Influence of resistance training on ambulatory blood pressure monitoring: a brief review

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Abstract

Arterial hypertension is considered a primary risk factor in the development of cardiovascular diseases. An effective non-pharmacological strategy against arterial hypertension is the practice of physical exercises. However, issues remain about the ambulatory behavior of blood pressure after different training protocols, especially strength exercises. In this sense, the objective of this study was to review and summarize the main results found in the literature that investigated the effects of strength training (isolated and associated with other interventions) on ambulatory blood pressure monitoring. A search was carried out in the free databases PubMed, Lilacs and Google Scholar, using the keywords in different combinations. Studies in the English language were considered, which investigated ambulatory blood pressure monitoring after acute strength training, after a period of strength training alone and/or in association with other interventions. To sum up, strength training (isolated and combined) is an essential measure for lowering blood pressure and improving/maintaining vascular health. The combination of different training strategies in a periodized manner can be adopted to generate broader benefits in hemodynamic measurements. An important point that was observed in the studies is that strength training can be implemented as an interesting option for those individuals who cannot do aerobics training, especially for the older people who need to stimulate the neuromuscular system. It can help with other benefits, such as blood pressure control, mood improvement, sleep quality, among others.

Key words: blood pressure; hypertension; exercise; health

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Introduction

Hypertension is considered a primary risk factor for the development of coronary artery disease, chronic kidney disease, acute myocardial infarction, kidney failure, among other disorders of the circulatory system [1, 2]. Literature data show that a large part of the world population is diagnosed with arterial hypertension [1, 3]. In this sense, intervention measures (both pharmacological and non-pharmacological) should be taken against the effect of arterial hypertension. One of the non-pharmacological measures is the systematic practice of physical exercises [1, 4, 5].

It is known, currently, that a single session of physical exercise can reduce blood pressure during the recovery period, both in hypertensive and normotensive individuals [6, 7]. This phenomenon is

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known as post-exercise hypotension and is characterized by reducing blood pressure below the pre-exercise situation or control session [1, 6].

To be clinically relevant, blood pressure reduction must present high magnitude and be sustained for long periods after the end of the training session. In this context, monitoring ambulatory blood pressure is an important means to assess blood pressure behavior for 24 hours [2]. This procedure helps to identify blood pressure variations during routine activities, presenting significant clinical applicability.

Among physical exercise modalities, strength training has been appointed by important health entities such as the American Heart Association and the American College of Sports Medicine as an auxiliary therapy in the treatment of arterial hypertension [1, 8]. However, issues remain about the ambulatory behavior of blood pressure after different strength training protocols. In this sense, due to the popularity of strength training and the increasing literature on the subject, the objective of this study was to review and summarize the main results found in the literature investigating the effects of strength training (isolated and associated with other interventions) on monitoring blood pressure clinic.

Material and methods

Literature search methodology

This is a literature review about the effects of strength training (isolated and associated with other interventions) on ambulatory blood pressure monitoring.

A search was carried out in the free databases PubMed, Lilacs and Google Scholar using the keywords in different combinations: "strength training", "resistance training", "strength exercise", "resistance exercise", "ambulatory blood pressure", "ambulatory bp", "ambulatory sbp", "ambulatory dbp", "24 hour blood pressure", "daytime blood pressure", "daytime bp". As inclusion criteria, studies in the English language were considered, which investigated ambulatory blood pressure monitoring after acute strength training and after a training period. Studies that investigated strength training in association with other interventions were also considered. No temporal limits were applied to the research period. As part of a secondary inclusion, the articles found in the reference list of each text were read and, if related to the topic, were examined and included in this article. The bibliographic survey was carried out in January 2022.

Results and Discussion

The temporal distribution of publications included in this article was as follows: 1 article from 1998, 1 from 2001, 1 from 2004, 1 from 2006; 1 from 2009, 1 from 2011, 1 from 2013, 1 from 2015, 1 from 2016, 2 from 2017, 1 from 2018, 4 from 2020, 2 from 2021, totaling 18 articles. Among these, 10 articles were conducted with hypertensive patients [6, 9–17], 6 with normotensives [7, 18–22], 2 with hypertensives and normotensives [15, 23], 7 studies researched older people [10, 11, 14–17, 23], 11 studies were conducted with adults (young and middle-aged) [6, 7, 9, 12, 13, 18–21, 24, 25], 1 study evaluated children and adolescents [22] and 2 studies investigated other complications (diabetes and metabolic syndrome) [24, 25]. The summary of the main findings is described in Table 1.

Muscle power work and ambulatory blood pressure monitoring

Muscle power is defined as the product of force and movement speed and is manifested in the ability to quickly produce force [26, 27]. Muscle power work is extremely important for improving the performance in sports activities and activities of daily living, especially among older people [26–29].

Thus, Schmitt et al. [14] investigated a protocol of muscular power resistance training in hypertensive older people of both sexes. The sample performed 3 sets from 8 to 10 repetitions; the speed was maximum for the concentric phase and controlled for the eccentric phase (1–2 seconds). The results demonstrated, during the first hour, a significant reduction in laboratory blood pressure (systolic blood pressure: –10 mm Hg; mean blood pressure: –6 mm Hg and diastolic blood pressure: –4 mm Hg). However, these values were not supported for ambulatory conditions.

When compared to differences between the sexes, older men presented better results in reducing blood pressure (reduction of systolic and diastolic blood pressure in the laboratory, reduction of 24-hour diastolic blood pressure and blood pressure at night) than older women after power training [16]. We can associate the magnitude and duration of responses to the manipulation of strength training variables, because, although the volume of training protocols being the same (sets and repetitions), the absolute load for men was significantly higher and, perhaps, this explained the differences between the sexes [16]. Regarding this topic, the literature has already demonstrated differences in hypotensive mechanisms between genders, with men lowering blood pressure

Table 1. Characteristics of training protocols

Study	Population	Training Protocol	Main Results
Hardy and Tuckey [9]	HT	7 exercises, 3 sets 8–12 reps, 1-minute rest	↓ of SBP and DBP for 1 hour
Roltsch et al. [18]	NT	12 exercises, 2 sets, 8 RM for upper limbs, 12 RM for lower limbs, 1 min rest	No statistical differences were observed in relation to the control session
Bermudes et al. [19]	NT	Aerobic session (AS): cycle ergometer (60%-70% of MHR), duration: 45 min. continuously Resistance exercise session (RES): circuit with weights, 3 sets, 10 exercises (stations), 20-25 reps, 40% of 1RM, 30-second rest; Control session (CS): no exercises;	AS: ↓ DBP (24-hour average) and during sleep RES: ↓ DBP during sleep CS: no effects
Melo et al. [6]	HT	6 exercises, 3 sets, 20 reps, 40% of 1RM, 45 seconds rest between sets and 90 seconds between exercises	Laboratory measurement: ↓ SBP (for 120 min) ↓ DBP (for 30 min) in relation to pre-exercise values Ambulatory measure: ↓ SBP and DBP (for 10 hours) in relation to the control session.
Queiroz et al. [7]	NT	6 exercises, 3 sets max, 50% of 1RM, 45 seconds rest between sets and 90 seconds between exercises	↓ blood pressure (SBP, DBP, MAP) in some periods in the laboratory condition (between pre-exercise measurements and control session); No statistical differences were observed for the ambulatory measurement
Morais et al. [24]	DM	AS: 20 min, cycle ergometer, 90% lactate threshold RES: 3 laps of a circuit of 6 exercises, 8 repetitions (70% of 1RM) and 40-second rest CS: non-exercise day	Both physical exercise protocols reduced blood pressure (SBP, DBP and MAP). However, RES was more effective than AS, as it presented differences in relation to the control session
Tibana et al. [25]	MS e WMS	8 weeks of training, 3 times a week, 3 sets, 8–12 max reps, 12 exercises and 1 min rest between sets and exercises	↓ nocturnal DBP (–3.9 mm Hg) and MBP (–5.5 mm Hg) in the MS group. No differences were observed in the WMS group
Tibana et al. [21]	NT	Acute session: 6 exercises (full body), 10 repetitions (60% of 1RM) and 1 min rest Training: 8 weeks, training frequency 3 times a week, 3 sets of 8–12 RM and 1 min rest	The reduction in blood pressure (SBP and DBP) after the acute RT session was strongly correlated with the chronic reduction in resting blood pressure
Yu, Clare Chung-Wah et al. [22]	NT	RTG: Circuit training (alternating the exercises in upper-body and lower-body), 3 sets, 12 repetitions, 16-second rest, 10 weeks of training, twice a week CG: no physical exercises	10 weeks of RT provided a significant increase in endothelial function in adolescents
Lima et al. [11]	HT	AG: 30 min of exercise on the treadmill. The intensity was based on the physical condition of each participant; ARG: Resistance training consisted of the circuit, 15 reps for upper limbs, 20 reps for lower limbs and trunk, and 1 min in each exercise. After the resistance exercise protocol, aerobic training was performed; CG: Did not participate in any training protocol The training protocols lasted 10 weeks with a training frequency of 3 times a week	Both training groups (AG and ARG) promoted changes in body mass index, waist circumference, and ambulatory blood pressure (24h SBP and DBP, wakefulness and sleep). The fat mass only changed in ARG
Bertani et al. [10]	HT	12 weeks of continuous aerobic training (CAT), aerobic interval training (AIT), resistance training (RT) and control (C)	Resistance training promoted a greater drop in blood pressure (↓ 10.8 mmHg for SBP and ↓ 11.0 mmHg for DBP) at night among hypertensive older people when compared to the AIT group
Cordeiro et al. [23]	NT e HT	RES: circuit training (resistance and aerobic exercises), duration of 40 min, intensity 60–70% of HRR, 15 repetitions CS: non-exercise day	↓ 24-hour blood pressure (SBP, DBP and MBP) at RES in hypertensive individuals. No statistical differences were observed in normotensive individuals
Matias et al. [13]	HT	Combined training (aerobic and resistance), 10 weeks duration, 3 times a week, 45 minutes duration: 5 minutes of warm-up, 20 min of aerobic and 20 min of resistance exercises	↓ chronic ambulatory blood pressure (SBP, DBP, MBP). No differences in acute effects
Schimitt et al. [14]	HT	RES: Muscle power training, 3 sets, 8–10 repetitions, the concentric phase was performed as quickly as possible, and the eccentric phase lasted 1–2 seconds CS: day without exercise	↓ of SBP (–10 mm Hg), MBP (–6 mm Hg) and DBP (–4 mm Hg) in the RES in the laboratory evaluation. No differences were observed in ambulatory measures

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Table 1. Characteristics of training protocols

Study	Population	Training Protocol	Main Results
Pires et al. [15]	HT	Aerobic session: treadmill exercise, 50–60% of HRmax for 45 minutes Resistance session: 6 exercises, 4 sets, 12 reps, 1 min rest between sets and exercises Combined session: aerobic exercise for 25 minutes, plus resistance exercise session with 2 sets, 12 reps	All protocols promoted reductions in ambulatory blood pressure. However, the combined protocol provided a longer duration of this effect (12 h) in relation to the aerobic (6 h) and resistance (3 h) protocols
Candidate et al. [12]	HT	The resistance training protocol was a circuit, consisting of 6 exercises, two sets of 10 reps, 50% of 1RM, 2 min rest, twice a week, for 6 weeks The study also consisted of the consumption of 2 capsules (500 mg) per day containing green tea extract or placebo	Significant reductions in-office blood pressure (SBP, MBP) and 24 h BP were observed in the RT and GR groups. Thus, the interaction of green tea extract consumption and resistance training may provide more benefits than adopting isolated interventions
De Oliveira Carpes et al. [16]	HT	RES: power training, 5 exercises, 3 sets, 8–10 reps, 50% 1RM, 2 min rest. The concentric phase was performed as quickly as possible. The eccentric phase lasted 1–2 seconds CS: protocol without exercises	Comparing RES with CS, there was a reduction in laboratory blood pressure: SBP (–14 mm Hg mean of 1 h) and DBP (–8 mm Hg mean of 1 h) in men. As for women, the only difference was observed in SBP (mean –7 mm Hg of 1 h)
Iellano et al. [17]	HT	Aerobic continue exercise (ACE): 45 min walk, 55–70% VO2 High-intensive interval exercise (HIIE): 3 peaks of high intensity (80–95% of VO2 during 5 min) were performed with low-intensity intervals (10 min) Combined exercise (aerobic and resistance) (CE): 25 min walk (55–70% VO2) and resistance exercise session — 2 sets, 10 reps, 60% 1RM, 2 min rest	The ACE and CE protocols promoted better results in sedentary patients. After a period of training, the HIIE protocol was more effective in reducing BP in a sustained way

HT — hypertensive; NT — normotensive; DM — diabetes mellitus; MHR — maximum heart rate; SBP —systolic blood pressure; DBP — diastolic blood pressure; MS — metabolic syndrome; WMS — without metabolic syndrome; AS — aerobic session; RES — resistance exercise session; CS — control session; RTG — resistance training group; CG — control group; AG — aerobic group; ARG — aerobic and resistance group

by lowering cardiac output and women by lowering peripheral vascular resistance [38].

Another point that can be discussed for the absence of significant differences in the ambulatory evaluation period in the power training protocols can be related to the length of the sets, because a feature of power training protocols is the fast speed of execution and consequently a shorter time of muscular work during the sets when compared to the traditional training protocol (controlled speed 1–2 seconds for each phase of muscular action, for example) [27]. Generally, training protocols with a longer set length (through slower speeds and a larger number of repetitions, for example) promote higher hemodynamic values [31, 32]. Thus, the shorter time of muscle contraction in muscle power training could not promote a stimulus that triggers physiological adjustments necessary to sustain the reduction of blood pressure during the ambulatory condition [14]. With respect to the above information, we can consider that the fast execution speed restricts the number of cross-bridges that can establish a connection (actin-myosin interaction) [33] and consequently a smaller vascular network would be active in the post-exercise period. Although other experiments have corroborated the effectiveness of power training in reducing laboratory blood pressure in older hypertensive people [16, 30], more studies should be conducted analyzing power training in older people and the possible physiological responses in reducing blood pressure.

Effects of different training protocols on ambulatory blood pressure monitoring

Analyzing the studies that evaluated a training period, we can verify different intervention methodologies in the literature. Regarding combined training, Lima et al., [11] found that 10 weeks of isolated aerobic and combined training (aerobic and resistance exercises) were equally effective in reducing blood pressure in hypertensive older people of both sexes. The results of this study showed other positive points for combined training, such as an increase in muscle strength levels, reduction in fat mass (measures that were not observed in the isolated aerobic group) and an increase similar to isolated aerobic training for the measurement of VO2 max. [11]. In the study by Matias et al., [13], even the combined training protocol did not promote an acute reduction in ambulatory blood pressure, after 10 weeks of training, a significant reduction in 24 hours ambulatory blood pressure (systolic, mean and diastolic) could be observed. We can attribute the results of the study by Matias et al. [13] to the law of initial values [1, 6].

Because, the sample showed blood pressure values close to normal in the baseline period and for this reason, the acute reduction in 24-hour blood pressure was not significant.

When analyzing the training status of the sample in different exercise protocols (continuous aerobics, combined and high-intensity interval training) it was observed that, in hypertensive older people who were beginners in a training program, a 24-hour blood pressure showed lower values in continuous aerobics and combined training [17]. On the other hand, after a training period, interval training was more effective for lowering 24-h blood pressure when compared to continuous aerobics and combined exercise protocols [17]. These results demonstrate the importance of periodization as training progresses and fitness increases.

There are also positive results of isolated resistance training (i.e. 6–10 repetitions with a load corresponding to 75% of 1RM) in reducing nocturnal diastolic blood pressure in hypertensive older people [10]. This response of resistance training in reducing nighttime blood pressure [10, 19] and contributing to better sleep quality [20] has important clinical applicability, because poor sleep quality has already been associated with autonomic dysfunction in hypertensive individuals [34].

Regarding the training protocol format, some studies have shown that lightweight circuit training (i.e. training performed with the own body weight or on machines that do not provide much resistance) can be an interesting alternative to reduce 24-hour blood pressure and nocturnal blood pressure, and promote vascular benefits related to increased vasodilation [22, 23].

We can also verify in the literature experiments that investigated other types of interventions. For example, Candidate et al. [12] found that the association of green tea consumption with the practice of resistance training promoted better responses than the control group and the resistance training group alone. Therefore, the interaction between exercise and consumption of green tea extract seems to induce more benefits in some cardiovascular parameters. In this case, it is worth mentioning that a specific professional in the nutritional area must supervise any nutritional intervention.

It is important to highlight that initial studies showed divergent results on this topic [6, 7, 18, 19]. For example, in the study by Bermudes et al. [19], a reduction in diastolic blood pressure was observed after the resistance exercise session only during the sleep period. In the study by Roltsch et al. [18], no statistical differences were observed, while in the study by Melo et al. [6], the training protocol provided significant differences in the blood pressure of hypertensive women between the control session and exercise for 10 hours. In the study by Queiroz et al. [7], statistical differences were only observed during the period of laboratory evaluation. We can attribute the divergence of results to some factors, such as the training protocol adopted (different volumes and intensities), the health status of the sample (normotensive and hypertensive individuals), age (young and older people), conditioning level (trained and sedentary), among others [6, 7, 9, 18, 19]. Thus, future studies could investigate different protocols, mainly exploring the manipulation of the methodological variables of the strength training, as well as inquiring about its applicability in the hypertensive target audience (being older people or not).

Conclusion

In conclusion, strength training (isolated and combined) is an important measure for lowering blood pressure and improving/maintaining vascular health. The combination of different training strategies in a periodized manner can be adopted to generate broader benefits in hemodynamic measures.

Important points

Strength training can be implemented as an interesting option for those individuals who cannot do aerobic training, especially for the older people who need to stimulate the neuromuscular system. In addition to exerting an important influence on the musculoskeletal system, it can help with other benefits, such as blood pressure control, mood improvement, sleep quality, among others [20, 24, 35, 36, 37]. From a practical point of view, the protocols that investigated exercises in the circuit format, in public square equipment, with bodyweight and other low-cost resistance implements [22, 23], reinforce that the important thing is to start exercising with professional supervision.

Another issue worth mentioning is that, from a clinical point of view, investigating the acute effects is extremely important, because when a given exercise session does not reduce blood pressure to certain values, it will not probably generate impacts on the control of blood pressure in these individuals chronically [21]. In this sense, early adjustments in training variables can be considered an important strategy for individuals to enjoy the potential benefits of physical exercise in blood pressure control [21].

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