1h after the exercises (5, 10, 15, 30, 45 and 60min) using an automated oscillometric device.
Ferrari et al., 2017[13]/ crossover	20 hypertensive men (age 65.3 ± 3.3) randomized in AE, ARE and CG.	AE: 45min of walking on the treadmill at 65-70% of VO_{2max}. ARE: 20min of resistance exercises at 70% of 1RM, followed by 25min of aerobic exercise at 65-70% of $VO_{2max.}$	45min of rest in the sitting position.	BP was measured by an oscillometric device after 20min of rest before the sessions. After the sessions, BP was measured every 5min for 1h. ABPM was installed and BP was measured automatically every 15min during the day (11h to 22h) and every 20min at night (22h to 6h).
Orsano et al., 2018[15]/ crossover	15 hypertensive women (age 67.1±6.9) randomized in RT and HSRT.	Both sessions consisted of 10 exercises at 70% of 10RM with 1min interval between sets. The RT group completed the concentric and eccentric phases of movement at a moderate pace (2-3s each), and the HSRT group completed the concentric phase as quickly as possible.	Absent.	BP was measured after 15min of rest (time point 0) before the sessions and at 5, 15, 30 and 45min after the experimental sessions using an oscillometric device.
Barili et al., 2018[16]/ cross over	16 hypertensive women (age 67±3.7) randomized in HIAE, LIAE and LIAE + VO.	Each subject performed 3 experimental protocols on the treadmill: HIAE (aerobic exercise at 50% of VO_{2max}); LIAE (aerobic exercise at 30% of VO_{2max}) and LIAE + VO (aerobic exercise at 30% of VO_{2max} with blood flow restriction at a pressure equivalent to 130% of SBP measured at rest).	Absent.	BP was measured after 15min of rest before the experimental protocols, after the exercise session, and 30min after recovery.

E1: exercise one; E2: exercise two; RM: repetition maximum; BP: blood pressure; ABPM: 24-hour ambulatory blood pressure monitoring; EG: experimental group; CG: control group; HR: heart rate; TRT: traditional resistance training; ERT: eccentric resistance training; PEH: post-exercise hypotension; RT: resistance training; RE: resisted exercise; TVO: training with vascular occlusion; TWVO: training without vascular occlusion; VO: vascular occlusion; ST: strength training; AE: aerobic exercise; VO_{2max}: maximal oxygen uptake; ARE: aerobic + resisted exercise; HSRT: high speed resistance training; HIAE: high intensity aerobic exercise; LIAE: low intensity aerobic exercise; LIAE + VO: low intensity aerobic exercise + vascular occlusion; SBP: systolic blood pressure.

	PEDro criteria											
Author and year	Eligibility	Subjects were randomly assigned	Blind Distribution	Similar Groups	Subjects were blinded	Therapists were blinded	Assessors were blinded	Results measured in >85% of participants	Intent-to-Treat analysis	Intergroup comparison	Measures of variability	Total
Scher et al., 2011[11]	S	S	N	S	N	N	N	S	S	S	S	6/10
Mota et al., 2013[18]	S	S	N	S	N	N	N	S	S	S	S	6/10
Dos Santos et al., 2014[19]	S	S	N	S	N	N	N	S	S	S	S	6/10
Moreira et al., 2016[12]	S	N	N	S	N	N	N	S	S	S	S	5/10
Coelho-Júnior et al., 2017[17]	S	S	S	S	S	N	N	S	S	S	S	8/10
Ferrari et al., 2017[13]	S	S	S	S	S	S	S	S	S	S	S	10/10
Pinto et al., 2018[14]	S	S	N	S	N	N	N	S	S	S	S	6/10
Orsano et al., 2018[15]	S	S	N	S	N	N	N	S	S	S	S	6/10
Barili et al., 2018[16]	S	S	S	S	N	N	N	S	S	S	S	7/10

Figure 2. PEDro classification for the studies included.

The considerable heterogeneity in training methods may have resulted in different responses in BP behavior. However, it is important to note that all intervention protocols carried out in the studies selected in this systematic review were effective in promoting post-exercise BP reduction when compared to the control group, but the absence of post-exercise BP monitoring in most studies ruled out the possibility of evaluating the duration of post-exercise hypotension (PEH). Only two articles[11,21] used ABPM in their experimental protocols to effectively evaluate the hypotensive effect for up to 24h after an acute exercise session, which makes it possible to measure how long PEH lasted, thus demonstrating a period of time in which exercisers can be "protected" from elevated blood pressure values and their associated health risks.

This observation is relevant to future studies since it would enable us to measure which of the interventions results in desirable pressure responses, and for how long the PEH status lasts. This would allow us to verify, for example, the optimal time for application of a new exercise overload, precisely when the hypotensive effect has ceased. Thus, following the basic principles of physical training, it would be possible to construct an overcompensation curve of the hypotensive effect for each type of exercise performed, such that, knowing the dose-response effect of the physical exercise undertaken, its application would be similar to the administration of a drug or combination of drugs with expected pharmacological effect.

Regarding the methodological quality of the studies included, assessed by the PEDro Scale, all were methodologically deficient, and only one study met all the criteria, which reinforces the risk of bias for interpretation and comparison of data, since most of the studies are subject to limitations such as the blinding of patients, therapists and assessors in treatment conditions, besides the lack of randomization and control.

Implications for clinical practice

Despite the distinction between exercise and/or training protocols used in the studies analyzed, the effect of PEH can be observed in all studies, a fact that may provide more support when planning physical training for both prevention and treatment of HT.

Limitations

This review was limited by the heterogeneity of intervention programs and variety in BP measurement protocols. In addition, the different equipment used, as well as the time points at which BP was measured, may influence the interpretation of PEH to compare the effect of the protocols of this particular study.

CONCLUSIONS

All the reviewed articles, regardless of the methods used, were effective in promoting post-exercise BP reduction. However, there is still a gap in the reviewed literature regarding the maintenance time of PEH in the elderly. This information could suggest how long individuals undergoing physical exercise would be "protected" from high blood pressure values and their health risks, and help plan exercise sessions at the precise time the hypotensive effect ceases to exist.

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All authors declare no potential conflict of interest related to this article

Table 2. Main results and conclusions of the studies.

Author/Year	Results	Conclusion
Scher et al., 2011[11]	BP was reduced in the first 60 min after session E1 and E2 compared to CG. E1: SBP reduction of 8 mmHg in the oscillometric method and 9 mmHg auscultatory method ($p < 0.01$); DBP reduced 6 mmHg oscillometric method and 3 mmHg auscultation method; E2: SBP reduction of 10 mmHg oscillometric and 12 mmHg auscultatory ($p < 0.01$); DBP reduced oscillometric 7 mmHg and auscultatory 4 mmHg ($p < 0.05$). BP of session E2 was lower than BP after E1 (SBP [95% CI, 0.46–3.9] oscillometric and [95% CI, 1.53–4.48] auscultatory, $p < 0.01$, and DBP [95% CI, 0.4–2.4] oscillometric and [95% CI, 0.3-2.2] auscultation, $p < 0.05$). Only E2 promoted a reduction in the mean 24-hour SBP and awake BP ($p < 0.05$) after exercise, with a higher DBP during sleep ($p < 0.05$). The 24h DBP and the SBP and DBP were higher during sleep after E1 ($p < 0.05$).	Acute sessions of resisted exercise at 40% intensity with different volumes reduced BP during the first 60min in hypertensive elderly subjects. However, only the highest volume promoted a reduction in mean 24h and awake SBP.
Mota et al., 2013[18]	SBP: at month 3 there was a significant difference in 30 min ($p = 0.009$) and 45 min ($p = 0.05$) recovery period between EG and CG. At month 4 there was a significant difference at all recovery times ($p \leq 0.05$). Acute PEH at months 2 (from 134.5 ± 14.6 to 126.4 ± 16.5) and 3 (from 124.9 ± 11.8 to 121.6 ± 11.9). Mean reduction 14.3 mmHg at the end of the training period. DBP: there was a significant difference at rest ($p = 0.001$) and in 60min recovery ($p = 0.001$) only at month 2 between CG and EG. Acute PEH at months 2 (from 80.9 ± 11.1 to 73.0 ± 10.0) and 4 (from 72.4 ± 9.3 to 69.7 ± 9.2). Mean reduction of 3.6 mmHg at the end of the training period. The CG had no variation.	Resistance training at 60% and 70% of 1RM was able to generate a reduction in post-exercise SBP in hypertensive women, while DBP underwent a 60% and 80% of 1RM post-exercise reduction. The 4-month period contributes to a chronic reduction in the EG BP.
Dos Santos et al., 2014[19]	There were significant interactions in the groups for lower SBP and DBP than in the CG. When the pre and post intervention periods were compared, there was a reduction in SBP of 6.94 ± 0.2 in the ERT group and 4.17 ± 0.57 mmHg in the TRT; in DBP there was a reduction of 12.03 ± 1.23 in ERT and 8.12 ± 1.10 in TRT. PEH in the ERT group underwent a reduction of 4.01 ± 0.37 in SBP in a greater magnitude than TRT, which had a reduction of 2.52 ± 0.388 mmHg. In DBP there was a reduction of 4.93 ± 0.95 in the ERT and 4.17 ± 0.57 in the TRT.	Both protocols of RT combined with aerobic exercise were effective in reducing BP after 16 weeks. Post-exercise SBP reduction was correlated with the magnitude of change in BP after chronic RT only in the ERT. ERT in combination with aerobic exercise is safe and effective for elderly hypertensive women.
Moreira et al., 2016[12]	There were no acute reductions in BP, but chronic reduction was observed. There were significant chronic decreases in SBP and DBP in participants with acute SBP and DBP reduction ($p < 0.05$). SBP changes after acute RE session were correlated with chronic changes in resting SBP after training ($r = 0.47$; $p = 0.03$). Similar correlations between acute and chronic responses were also observed for DBP ($r = 0.70$; $p = 0.01$), mean BP ($r = 0.58$; $p = 0.01$), and HR ($r = 0.73$; $p < 0.01$).	Acute BP responses after a single RE session were associated with chronic changes in BP after the training program. This finding makes the magnitude of changes in BP a promising candidate for predicting BP-related individuals, which may contribute to the prescription of resistance training in hypertensive patients.
Pinto et al., 2018[14]	Significant elevation in SBP and DBP ($p < 0.05$) at all time points of the experimental sessions compared to the control session. SBP and DBP were lower during rest intervals in the session with VO ($p < 0.05$). A significant difference was observed in SBP and DBP at the pre and post-session time points, but the TVO tended to reduce SBP (from 132.7 ± 3.1 to 129.8 ± 2.9 mmHg) and DBP (from 76.0 ± 2.3 to 74.2 ± 2.5 mmHg), while the TWVO increased SBP (from 130.3 ± 4.2 to 138.5 ± 5.9 mmHg) and reduced DBP (from 73.2 ± 1, 8 to 71.1 ± 2.4 mmHg).	Although there was no significant difference between pre and post BP values in the experimental sessions, TVO presented lower BP values during the intervals at all time points and a tendency to decrease at the post-session time point, besides being easier to perform as the participants were expected to lift lighter loads until failure, proving to be a safer method for hypertensive women as compared to TWVO.
Coelho-Júnior et al., 2017[17]	SBP in the ST group decreased by 10 (-7.8 ± 8.0), 15 (7.3 ± 7.4), 30min (-9.1 ± 10.0) and 45min (-7.5 ± 10.2) after the exercise session compared with rest ($p = 0.001$), while RT showed no significant difference despite a downtrend. DBP showed no significant difference in the CG, RT and ST groups.	An acute session of ST and RT may be effective in causing benefits for BP, but ST has been shown to be superior in inducing a reduction in SBP, indicating the potential of this type of physical training to be used as a non-pharmacological tool in the treatment of hypertensive elderly women.
Ferrari et al., 2017[13]	DBP was lower after AE and ARE compared to the CG at 20min of recovery ($p < 0.05$); mean BP was lower after AE and ARE compared to the CG from 10 to 50min of recovery ($p < 0.05$). SBP decreased after AE from 10 to 50min of recovery and after the ARE session from 10 to 40min ($p < 0.05$). In the CG no immediate effect was observed. DBP decreased after ARE from 10 to 40min of recovery and at 10min after the AE session, while it increased 10, 40, 50 and 60min after control session ($p < 0.05$). Mean BP decreased after ARE from 10 to 30min of recovery and after the AE session at 10min of recovery, while it increased from 40 to 60min after control session ($p < 0.05$). During the first hour after the sessions, DBP was lower after AE (-5 mmHg) and ARE (-6 mmHg) compared to the CG. Daytime DBP was significantly lower after AE (-7 mmHg) when compared to the CG. No significant differences were found between the three experimental sessions for DBP.	Combined exercise produced acute PEH similar to aerobic exercise, but this effect did not last as long as aerobic exercise in hypertensive elderly subjects. During the first hour after the sessions, DBP was lower after AE (-5 mmHg) and ARE (-6 mmHg) compared to the CG. Daytime DBP was significantly lower after AE (-7 mmHg) when compared to the CG. No significant differences were found between the three experimental sessions for nighttime and 24h DBP, or for daytime, nighttime and 24h BP.
Orsano et al., 2018[15]	There was no significant difference in SBP between the experimental sessions at baseline and for 30min after the sessions. DBP did not change significantly ($p > 0.05$) between conditions at baseline and for 45min after the sessions. SBP was significantly higher ($p = 0.049$) for the HSRT session compared with RT only after 45min of exercise. SBP was also significantly higher ($p < 0.05$) at 30 and 45 min after the HSRT session compared with resting values, while it was significantly higher ($p < 0.05$) at time point 0 only after the RT session in comparison with rest values. DBP was significantly higher ($p < 0.05$) after time point 0 and after 5min only after the RT session in comparison with rest values.	Both HSRT and RT performed at the study intensity and volume present benefits in acute BP responses, suggesting they are safe for elderly hypertensive women receiving medication.
Barili et al., 2018[16]	BP increased from rest to post-exertion ($p < 0.05$) and decreased from post-exertion to recovery ($p < 0.05$) in all protocols. SBP and DBP returned to resting levels after the recovery period in LIAE and LIAE + VO. However, in the LIAE protocol, BP was lower after recovery compared to the rest period ($p < 0.05$).	The results support the indication of LIAE and LIAE + VO in chronic intervention protocols with potential benefits for hypertensive elderly patients.

DBP: diastolic blood pressure; CI: confidence interval.

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