



Resistance training configurations and resting blood pressure in older women: a 16-week randomized controlled trial

Configuraciones del entrenamiento de fuerza y presión arterial en reposo en mujeres mayores: ensayo controlado aleatorizado de 16 semanas

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Abstract

Introduction: Resistance training supports healthy aging and may contribute to blood pressure control, but comparative evidence across different configurations in older women remains limited.

Objective: This study compared resistance training with a non-training control condition and examined blood pressure responses to four training configurations.

Methodology: Of 145 older women initially randomized by simple random draw, 95 completed the 16-week study: Control (n = 19), traditional resistance training (n = 17), power training (n = 18), strength-endurance training (n = 20), and absolute-strength training (n = 21). Training was performed twice weekly. Resting blood pressure was assessed at baseline and weeks 4, 8, and 16.

Results: Pooled resistance training versus Control showed a significant group-by-time interaction for systolic blood pressure (p = .007). Pooled training had lower values at weeks 4, 8, and 16 than at baseline (all p < .001), whereas Control did not change. From week 8 to week 16, no significant group effect or interaction was detected when the four configurations and Control were analyzed separately. Diastolic blood pressure showed an overall time effect without significant group or interaction effects.

Discussion: The most consistent response was a sustained systolic reduction when resistance training was considered collectively; the protocol-specific analysis did not identify a superior configuration.

Conclusions: Resistance training was associated with lower resting systolic blood pressure in older women. Because no statistically significant superiority was detected among configurations, protocol selection may also consider functional goals, tolerance, and adherence within the population studied.

Keywords

Aging; blood pressure; older women; resistance training; strength training.

Resumen

Introducción: el entrenamiento de fuerza puede contribuir al envejecimiento saludable y al control de la presión arterial, pero la comparación entre distintas configuraciones en mujeres mayores sigue siendo limitada.

Objetivo: este estudio comparó el entrenamiento de fuerza con una condición control y examinó la presión arterial ante cuatro configuraciones de entrenamiento.

Metodología: de 145 mujeres mayores aleatorizadas mediante sorteo simple, 95 completaron 16 semanas: Control (n = 19), entrenamiento tradicional (n = 17), potencia (n = 18), fuerza-resistencia (n = 20) y fuerza absoluta (n = 21). El entrenamiento se realizó dos veces por semana. La presión arterial en reposo se evaluó al inicio y en las semanas 4, 8 y 16.

Resultados: el entrenamiento agrupado frente a Control mostró una interacción grupo por tiempo significativa para la presión sistólica (p = .007). El entrenamiento agrupado presentó valores inferiores en las semanas 4, 8 y 16 respecto al inicio (todos p < .001), mientras que Control no cambió. Entre las semanas 8 y 16 no se detectó efecto de grupo ni interacción al analizar por separado las cuatro configuraciones y Control. La presión diastólica presentó un efecto global del tiempo, sin efectos de grupo o interacción.

Discusión: la respuesta más consistente fue una reducción sistólica sostenida al considerar el entrenamiento de fuerza de forma conjunta; el análisis específico no identificó una configuración superior.

Conclusiones: el entrenamiento de fuerza se asoció con menor presión sistólica en reposo. Como no se detectó superioridad estadísticamente significativa entre configuraciones, la selección del protocolo también puede considerar objetivos funcionales, tolerancia y adherencia en la población estudiada.

Palabras clave

Entrenamiento de fuerza; envejecimiento; mujeres mayores; presión arterial; resistencia muscular.



Introduction

Population aging is accelerating worldwide. The World Health Organization projects that the number of people aged 60 years or older will reach approximately 2.1 billion by 2050, almost twice the 2020 level (World Health Organization, 2025). Longer life expectancy increases the importance of preserving functional independence and cardiovascular health across later life (Gianfredi et al., 2025). Age-related skeletal-muscle dysfunction contributes to losses in strength, mobility, and physical resilience (Pabla et al., 2024), while cardiovascular risk becomes increasingly important in older women. This sex-specific context is clinically relevant because the menopausal transition and subsequent aging are accompanied by changes in blood pressure regulation and cardiovascular risk, although menopausal status was not formally assessed in the present study (Li et al., 2024; Uddenberg et al., 2024).

Resistance training (RT) is a central component of exercise prescription for older adults because it improves or preserves strength, muscle function, and capacity for activities of daily living (Fragala et al., 2019). Contemporary cardiovascular guidance also recognizes RT as a useful component of cardiovascular health promotion when appropriately prescribed (Paluch et al., 2024). Chronic RT has been associated with lower resting blood pressure (BP), including in older adults with elevated BP or hypertension (Henkin et al., 2023; Oliveira-Dantas et al., 2020). Recent evidence likewise reinforces the role of structured exercise and strength-oriented interventions in BP management and healthy aging (Alvarez et al., 2024; Andrades-Ramírez et al., 2026).

The physiological and functional stimulus generated by RT depends on the organization of acute program variables, including load, repetition number, set volume, recovery interval, movement velocity, and time under tension (Coratella, 2022; Mcleod et al., 2024). These variables can be combined to emphasize different manifestations of muscular performance, such as traditional strength development, muscular endurance, absolute strength, or power. Such flexibility is especially relevant for older adults because program selection must balance the desired adaptation with functional capacity, tolerance, adherence, and cardiovascular considerations (Barón Barón et al., 2024; Galdames Maliqueo et al., 2025).

Different RT configurations have already been compared in older women for neuromuscular and functional outcomes. Mazini Filho et al. (2022) compared distinct resistance-training approaches and reported changes in maximal strength, muscle power, and functional capacity, while Leitão et al. (2022) examined balance, quality of life, and physical-activity outcomes across different RT protocols. These studies are directly relevant to the present training model, but they did not establish whether the same configurations produce distinct chronic responses in resting BP. Evidence on BP has more often examined RT as a single modality, a traditional versus high-speed approach, or acute hemodynamic responses (Coelho-Júnior et al., 2022; de Oliveira Carpes et al., 2021; Galvão et al., 2023; Sardeli et al., 2017). Thus, direct comparative evidence regarding chronic resting BP responses to multiple RT configurations in untrained older women remains limited.

Accordingly, this study had two complementary aims: (1) to evaluate the 16-week BP response to RT considered collectively compared with a non-training control condition; and (2) to compare BP responses among traditional resistance training (TRT), power training (PWT), strength-endurance training (SET), and absolute-strength training (AST) during the protocol-specific phase. We hypothesized that RT would favor resting BP control and that no single RT configuration would demonstrate a clearly superior BP response.

Method

Participants

A total of 145 women aged 60–75 years were initially enrolled and randomly allocated by simple random draw to one of five study conditions. During follow-up, 50 participants did not complete the protocol or were not retained in the final completer analysis because of health-related events or conditions that precluded safe continuation ($n = 19$), withdrawal or loss to follow-up ($n = 13$), or adherence below the predefined minimum of 75% of training sessions ($n = 18$). The final analysis therefore included 95 participants: Control ($n = 19$), TRT ($n = 17$), PWT ($n = 18$), SET ($n = 20$), and AST ($n = 21$).



The inclusion criteria were age between 60 and 75 years, independence in activities of daily living, no previous experience with RT, and no participation in structured exercise programs. For safety, participants were required to present controlled BP at study entry; uncontrolled hypertension was not permitted. Participants continued their usual physician-prescribed medications throughout the study. Pharmacological treatment was not manipulated by the protocol, and medication class, dose, adherence, and changes were not systematically characterized as study variables.

The study was approved by the Ethics Committee of the Federal University of Juiz de Fora (protocol 2.887.652) and conducted in accordance with the Declaration of Helsinki. All participants received detailed information about the procedures and provided written informed consent before participation.

Procedure

Experimental design

This randomized controlled study lasted 16 weeks, with BP assessed at baseline and after 4, 8, and 16 weeks. The first 8 weeks provided a common familiarization and progressive-adaptation period for the RT groups; the group-specific configurations were implemented from weeks 9–16. Consequently, the first longitudinal model examined pooled RT versus Control across the complete intervention, whereas the second model compared Control, TRT, PWT, SET, and AST from week 8 to week 16, corresponding to the transition into and completion of the protocol-specific phase.

Participants allocated to Control received general health guidance and were instructed to maintain their usual activities of daily living throughout the 16-week period. They did not participate in a structured or systematic physical-exercise program during the study.

Muscle-strength assessment and training-load control

The 10-repetition maximum (10RM) test was used to assess muscular strength and support load prescription. Perceived exertion was monitored using the OMNI Resistance Exercise Scale (OMNI-RES), a validated scale for resistance exercise (Lagally & Robertson, 2006). RPE targets were 5–7 during the first 8 weeks (familiarization and progressive adaptation) and 6–8 during the following 8 weeks (specific intervention).

Resistance-training protocols

The RT program consisted of two sessions per week, with 72–96 h of recovery between sessions, over 16 weeks. All training groups performed the same exercises in the same order: abdominal crunch, seated row, horizontal leg press, seated chest press, standing calf raises, and seated leg curl. The program was divided into three phases: familiarization (weeks 1–2), progressive adaptation (weeks 3–8), and specific training according to group allocation (weeks 9–16). This staged approach was intended to provide a common technical and neuromuscular preparation before the configurations diverged.

During familiarization, all RT groups performed 2 sets of 15 repetitions at 50–60% of 10RM, with 1 min of rest between sets and exercises. During progressive adaptation, all RT groups performed 3 sets of 12–15 repetitions at approximately 60% of 10RM, with 1 min between sets and 2 min between exercises.

During the specific phase, participants followed their allocated protocol: (1) TRT, 2–3 sets of 8–12 repetitions; (2) PWT, 2–3 sets of 8–12 repetitions with the concentric phase performed at maximal intended velocity using approximately 50% of 10RM; (3) SET, 1 set of 20–25 repetitions; and (4) AST, 4–5 sets of 4–5 repetitions. Training loads were adjusted using the OMNI-RES scale, with perceived effort maintained between 6 and 8 (Lagally & Robertson, 2006). Training volume was approximately equalized across groups by adjusting sets and repetitions so that participants completed about 20–25 repetitions per exercise. Recovery intervals were standardized at 3 min between sets and exercises. In TRT, AST, and SET, concentric and eccentric phases lasted 2 s and were controlled by metronome. In PWT, the concentric phase was performed with maximal intended velocity, while the eccentric phase remained controlled. No exercise was performed to voluntary failure. These prescription variables are reported because load, repetition number, movement velocity, recovery, and time under tension can materially alter the resistance-training stimulus (Coratella, 2022).

Anthropometric measurements



Body mass (kg) and body mass index (BMI, kg/m²) were assessed using a digital scale (Omron, Kyoto, Japan). Height was measured with a stadiometer (Sanny, Fortaleza, Brazil) using the Frankfurt plane for anatomical positioning. Measurements were obtained at baseline and after 4, 8, and 16 weeks of intervention.

Blood-pressure assessment

Resting BP assessments were conducted in the morning, before the training session, at a consistent time of day across assessment visits. Participants remained seated at rest for at least 5 min in a quiet, temperature-controlled room (24°C) before measurement. BP was then measured three times at 5-min intervals using a mercury sphygmomanometer (Tycos, USA) and stethoscope (Littmann Quality, Germany), with the cuff placed on the left arm. The median of the three readings was prespecified as the representative individual value for that assessment and was applied consistently at baseline and weeks 4, 8, and 16. These individual values were subsequently summarized at group level as mean $\pm$ standard deviation and entered into the longitudinal statistical models.

Current clinical BP-measurement recommendations generally favor averaging repeated office readings (Brandão et al., 2025; McEvoy et al., 2024; Muntner et al., 2019). The present study retained the originally defined median-based within-visit summary rather than retrospectively changing the measurement rule; this methodological difference is acknowledged in the limitations.

Data analysis

Data are presented as mean $\pm$ standard deviation. Assumptions of normality and homogeneity were evaluated using the Kolmogorov-Smirnov and Levene tests, respectively. Age, body mass, height, and BMI satisfied the normality assumption and were compared across groups using one-way ANOVA. SBP and DBP did not satisfy the normality assumption and were therefore analyzed using generalized estimating equations (GEE).

Two GEE models were used, with Gamma distribution, log link, and an exchangeable correlation matrix to account for within-participant dependency; body mass was included as a covariate. The first model compared Control with the pooled RT group across baseline and weeks 4, 8, and 16. The second model compared the five groups separately (Control, TRT, PWT, SET, and AST) from week 8 to week 16; the RT groups were not pooled in this second analysis. When a significant effect was identified, estimated marginal means were compared using Bonferroni-adjusted post hoc tests. Statistical analyses were performed using SPSS version 19.0 (IBM Corp., Armonk, NY, USA).

Results

Ninety-five women completed the study and met the criteria for inclusion in the final analysis (Control, $n = 19$; TRT, $n = 17$; PWT, $n = 18$; SET, $n = 20$; AST, $n = 21$). Age, height, body mass, and BMI are presented in Table 1. There were no between-group differences for age ($F = 1.37$, $p = .26$), height ($F = 0.76$, $p = .55$), or BMI ($F = 2.27$, $p = .08$). A group effect was observed for body mass ($F = 3.39$, $p = .017$); body mass was higher in AST than TRT ($p = .017$). Body mass was therefore included as a covariate in subsequent analyses.

Table 1. Participant characteristics at baseline

Variable	Control ($n = 19$)	TRT ($n = 17$)	PWT ($n = 18$)	SET ($n = 20$)	AST ($n = 21$)
Age (years)	68.4 $\pm$ 5.1	66.9 $\pm$ 4.1	66.3 $\pm$ 3.9	64.8 $\pm$ 4.2	66.3 $\pm$ 4.9
Height (cm)	155.7 $\pm$ 5.8	154.6 $\pm$ 6.6	156.7 $\pm$ 4.8	154.4 $\pm$ 5.3	156.8 $\pm$ 5.2
Body mass (kg)	67.8 $\pm$ 11.0	60.7 $\pm$ 9.9	71.0 $\pm$ 14.3	69.7 $\pm$ 13.8	74.0 $\pm$ 12.8*
BMI (kg/m ²)	28.2 $\pm$ 5.1	25.5 $\pm$ 4.5	28.8 $\pm$ 5.2	29.2 $\pm$ 5.2	30.2 $\pm$ 5.4

Note. Values are mean $\pm$ SD. AST = absolute-strength training; BMI = body mass index; PWT = power training; SET = strength-endurance training; TRT = traditional resistance training. * $p = .017$ versus TRT.

Table 2 presents the analysis in which the four RT groups were pooled ($n = 76$) and compared with Control ($n = 19$) across 16 weeks. A significant group $\times$ time interaction was found for SBP (Wald $\chi^2 =$



12.05, $p = .007$). SBP remained unchanged in Control ($p > .05$), whereas the pooled RT group had lower SBP at weeks 4, 8, and 16 than at baseline (all $p < .001$). No other significant SBP changes were identified ($p > .05$).

For DBP, there was no significant group $\times$ time interaction (Wald $\chi^2 = 4.22$, $p = .24$) and no group effect (Wald $\chi^2 = 0.11$, $p = .74$). A significant overall time effect was found (Wald $\chi^2 = 19.57$, $p < .001$). Across the model, DBP at week 16 (83 ± 8 mmHg) was higher than at baseline (82 ± 11 mmHg, $p = .044$), week 4 (79 ± 10 mmHg, $p < .001$), and week 8 (81 ± 9 mmHg, $p < .001$). Because neither the group effect nor the group $\times$ time interaction was significant, this DBP finding should be interpreted as an overall time effect rather than a treatment-specific increase in either group.

Table 2. Resting systolic and diastolic blood pressure over 16 weeks

Group / variable	Baseline	Week 4	Week 8	Week 16
Control (n = 19) – SBP	128 $\pm$ 13	124 $\pm$ 10	127 $\pm$ 12	127 $\pm$ 11
Control (n = 19) – DBP	81 $\pm$ 12	80 $\pm$ 13	82 $\pm$ 11	85 $\pm$ 9
Pooled RT (n = 76) – SBP	129 $\pm$ 13	123 $\pm$ 13*	123 $\pm$ 10*	124 $\pm$ 9*
Pooled RT (n = 76) – DBP	83 $\pm$ 10	79 $\pm$ 10	81 $\pm$ 9	83 $\pm$ 8

Note. Values are mean $\pm$ SD, in mmHg. DBP = diastolic blood pressure; RT = resistance training; SBP = systolic blood pressure. * $p < .001$ versus baseline within the pooled RT group. The significant DBP finding was an overall time effect and was not group-specific.

Table 3 presents the second GEE, in which Control and the four RT configurations were analyzed separately from week 8 to week 16; the RT groups were not pooled. For SBP, no significant group $\times$ time interaction (Wald $\chi^2 = 2.48$, $p = .48$), group effect (Wald $\chi^2 = 0.23$, $p = .97$), or time effect (Wald $\chi^2 = 2.92$, $p = .09$) was detected. Thus, the analysis did not identify a statistically significant SBP difference between TRT, PWT, SET, AST, and Control during the protocol-specific phase.

For DBP, there was no significant group $\times$ time interaction (Wald $\chi^2 = 7.47$, $p = .06$) and no group effect (Wald $\chi^2 = 1.01$, $p = .79$). A significant overall time effect was observed (Wald $\chi^2 = 5.66$, $p = .017$), with the model-estimated DBP at week 16 (83 ± 8 mmHg) higher than at week 8 (81 ± 9 mmHg, $p = .017$). This time effect was not attributable to a specific RT configuration because the group and interaction terms were not significant.

Table 3. Resting systolic and diastolic blood pressure by training configuration

Group	SBP week 8	SBP week 16	DBP week 8	DBP week 16
Control (n = 19)	127 $\pm$ 12	127 $\pm$ 11	82 $\pm$ 11	85 $\pm$ 9
TRT (n = 17)	122 $\pm$ 10	123 $\pm$ 9	80 $\pm$ 7	79 $\pm$ 7
PWT (n = 18)	124 $\pm$ 8	124 $\pm$ 7	82 $\pm$ 9	84 $\pm$ 8
SET (n = 20)	121 $\pm$ 11	124 $\pm$ 11	80 $\pm$ 10	83 $\pm$ 8
AST (n = 21)	123 $\pm$ 10	126 $\pm$ 10	80 $\pm$ 8	85 $\pm$ 7

Note. Values are mean $\pm$ SD, in mmHg. AST = absolute-strength training; DBP = diastolic blood pressure; PWT = power training; SBP = systolic blood pressure; SET = strength-endurance training; TRT = traditional resistance training. No significant group or group $\times$ time effect was detected for SBP or DBP. DBP showed an overall time effect from week 8 to week 16 ($p = .017$).

Discussion

The principal finding of this study was that RT, when considered collectively, was associated with a sustained reduction in resting SBP across 16 weeks in older women with controlled BP at study entry. The pooled RT group decreased descriptively from 129 ± 13 mmHg at baseline to 123 ± 13 mmHg at week 4, 123 ± 10 mmHg at week 8, and 124 ± 9 mmHg at week 16, whereas Control showed no significant longitudinal change. A second, distinct finding was that the protocol-specific analysis from week 8 to week 16 detected no statistically significant between-group difference in SBP among TRT, PWT, SET, AST, and Control. These results support the antihypertensive potential of RT as a general exercise strategy but do not demonstrate formal equivalence among the four RT configurations.

The approximately 5-mmHg descriptive reduction in pooled RT SBP from baseline to week 16 is consistent in direction and magnitude with the broader evidence base. Henkin et al. (2023), in a systematic review and meta-analysis of older adults with prehypertension or hypertension, reported pooled reductions of 6.88 mmHg for SBP and 3.37 mmHg for DBP following dynamic RT. Resistance training has also

improved BP-related outcomes in hypertensive older women (Oliveira-Dantas et al., 2020), while Gerage et al. (2013) demonstrated cardiovascular adaptations to RT in older postmenopausal women. More recent work has continued to show favorable hemodynamic responses to strength-oriented exercise in older adults, including power-oriented combined training (Gambassi et al., 2024) and a recent muscle-strength training intervention in older adults with hypertension (Andrades-Ramírez et al., 2026). The present findings extend this literature by examining a common preparatory phase followed by four distinct RT configurations within the same randomized design.

The temporal pattern is also relevant. In pooled RT, the largest descriptive SBP reduction was already evident at week 4 (approximately 6 mmHg below baseline) and remained of similar magnitude at weeks 8 and 16. Because the inferential model showed lower SBP at each of these time points compared with baseline, the data are more consistent with an early reduction that was maintained than with a progressive dose-response decrease throughout the entire 16 weeks. This distinction may be useful for practitioners because it suggests that a BP-related adaptation can coexist with the gradual technical and neuromuscular progression required when previously untrained older women begin RT.

The absence of a statistically significant difference among the specific configurations should be interpreted carefully. A non-significant group effect does not establish equivalence or non-inferiority. Rather, within the present sample and analytic model, no configuration demonstrated statistical superiority for resting SBP from week 8 to week 16. This result is physiologically plausible because all groups trained the same major muscle groups, had an approximately equalized repetition volume, and performed RT twice weekly; the primary distinctions involved repetitions per set, set number, load, and concentric velocity. Evidence from high-speed versus traditional RT similarly suggests that both forms can affect BP in older adults without a consistently superior chronic pattern (Coelho-Júnior et al., 2022). Acute studies further demonstrate that load, velocity, fatigue, and other resistance-exercise variables can alter immediate hemodynamic responses (de Oliveira Carpes et al., 2021; Galvão et al., 2023; Sardeli et al., 2017). However, acute BP responses were not measured in the present trial and should not be inferred from the resting values.

This point also clarifies the study's originality relative to Mazini Filho et al. (2022). That randomized study compared distinct RT configurations in older women but focused on maximal strength, muscular power, and functional capacity. Leitão et al. (2022) likewise examined balance, quality of life, and physical activity across different RT protocols. The present analysis therefore does not claim that different forms of RT have never been compared in older women. Its contribution is narrower and hemodynamically focused: it examines resting SBP and DBP as outcomes across four configurations and a control condition. The distinction is important because program variables that are meaningful for neuromuscular adaptation do not necessarily translate into different chronic resting-BP responses.

DBP did not display the same pattern as SBP. In the pooled analysis, neither the group effect nor the group $\times$ time interaction was significant, although an overall time effect was detected. Similarly, the protocol-specific analysis showed an overall DBP time effect from week 8 to week 16 without a significant group or interaction effect. Accordingly, the present data do not support attributing the DBP increase to a particular training configuration, nor do they support the earlier wording that DBP increased in every group. This more conservative interpretation is consistent with the fact that chronic RT effects on DBP can vary across populations and protocols (Henkin et al., 2023).

Several mechanisms may contribute to chronic BP adaptation after RT, including changes in vascular function, autonomic modulation, peripheral resistance, and molecular pathways involved in vascular regulation (Ferreira Mendes et al., 2024; Oliveira-Dantas et al., 2020). Nevertheless, the present study did not directly measure autonomic function, endothelial function, vascular resistance, or acute exercise BP. These mechanisms should therefore be considered plausible explanations derived from previous research rather than measured mediators of the current findings. Similarly, although the four protocols differed in variables that influence time under tension and acute cardiovascular demand, the study did not quantify within-set BP or total time under tension as outcomes.

Medication use requires a similarly balanced interpretation. Participants continued their usual physician-prescribed medications, and treatment was not withdrawn or experimentally manipulated. However, medication class, dose, adherence, and changes were not systematically characterized or in-

cluded as covariates. The independent contribution of RT cannot therefore be isolated from usual pharmacological care. At the same time, preserving routine medical treatment reflects the real-world conditions under which exercise is commonly prescribed to older adults with controlled BP. This feature increases the ecological relevance of the findings while remaining a limitation for causal attribution to exercise alone.

Practical applications

For exercise professionals, the findings support two practical messages. First, a twice-weekly, progressive RT program can be incorporated into the usual care of previously untrained older women with controlled BP, with the present data showing a sustained SBP reduction when RT is considered collectively. Second, because no statistically significant SBP superiority was detected among TRT, PWT, SET, and AST during the specific phase, protocol selection may also consider the individual's functional objective, tolerance, preference, adherence, and need to emphasize strength, muscular endurance, or power. This flexibility is relevant because different strength-training approaches can support functional autonomy and physical capacity in older adults (Barón Barón et al., 2024; Galdames Maliqueo et al., 2025; Mazini Filho et al., 2022). The finding should not be interpreted as proof that the protocols are equivalent or interchangeable for every health outcome, and BP monitoring remains important when training older adults.

Limitations

The study has limitations that should guide interpretation. First, the final sample consisted only of older women, and menopausal status was not formally characterized; extrapolation to men, younger adults, or other clinical populations is therefore limited. Second, 50 of the 145 initially randomized participants were not included in the final analysis for health, follow-up, or adherence-related reasons, and the final analysis reflects participants who completed the protocol and met the predefined attendance criterion. Third, medication use was maintained as usual care but was not systematically characterized or modeled, preventing separation of pharmacological and exercise-related contributions to BP. Fourth, resting office BP was summarized using the median of three readings at each assessment. Although this rule was applied consistently, contemporary clinical guidelines generally recommend averaging repeated readings (Brandão et al., 2025; McEvoy et al., 2024; Muntner et al., 2019). Fifth, ambulatory BP, acute exercise BP, vascular function, and mechanistic biomarkers were not measured. Finally, the absence of significant between-protocol differences should not be interpreted as formal equivalence because the trial was not designed as an equivalence or non-inferiority study.

Future studies should prospectively characterize medication exposure, include ambulatory BP and acute hemodynamic monitoring, and test whether specific training configurations differ in women with clearly defined BP phenotypes. Studies designed specifically for equivalence or non-inferiority could also determine whether the apparent flexibility in RT configuration is supported by formal comparative inference.

Conclusions

Sixteen weeks of resistance training, considered collectively, was associated with lower resting systolic blood pressure in previously untrained older women with controlled blood pressure at study entry, with reductions evident by week 4 and maintained through week 16. During the protocol-specific phase, no statistically significant superiority of traditional, power, strength-endurance, or absolute-strength training was detected for systolic blood pressure. Diastolic blood pressure showed an overall time effect without a group-specific pattern. These findings support resistance training as a practical component of blood-pressure management within usual medical care and suggest that, for resting systolic blood pressure, exercise professionals may have flexibility to select a resistance-training configuration according to broader functional goals, tolerance, and adherence. This flexibility should not be interpreted as proof of formal equivalence among protocols.

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References

- Alvarez, C., Peñailillo, L., Ibañe, P., Tuesta, M., Jerez-Mayorga, D., Domaradski, J., Andrade, D. C., Andrade-Mayorga, O., Cano-Montoya, J., & Delgado-Floody, P. (2024). Ejercicio físico es efectivo para la rehabilitación de la presión y rigidez arterial en adultos con hipertensión (Exercise training is effective for arterial stiffness and blood pressure rehabilitation in hypertensive adults). *Retos*, 56, 301–311. <https://doi.org/10.47197/retos.v56.104740>
- Andrades-Ramírez, O., Almonacid-Santana, F., Sepúlveda-Espinoza, I., Amaro-Hernández, J., Orellana-Castillo, S., Seguel-López, M. E., Romero-Vera, L., & Alfaro-Castillo, B. (2026). Efecto de un programa de entrenamiento de fuerza muscular en adultos mayores con hipertensión arterial. *Retos*, 79, 67–77. <https://doi.org/10.47197/retos.v79.118404>
- Barón Barón, A. C., Fernandez Ortega, J. A., & Camargo Rojas, D. A. (2024). Efectos de dos programas de entrenamiento de fuerza sobre la capacidad física funcional y activación muscular en un grupo de adultos mayores (Effects of two strength training programs on functional physical capacity and muscle activation in a group of older adults). *Retos*, 51, 741–748. <https://doi.org/10.47197/retos.v51.99901>
- Brandão, A. A., Rodrigues, C. I. S., Bortolotto, L. A., Armstrong, A. C., Mulinari, R. A., Feitosa, A. D. M., Mota-Gomes, M. A., Barbosa, E. C. D., Moura Neto, J. A., Neves, M. F. T., Barroso, W. K. S., Forjaz, C. L. M., Klein, M. R. S. T., Nobre, F., Jardim, P. C. B. V., Amodeo, C., de Paula, R. B., Ferreira Filho, S. R., Gemelli, J. R., ... Nadruz, W. (2025). Diretriz Brasileira de Hipertensão Arterial – 2025. *Arquivos Brasileiros de Cardiologia*, 122(9), e20250624. <https://doi.org/10.36660/abc.20250624>
- Coelho-Júnior, H. J., Aguiar, S. S., Calvani, R., Picca, A., Carvalho, D. A., Rodrigues, B., Zwarg-Sá, J. C., Bacurau, R. F., Cesari, M., Marzetti, E., & Uchida, M. C. (2022). Acute and chronic effects of traditional and high-speed resistance training on blood pressure in older adults: A crossover study and systematic review and meta-analysis. *Experimental Gerontology*, 163, 111775. <https://doi.org/10.1016/j.exger.2022.111775>
- Coratella, G. (2022). Appropriate reporting of exercise variables in resistance training protocols: Much more than load and number of repetitions. *Sports Medicine - Open*, 8, 99. <https://doi.org/10.1186/s40798-022-00492-1>
- de Oliveira Carpes, L., Domingues, L. B., Schmitt, R., Fuchs, S. C., Alhalimi, T., Tanaka, H., & Ferrari, R. (2021). Sex differences in post-exercise hypotension, ambulatory blood pressure variability, and endothelial function after a power training session in older adults. *Frontiers in Physiology*, 12, 657373. <https://doi.org/10.3389/fphys.2021.657373>
- Ferreira Mendes, B., Improta-Caria, A. C., Diniz e Magalhães, C. O., Dias Peixoto, M. F., Cardoso Cassilhas, R., de Oliveira, E. M., & de Sousa, R. A. L. (2024). Resistance training reduces blood pressure: Putative molecular mechanisms. *Current Hypertension Reviews*, 20(1), 52–56. <https://doi.org/10.2174/0115734021277791240102041632>
- Fragala, M. S., Cadore, E. L., Dorgo, S., Izquierdo, M., Kraemer, W. J., Peterson, M. D., & Ryan, E. D. (2019). Resistance training for older adults: Position statement from the National Strength and Conditioning Association. *Journal of Strength and Conditioning Research*, 33(8), 2019–2052. <https://doi.org/10.1519/JSC.0000000000003230>
- Galdames Maliqueo, S., Huerta Ojeda, Á., Jofré-Saldía, E., Carrasco-Beltrán, H., Yeomans-Cabrera, M.-M., & Bravo, M. (2025). El entrenamiento de fuerza en bloques mejora la autonomía funcional y la calidad de vida en mujeres mayores que viven en la comunidad. *Retos*, 65, 114–126. <https://doi.org/10.47197/retos.v65.110371>
- Galvão, L., Póvoa, T. I. R., Jardim, P. C. V., Lima, A. L., Barroso, W. K. S., Seguro, C. S., Gentil, P., & Jardim, T. V. (2023). Acute effects of high-intensity resistance training on central blood pressure parameters of elderly hypertensive women: A crossover clinical trial. *Journal of Hypertension*, 41(6), 912–917. <https://doi.org/10.1097/HJH.0000000000003355>
- Gambassi, B. B., Chaves, L. F. C., Sousa, T. M. S., Ribeiro, M. J. S., Souza, T. A., & Schwingel, P. A. (2024). Short-duration dynamic power training with elastic bands combined with endurance training: A promising approach to hypertension management in older adults. *Journal of Hypertension*, 42(4), 735–742. <https://doi.org/10.1097/HJH.0000000000003681>
- Gerage, A. M., Forjaz, C. L. M., Nascimento, M. A., Januário, R. S. B., Polito, M. D., & Cyrino, E. S. (2013). Cardiovascular adaptations to resistance training in elderly postmenopausal women. *International Journal of Sports Medicine*, 34(9), 806–813. <https://doi.org/10.1055/s-0032-1331185>



- Gianfredi, V., Nucci, D., Pennisi, F., Maggi, S., Veronese, N., & Soysal, P. (2025). Aging, longevity, and healthy aging: The public health approach. *Aging Clinical and Experimental Research*, 37, 125. <https://doi.org/10.1007/s40520-025-03021-8>
- Henkin, J. S., Pinto, R. S., Machado, C. L. F., & Wilhelm, E. N. (2023). Chronic effect of resistance training on blood pressure in older adults with prehypertension and hypertension: A systematic review and meta-analysis. *Experimental Gerontology*, 177, 112193. <https://doi.org/10.1016/j.exger.2023.112193>
- Lagally, K. M., & Robertson, R. J. (2006). Construct validity of the OMNI Resistance Exercise Scale. *Journal of Strength and Conditioning Research*, 20(2), 252–256. <https://doi.org/10.1519/R-17224.1>
- Leitão, L., Venturini, G. R. O., Junior, R. P., Monteiro, E. R., Telles, L. G., Araújo, G., Novaes, J., Tavares, C., Marques-Neto, S., & Mazini, M. (2022). Impact of different resistance training protocols on balance, quality of life and physical activity level of older women. *International Journal of Environmental Research and Public Health*, 19(18), 11765. <https://doi.org/10.3390/ijerph191811765>
- Li, S., Tan, I., Atkins, E., Schutte, A. E., & Gnanenthiran, S. R. (2024). The pathophysiology, prognosis and treatment of hypertension in females from pregnancy to post-menopause: A review. *Current Heart Failure Reports*, 21(4), 322–336. <https://doi.org/10.1007/s11897-024-00672-y>
- Mazini Filho, M., Venturini, G. R. O., Moreira, O. C., Leitão, L., Mira, P. A. C., de Castro, J. B. P., Aidar, F. J., da Silva Novaes, J., Vianna, J. M., & Caputo Ferreira, M. E. (2022). Effects of different types of resistance training and detraining on functional capacity, muscle strength, and power in older women: A randomized controlled study. *Journal of Strength and Conditioning Research*, 36(4), 984–990. <https://doi.org/10.1519/JSC.0000000000004195>
- McEvoy, J. W., McCarthy, C. P., Bruno, R. M., Brouwers, S., Canavan, M. D., Ceconi, C., Christodorescu, R. M., Daskalopoulou, S. S., Ferro, C. J., Gerds, E., Hanssen, H., Harris, J., Lauder, L., McManus, R. J., Molloy, G. J., Rahimi, K., Regitz-Zagrosek, V., Rossi, G. P., Sandset, E. C., ... Touyz, R. M. (2024). 2024 ESC Guidelines for the management of elevated blood pressure and hypertension. *European Heart Journal*, 45(38), 3912–4018. <https://doi.org/10.1093/eurheartj/ehae178>
- McLeod, J. C., Currier, B. S., Lowisz, C. V., & Phillips, S. M. (2024). The influence of resistance exercise training prescription variables on skeletal muscle mass, strength, and physical function in healthy adults: An umbrella review. *Journal of Sport and Health Science*, 13(1), 47–60. <https://doi.org/10.1016/j.jshs.2023.06.005>
- Muntner, P., Shimbo, D., Carey, R. M., Charleston, J. B., Gaillard, T., Misra, S., Myers, M. G., Ogedegbe, G., Schwartz, J. E., Townsend, R. R., Urbina, E. M., Viera, A. J., White, W. B., & Wright, J. T., Jr. (2019). Measurement of blood pressure in humans: A scientific statement from the American Heart Association. *Hypertension*, 73(5), e35–e66. <https://doi.org/10.1161/HYP.0000000000000087>
- Oliveira-Dantas, F. F., Brasileiro-Santos, M. S., Thomas, S. G., Silva, A. S., Silva, D. C., Browne, R. A. V., Farias-Junior, L. F., Costa, E. C., & Santos, A. C. (2020). Short-term resistance training improves cardiac autonomic modulation and blood pressure in hypertensive older women: A randomized controlled trial. *Journal of Strength and Conditioning Research*, 34(1), 37–45. <https://doi.org/10.1519/JSC.00000000000003182>
- Pabla, P., Jones, E. J., Piasecki, M., & Phillips, B. E. (2024). Skeletal muscle dysfunction with advancing age. *Clinical Science*, 138(14), 863–882. <https://doi.org/10.1042/CS20231197>
- Paluch, A. E., Boyer, W. R., Franklin, B. A., Laddu, D., Lobelo, F., Lee, D.-C., McDermott, M. M., Swift, D. L., Webel, A. R., & Lane, A. (2024). Resistance exercise training in individuals with and without cardiovascular disease: 2023 update: A scientific statement from the American Heart Association. *Circulation*, 149(3), e217–e231. <https://doi.org/10.1161/CIR.0000000000001189>
- Sardeli, A. V., do Carmo Santos, L., Ferreira, M. L. V., Gáspari, A. F., Rodrigues, B., Cavaglieri, C. R., & Chacon-Mikahil, M. P. T. (2017). Cardiovascular responses to different resistance exercise protocols in elderly. *International Journal of Sports Medicine*, 38(12), 928–936. <https://doi.org/10.1055/s-0043-115737>
- Uddenberg, E. R., Safwan, N., Saadedine, M., Hurtado, M. D., Faubion, S. S., & Shufelt, C. L. (2024). Menopause transition and cardiovascular disease risk. *Maturitas*, 185, 107974. <https://doi.org/10.1016/j.maturitas.2024.107974>
- World Health Organization. (2025, October 1). Ageing and health. <https://www.who.int/news-room/fact-sheets/detail/ageing-and-health>



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