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Acute pressor response after isometric training session in adults with controlled hypertension

Respuesta presora aguda tras una sesión de entrenamiento isométrico en adultos con hipertensión controlada

Isaías Cabezas-Gaete,* Nicolás Donoso-Martínez,‡ Sebastian Norambuena-Meza,§,¶ Javier Russell-Guzmán,§,‖ Alexis Espinoza-Salinas§,**

Keywords:
handgrip strength, high blood pressure, isometric resistance training, exercise, blood pressure.

Palabras clave:
fuerza de prensión manual, hipertensión arterial, entrenamiento de resistencia isométrica, ejercicio, presión arterial.

* Programa de Magister en Fisiología Clínica del Ejercicio, escuela de Kinesiología, Universidad Mayor. Chile. ORCID: 0000-0002-3461-4268
‡ Centro de Salud Familiar (CESFAM) Dr. Raúl Moya Muñoz. Comuna de Paine, Chile. ORCID: 0009-0009-7170-958X
§ Escuela de Kinesiología, Facultad de Salud, Universidad Santo Tomás. Santiago, Chile.

ORCID:
¶ 0009-0008-0258-1079
‖ 0000-0003-4452-9312
** 0000-0001-9709-2850

ABSTRACT

Introduction: hypertension is the main risk factor for cardiovascular diseases and has a high global prevalence. Its treatment includes physical activity, exercise, and lifestyle changes. Isometric handgrip strength training has shown significant long-term reductions in blood pressure. However, knowing its acute effect is key to understanding the immediate effects and efficacy, although it has been little studied. **Objective:** to assess the blood pressure response after a single session of isometric resistance training in adults with hypertension and hypertension combined with insulin resistance. **Material and methods:** thirty older adults from the More Self-Sufficient Older Adults program (MSROA) participated in Paine, Chile. They were divided into two groups: twenty with pure hypertension (G-HTN) and ten with hypertension and insulin resistance (G-HTN/IR). Both groups performed one session of four isometric contractions, each lasting two minutes at 30% of their maximum strength, with two-minute rest intervals between each contraction. Blood pressure was measured post-intervention for one hour and again after 24 hours. **Results:** significant differences were found in systolic arterial pressure (SAP) between groups at minutes one and twenty, while diastolic arterial pressure (DAP) and mean arterial pressure (MAP) showed no significant differences. Both groups showed reductions in SAP and MAP, with decreases of −8.21 mmHg (SAP) and −4.49 mmHg (MAP) in G-HTN, and −11.3 mmHg (SAP) and −1.43 mmHg (MAP) in G-HTN/IR. **Conclusion:** isometric training reduces SAP and MAP. Although a transient increase in SAP is observed immediately after the intervention, this effect is followed by a significant reduction at 24 hours.

RESUMEN

Introducción: *la hipertensión es el principal factor de riesgo de las enfermedades cardiovasculares y tiene una elevada prevalencia mundial. Su tratamiento incluye actividad física, ejercicio y cambios en el estilo de vida. El entrenamiento de fuerza isométrica de prensión manual ha demostrado reducciones significativas de la presión arterial a largo plazo. Sin embargo, conocer su efecto agudo resulta clave para comprender los efectos y eficacia inmediata, aunque ha sido escasamente estudiado.* ***Objetivo:*** *evaluar la respuesta de la presión arterial tras una única sesión de entrenamiento de resistencia isométrica en adultos con hipertensión e hipertensión combinada con resistencia a la insulina.* ***Material y métodos:*** *participaron treinta adultos mayores del programa Más Adultos Mayores Autosuficientes (AMA) en Paine, Chile. Se dividieron en dos grupos: 20 con hipertensión pura (G-HTN) y 10 con hipertensión y resistencia a la insulina (G-HTN/IR). Ambos grupos realizaron una sesión de cuatro contracciones isométricas de dos minutos de duración cada una al 30% de su fuerza máxima, con intervalos de descanso de dos minutos entre cada contracción. Se midió la presión arterial después de la intervención durante una hora y de nuevo al cabo de 24 horas.* ***Resultados:*** *se encontraron diferencias significativas en la presión arterial sistólica (PAS) entre los grupos en los minutos uno y veinte, mientras que la presión arterial diastólica (PAD) y la presión arterial media (PAM) no mostraron diferencias significativas. Ambos grupos mostraron reducciones de la PAS y la PAM, con descensos de −8.21 mmHg (PAS) y −4.49 mmHg (PAM) en G-HTN, y de −11.3 mmHg (PAS) y −1.43 mmHg (PAM) en G-HTN/IR.* ***Conclusión:*** *el entrenamiento isométrico reduce la PAS y PAM. Si bien se observa un aumento transitorio de la PAS inmediatamente posterior a la intervención, este efecto es seguido por una reducción significativa a las 24 horas.*

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Abbreviations:
BP = Blood Pressure
CO = Cardiac Output
DAP = Diastolic Arterial Pressure
G-HTN = Group with Isolated Diagnosis of HTN
G-HTN/IR = Group with both HTN and Insulin Resistance
HTN = Hypertension
IR = Insulin Resistance
MAP = Mean Arterial Pressure
MIGS = Maximal Isometric Grip Strength
MSROA = More Self-Sufficient Older Adults program
SAP = Systolic Arterial Pressure
TPR = Total Peripheral Resistance

INTRODUCTION

Arterial hypertension (HTN) is the leading risk factor for cardiovascular diseases, affecting 30% of the global population (1.4 billion adults), with a projected increase to 1.6 billion by 2025, according to the World Health Organization (WHO).[1] It is closely associated with overweight and obesity, increasing the risk of complications such as heart failure, ventricular hypertrophy, cerebrovascular accidents, and chronic kidney disease. Cardiovascular events are linked to the deterioration of vascular function and endothelial tissue, impairing the regulation of vascular tone and peripheral vascular resistance.[2]

The treatment of HTN includes both pharmacological and non-pharmacological therapy.[3] Within the latter, in addition to lifestyle and dietary modifications, regular physical activity stands out,[4] with recommendations of 150-300 minutes per week of moderate-intensity exercise, 75-150 minutes of vigorous-intensity exercise, or an equivalent combination of both.[5,6]

Aerobic exercise and resistance training contribute to blood pressure (BP) regulation[7] and may reduce the reliance on antihypertensive medications.[8] However, many individuals do not engage in these activities due to barriers such as a lack of time or motivation.[9] In this context, isometric resistance training has emerged as a more effective strategy for BP control.[10,11] This modality involves muscle contractions against a fixed load, such as handgrip exercises, with the most common protocol consisting of unilateral upper limb training, performing four sustained contractions of two minutes each at 30% of maximal voluntary contraction, three times per week.[11,12] This therapeutic approach has demonstrated clinically significant BP reductions in both hypertensive and normotensive individuals over short- and long-term periods, with greater efficacy than antihypertensive medications,[13] However, the immediate effects following a single session remain insufficiently explored. Therefore, knowing the effects of isometric training would be of great relevance since it is of low volume and intensity can generate cardiovascular changes in the short-term whit at low cost and high applicability, it could be an effective strategy with good adherence. Thus, the objective of this study is to evaluate the pressor response following a single session of isometric resistance training in adults with hypertension and hypertension combined with insulin resistance.

MATERIAL AND METHODS

This quasi-experimental, analytical, cross-sectional, and prospective study was approved by the Scientific Ethics Committee of the Metropolitan South Health Service in Santiago, Chile (MEMO 155/2024, PROTOCOL 75-23072024), adhering to the seven ethical principles for human research outlined by Ezekiel Emanuel.[14,15]

Participants were selected through convenience sampling and comprised 100% of the population enrolled in the national More Self-Sufficient Older Adults program (MSROA) at CESFAM Dr. Raúl Moya Muñoz in the municipality of Paine. The study included 30 older adults (≥ 65 years) diagnosed with HTN *(Table 1)*. Participants with an isolated diagnosis of HTN were assigned to the G-HTN group (n = 20), while those with both HTN and insulin resistance (IR) were assigned to the G-HTN/IR group (n = 10).

The inclusion criteria required active participation in the MSROA program, up-to-date medical check-ups, and the absence of musculoskeletal injuries, uncontrolled chronic diseases, or neurological conditions that could affect participation.

Procedure

Day 1. Prior to the training session, blood pressure (BP) was recorded while the participant

was seated in a chair with back support and no armrests. Measurements were taken on the dominant upper limb using a digital blood pressure monitor (Omron HEM 7130),[16] after five minutes of rest. Following BP measurement, maximal isometric grip strength (MIGS) was directly assessed using a Jamar hydraulic hand dynamometer,[17] *(Table 2)* on the dominant upper limb. The test was conducted in a seated position without armrests, with feet flat on the floor, the upper limb adducted, the elbow flexed at 90º, the wrist in a neutral position, and the back upright while looking straight ahead,[18] The highest value from three maximal grip strength attempts, with one-minute rest intervals between trials, was recorded.

Table 1: Antihypertensive pharmacological treatment categorization in both groups.

Drug	G-HTN (n = 20)	G-HTN/IR (n = 10)
Losartan	6	3
Enalapril	5	0
Losartan-Amlodipine	6	6
Losartan-Carvedilol	1	0
Atenolol-Hydrochlorothiazide	1	0
Losartan-Amlodipine-Hydrochlorothiazide	1	1

G-HTN = Group with Isolated Diagnosis of HTN. G-HTN/IR = Group with both HTN and Insulin Resistance. HTN = Hypertension.

Day 2. After baseline BP and MIGS measurements, each participant performed the isometric training protocol, consisting of four isometric muscle contractions sustained for two minutes at 30% of their MIGS, with two-minute rest intervals between repetitions, maintaining the same position used for the MIGS assessment. BP was measured on the dominant arm immediately after the final repetition, every 10 minutes for one hour, and again at 24 hours *(Figure 1)*.

Throughout days one and two, participants were advised to abstain from consuming cardiovascular system stimulants (such as caffeine, alcohol, tobacco, and yerba mate) and to avoid strenuous exercise while maintaining their regular antihypertensive medication regimen without interruption.

Statistical analysis

A statistical analysis was conducted, including both descriptive and inferential approaches, to evaluate differences between the G-HTN and G-HTN/IR groups.

Table 2: Mean baseline characteristics of each intervention group, including age, sex, systolic arterial pressure (SAP), diastolic arterial pressure (DAP), one-repetition maximum (1RM), and mean arterial pressure (MAP).

	All (n = 30)			G-HTN (n = 20)			G-HTN/IR (n = 10)		
	Mean ± SD	LL	UL	Mean ± SD	LL	UL	Mean ± SD	LL	UL
Age (years)	72.07 ± 6.43	65	86	70.11 ± 5.37	65	83	76.5 ± 6.1	65	86
SAP (mmHg)	140.27 ± 18.72	103	198	136.63 ± 16.79	103	168	148.90 ± 19.64	130	198
DAP (mmHg)	75.10 ± 8.19	59	93	75.32 ± 8.87	63	93	74.10 ± 6.85	59	86
MAP (mmHg)	96.82 ± 10.27	78.33	120	95.75 ± 10.31	78.33	116.33	99.03 ± 10.36	82.67	120
1RM (kg)	25.10 ± 9.15	10.8	46.8	24.85 ± 8.03	11.10	45.80	25.90 ± 11.25	10.80	46.80
Sex									
Male	8			6			1		
Female	22			14			9		

G-HTN = Group with Isolated Diagnosis of HTN. G-HTN/IR = Group with both HTN and Insulin Resistance. HTN = Hypertension. LL = Lower Limit. SD = Standard Deviation. UL = Upper Limit.

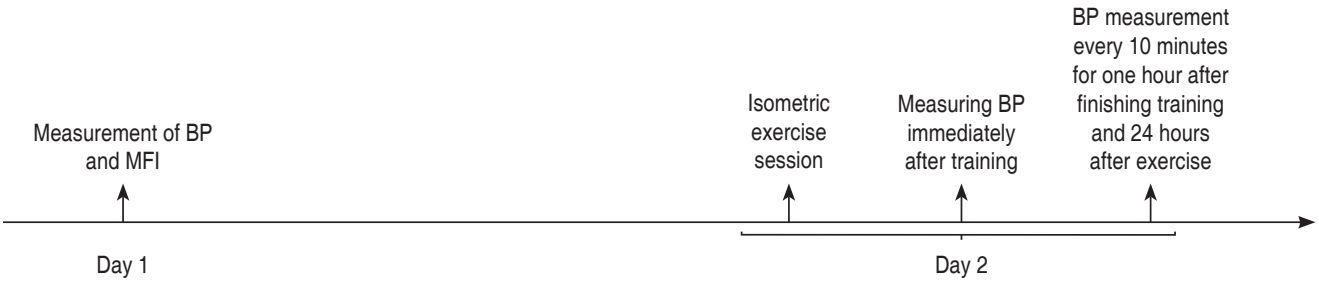

Figure 1: Summary of the intervention process.
Note: Isometric exercise session: four sustained contractions for two minutes at 30% of MFI, with two minutes of rest between contractions. The two intervention days are consecutive.
BP = Blood Pressure. MFI = Maximum Isometric Force.

RESULTS

The isometric handgrip intervention elicited distinct hemodynamic responses between the study groups. Participants with G-HTN/IR consistently exhibited higher systolic arterial pressure (SAP) and mean arterial pressure (MAP) values compared to those with G-HTN, from the first minute of the intervention through the 24-hour follow-up *(Figure 2)*. The peak SAP in the G-HTN/IR group was observed at minute 10 (148.5 ± 16.42 mmHg), whereas the corresponding value in the G-HTN group was 135.95 ± 15.31 mmHg. At 24 hours, both SAP and MAP remained elevated in the G-HTN/IR group (137.6 ± 10.13 mmHg and 97.6 ± 7.58 mmHg, respectively), relative to the G-HTN group (128.42 ± 14.28 mmHg and 91.26 ± 10.61 mmHg). All values are reported with a 95% confidence interval, supporting the reliability of the findings and indicating a more sustained hemodynamic burden in individuals with concomitant insulin resistance in response to isometric loading.

Low-intensity isometric resistance training was well tolerated by both groups, with no adverse effects or significant discomfort reported during or after the intervention, thereby confirming its safety as a training modality in this population. The majority of participants in both groups were women: the G-HTN group comprised 14 women and six men, whereas the G-HTN/IR group included nine women and one man. Mean maximal handgrip strength was comparable between groups, recorded at 24.85 ± 8.03 kg in the G-HTN group and 25.9 ± 11.25 kg in the G-HTN/IR group. Notably, the G-HTN group exhibited lower mean blood pressure values across all time points compared to the G-HTN/IR group, which also presented with a higher mean age, potentially contributing to the augmented cardiovascular response observed.

Prior to analysis, normality tests were conducted using the Kolmogorov-Smirnov test to ensure that the data met the necessary assumptions. The statistical significance level was set at $p < 0.05$, indicating that observed differences were statistically significant. All statistical analyses were performed using IBM SPSS 19.[19]

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DISCUSSION

Our results indicate that a single session of isometric handgrip strength exercise initially increases systolic arterial pressure (SAP), diastolic arterial pressure (DAP), and mean arterial pressure (MAP) post-exercise, followed

by a gradual decrease in these pressures for at least 24 hours after the intervention *(Table 3)*. This finding aligns with Wiles (2018), who assessed heart rate (HR) and blood pressure (BP) during isometric lower limb training and aerobic exercise. Wiles demonstrated that BP and HR initially increased in response to exercise, attributed to vascular compression or, in some cases, occlusion of blood vessels in active muscles. This phenomenon leads to increased cardiac output (CO) due to enhanced chronotropic activity, without significant changes in total peripheral resistance (TPR).[20,21] These alterations in the components of the blood pressure (GC × TPR These alterations in BP components (CO × TPR) result in a pronounced rise in BP, particularly in hypertensive individuals, explaining the acute BP elevation during exercise and within the first minute post-intervention.

Additionally, we observed a notable post-training reduction in SAP and MAP *(Figures 3A, 3B and 3C)*, but not in DAP. In fact, SAP significantly decreased at minutes 1 and 20 when comparing the G-HTN and G-HTN/IR groups. This finding is consistent with the review by Almeida (2021), who analyzed the effects of isometric handgrip exercise on BP and heart rate variability. Almeida concluded that isometric handgrip training positively impacts SAP but does not significantly affect DAP or heart rate variability. The reduction in SAP was attributed to a decrease in peripheral vascular resistance, triggered by endothelium-dependent vasodilation in response to reactive hyperemia caused by

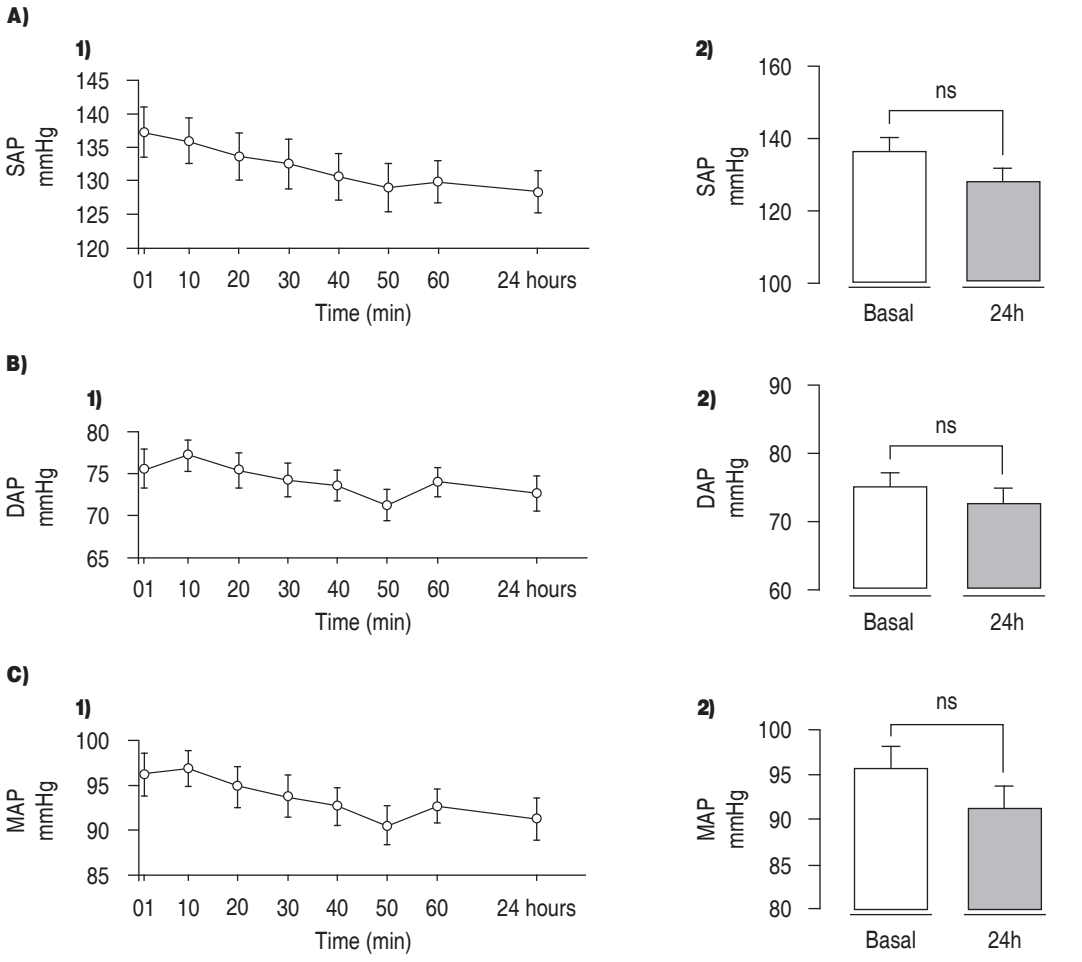

Figure 2: Blood Pressure of the G-HTN group during intervention.

Table 3: Average systolic arterial pressure (SAP), diastolic arterial pressure (DAP), and mean arterial pressure (MAP) values following isometric training.

Blood pressure (mmHg)	G-HTN (n =20)			G-HTN/IR (n =10)		
	Mean ± SD	LL	UL	Mean ± SD	LL	UL
	Minute 1					
SAP	137.37 ± 16.47	110	172	152.00 ± 11.58	140	178
DAP	75.63 ± 10.62	58	101	78.30 ± 4.45	73	87
MAP	96.21 ± 10.78	79	124.7	102.87 ± 5.98	96	117.3
	Minute 10					
SAP	135.95 ± 15.31	111	161	148.50 ± 16.42	119	179
DAP	77.26 ± 8.81	61	95	75.50 ± 7.90	57	87
MAP	96.82 ± 9.06	79	116.7	99.83 ± 9.86	77.7	117.7
	Minute 20					
SAP	133.63 ± 15.65	111	163	147.20 ± 14.21	127	175
DAP	75.42 ± 9.85	56	96	77.50 ± 7.53	58	86
MAP	94.82 ± 10.31	78	115	100.73 ± 9.08	81	113.7
	Minute 30					
SAP	132.58 ± 16.33	103	159	144.10 ± 14.52	118	176
DAP	74.32 ± 9.49	58	95	76.70 ± 6.28	63	84
MAP	93.74 ± 10.51	73	116.3	99.17 ± 8.67	81.3	114.7
	Minute 40					
SAP	130.68 ± 15.29	103	159	143.90 ± 17.06	110	171
DAP	73.68 ± 8.60	55	90	78.12 ± 7.29	58	86
MAP	92.68 ± 9.61	71	110	100.03 ± 9.76	75.3	11.7
	Minute 50					
SAP	129 ± 15.96	99	158	141.70 ± 17.74	109	171
DAP	71.37 ± 8.42	56	87	76.20 ± 7.45	58	86
MAP	90.58 ± 9.83	71	104	98.03 ± 10.46	75	111
	Minute 60					
SAP	129.95 ± 13.93	103	155	140.80 ± 16.20	112	168
DAP	74.11 ± 7.98	63	89	76.60 ± 7.62	62	88
MAP	92.72 ± 8.49	78.7	107.7	98 ± 9.93	81	111.3
	24 hours					
SAP	128.42 ± 14.28	103	156	137.60 ± 10.13	120	153
DAP	72.68 ± 9.51	54	90	77.60 ± 7.95	58	92
MAP	91.26 ± 10.61	70.3	110	97.60 ± 7.58	80.7	111

G-HTN = Group with Isolated Diagnosis of HTN. G-HTN/IR = Group with both HTN and Insulin Resistance. HTN = Hypertension. LL = Lower Limit. SD = Standard Deviation. UL = Upper Limit.

isometric training, along with shear stress that enhances nitric oxide bioavailability.[22] Furthermore, Almeida suggested that the lack of significant DAP response to exercise could be explained by the normal baseline DAP values before the intervention and the use of antihypertensive medications with peripheral actions (e.g., angiotensin-converting enzyme

inhibitors, aldosterone antagonists, and diuretics). This finding is particularly relevant to our study, as both intervention groups had controlled hypertension managed with these medications, which may have attenuated the effects of exercise on DAP and contributed to the observed post-intervention fluctuations.[11,23]

Similarly, in 2013, Halliwill and colleagues explained that following an aerobic training session, a rapid reactivation of blood flow occurs in previously compressed vessels, similar to the response observed in isometric exercise. This process induces a phase of reactive hyperemia, which increases endothelial shear stress and promotes the release of vasoactive substances such as nitric oxide, prostaglandins, potassium, adenosine triphosphate, and, importantly, the activation of histamine H1 and H2 receptors. The release of nitric oxide contributes to sustained post-exercise vasodilation by reducing α-adrenergic receptor sensitivity, which is associated with enhanced baroreflex reestablishment and increased sympathetic inhibition. This mechanism explains why, in our study, blood pressure (BP) continued to decrease up to 24 hours post-intervention *(Figure 4)*. Additionally, the activation of histamine receptors acts as a potent immediate vasodilator following exercise, accounting for the BP reduction observed during the first hour post-intervention in our investigation.[24-27]

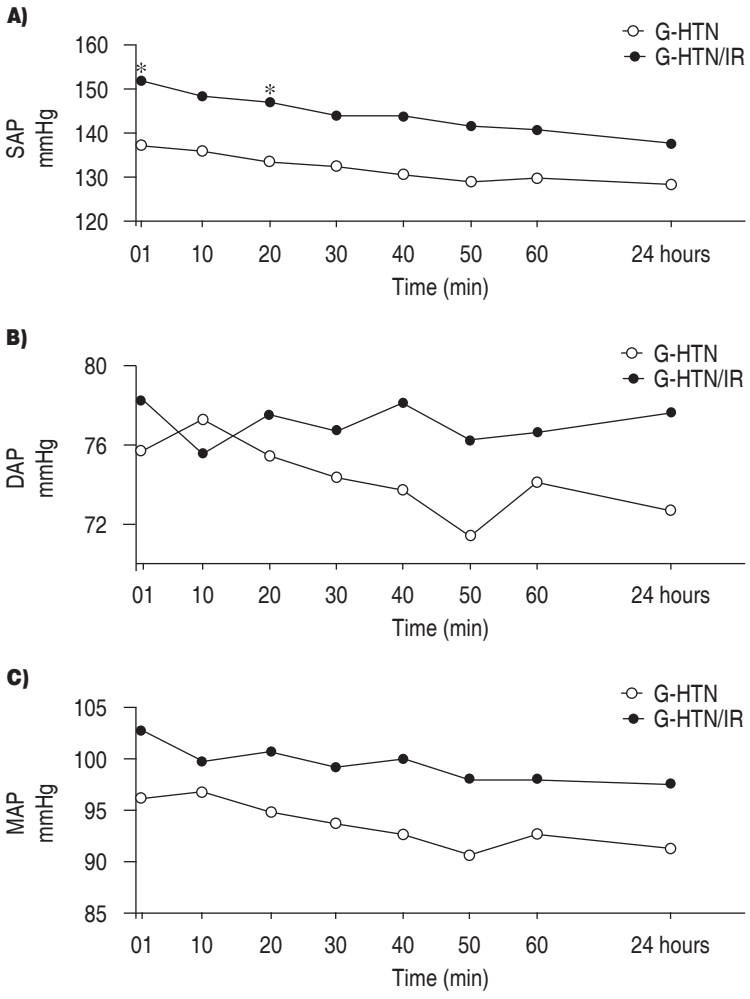

Figure 3: Blood pressure of G-HTN group versus G-HTN/IR group.

Another important point is that, similar to antihypertensive pharmacological treatment, a higher baseline resting BP is generally associated with more significant BP reductions following physical training. In normotensive individuals, these reductions are limited by counter-regulatory mechanisms that prevent BP from dropping below clinically homeostatic levels.[28] This observation aligns with our results, which suggest that the G-HTN/IR group experienced a more pronounced BP reduction post-training, likely due to their higher baseline BP values.

For optimal benefits, isometric handgrip training should be performed at 30% of one repetition maximum when targeting upper limb muscles. Lower or higher intensities have not been shown to yield distinct or enhanced benefits. A study by Espinoza et al. (2019) compared the hypotensive response induced by one week of isometric handgrip training at different intensities in small versus large muscle groups in young obese adults. Their findings suggested that the most potent hypotensive effect occurred in individuals training small muscle groups at low intensity (30% of maximal isometric force).[29] Future research should explore these effects in larger muscle groups to identify the exercise modality that provides the most beneficial BP response, as evidence suggests that interventions targeting larger muscle groups may yield superior outcomes.

Additionally, our study population is affected by physiological aging-related changes, including hemodynamic alterations, arterial stiffness, reduced baroreflex sensitivity,

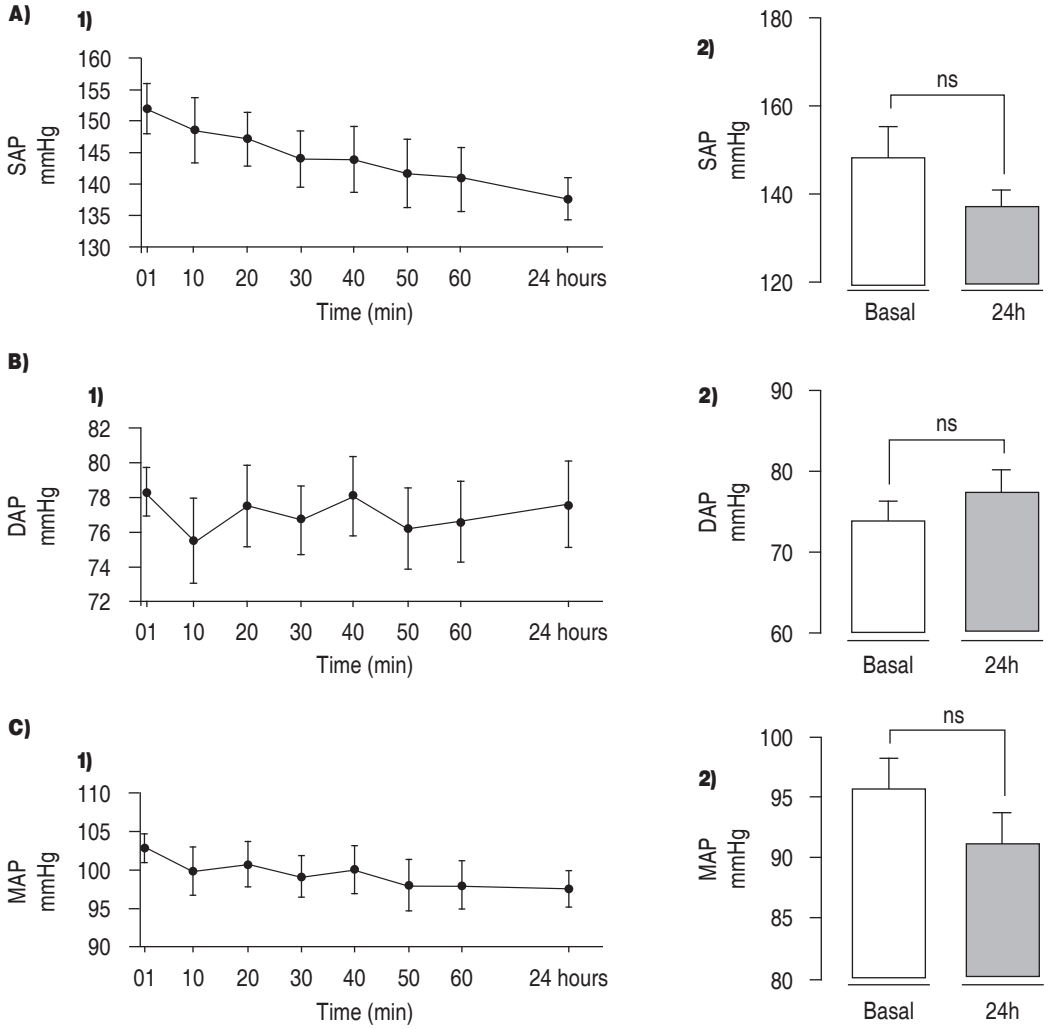

Figure 4: Blood Pressure of the G-HTN/IR group during intervention.

and neurohormonal, autonomic, and renal modifications, all of which contribute to hypertension and may explain the diminished BP response observed in some cases.

From a clinical perspective, the reductions in SAP and MAP observed in the G-HTN and G-HTN/IR groups after a single session of isometric exercise could lower the risk of cardiovascular disease, stroke, and chronic kidney disease, highlighting the importance of this intervention in the ambulatory management of hypertension. Therefore, the inclusion of an isometric training protocol at 30% of maximal manual grip strength during cardiovascular rehabilitation could constitute an effective strategy to induce a hypotensive response. Moreover, this type of intervention presents additional advantages such as high patient adherence and low implementation cost.

Finally, it is important to acknowledge that the studies by Espinoza, Wiles, Almeida, and Halliwill utilized larger population samples than our study. Future research should consider this factor to enhance the generalizability of findings.

CONCLUSION

In conclusion, a single session of isometric handgrip exercise at 30% of maximal isometric

force significantly reduces SAP and MAP values in individuals with hypertension and those with hypertension and insulin resistance. This intervention is safe, well-tolerated, and presents a promising non-pharmacological approach for the outpatient management of hypertension.

The evaluation of the effects within the first 24 hours is relevant, as it allows us to understand the magnitude and temporality of the acute hemodynamic response. This projects the efficacy of isometric training in contexts of continuous exercise prescription.

Future studies should consider a larger sample size, reduced heterogeneity in pharmacological treatment, and greater control over nutritional factors to clarify further the acute effects of an isometric training session in the studied population.

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Correspondence:
Alexis Espinoza Salinas
E-mail: alexisespinozasa@santotomas.cl