

Treadmill Test and Ambulatory Blood Pressure Monitoring: Can They Be Performed on the Same Day? Can the Effort Reached on the Treadmill Interfere?

Paulo Magno Martins Dourado,¹ Larissa de Almeida Dourado,¹ Letícia Raiane dos Anjos Silva,¹ Jaciara Gomes de Oliveira,¹ Karolyne de Oliveira Matos,¹ João Paulo de Almeida Dourado,¹ Ludhmila Abrahão Hajjar,² Pedro Gabriel Senger Braga^{1,3}

Clínica Pró-Coração,¹ São Paulo, SP – Brazil

Unidade de Terapia Intensiva do Pronto Atendimento do Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo,² São Paulo, SP – Brazil

Departamento de Cardio-Oncologia, Instituto do Coração do Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo,³ São Paulo, SP – Brazil

Abstract

The present study aimed to assess whether the exercise stress test influences the results of ambulatory blood pressure monitoring (ABPM) in individuals who undergo both examinations on the same day, and whether the intensity reached during the test affects the blood pressure values obtained through ABPM.

A total of 190 adults participated in the study, which included two analyses: performing the tests on the same day (n=145) versus on different days (n=45) and reaching submaximal (n=95) versus maximal (n=50) heart rate during the exercise stress test.

Performing the exercise stress test and ABPM on the same day did not affect maximum systolic blood pressure during wakefulness (p=0.5307) or sleep (p=0.7383), maximum diastolic pressure during wakefulness (p=0.2691) or sleep (p=0.3974), minimum systolic pressure during wakefulness (p=0.4615) or sleep (p=0.5584), or minimum diastolic pressure during wakefulness (p=0.1289) or sleep (p=0.8075). When comparing the intensity of effort reached, there were no differences in maximum systolic pressure during wakefulness (p=0.1029) or sleep (p=0.2149), maximum diastolic pressure during wakefulness (p=0.2062) or sleep (p=0.1851), minimum systolic pressure during wakefulness (p=0.7964) or sleep (p=0.8991), and minimum diastolic pressure during wakefulness (p=0.8864) or sleep (p=0.4892).

No differences were found in ABPM blood pressure values between individuals who performed the exercise

stress test on the same day and those who did so on different days. Additionally, the intensity reached during the test, whether submaximal or maximal, did not influence ABPM results.

Introduction

Ambulatory blood pressure monitoring (ABPM) is considered the gold standard for diagnosing systemic arterial hypertension (SAH) and for monitoring pharmacological treatment. Compared to office blood pressure (BP) measurements, ABPM offers greater predictive power and sensitivity for assessing cardiovascular outcomes – such as fatal and non-fatal coronary events and stroke – as well as target organ damage.^{1,2} In routine cardiological evaluations, patients commonly undergo a treadmill exercise test, and if symptoms or an exaggerated blood pressure response to exertion are observed, ABPM is performed on the same day or shortly thereafter.

Aerobic exercise is known to reduce both systolic BP (SBP) and diastolic BP (DBP), with effects lasting up to 24 hours post-exercise.³⁻⁶ However, it remains unclear whether a brief (<10 minutes), maximal or submaximal physical effort can influence blood pressure readings during hypertension assessment. Therefore, the present study aims to: (1) determine whether physical exertion affects ABPM results in individuals who undergo both tests on the same day; and (2) among those tested on the same day, assess whether the intensity reached during the treadmill test impacts the BP values recorded by ABPM.

Methods

Patients

For this study, a convenience sample was collected based on patients attending the outpatient service at Clínica Pró-Coração. Inclusion criteria were: performing an exercise stress test with at least submaximal intensity ($\geq 85\%$ of the age-predicted maximum heart rate); undergoing both ABPM and the stress test on the same day or, at most, within the same week. For ABPM interpretation, at least 80% of valid readings were required for the exam to be considered satisfactory.

Keywords

Arterial Pressure; Exercise Test; Ambulatory Blood Pressure Monitoring

Mailing Address: Pedro Gabriel Senger Braga •

Av. Dr. Enéas Carvalho de Aguiar, 44. Postal Code 05403-900, Cerqueira César, São Paulo, SP – Brazil

E-mail: pedro.senger@gmail.com

Manuscript received June 16, 2025, revised manuscript July 29, 2025, accepted October 23, 2025

Editor responsible for the review: Paulo B. Veiga Jardim

DOI: <https://doi.org/10.36660/abc.20250412>

Exclusion criteria included: use of antihypertensive medications; SBP ≥ 180 mmHg or DBP ≥ 110 mmHg prior to the stress test; unreadable electrocardiogram or positive signs of myocardial ischemia. Physically active individuals, night-shift workers, smokers, and those with a history of cardiovascular events were also excluded. Participants were instructed to avoid alcohol consumption and refrain from physical exertion during the ABPM monitoring period.

Based on these data, two analyses were conducted: (1) a comparison between individuals who underwent both the exercise stress test and ABPM on the same day or on different days within the same week; and (2) among those who completed both tests on the same day, participants were divided into two groups—those who reached submaximal effort ($\geq 85\%$ of age-predicted maximum heart rate) and those who reached maximal effort ($\geq 95\%$ of age-predicted maximum heart rate).

The study was approved by the Ethics Committee of the Hospital das Clínicas, Faculty of Medicine, University of São Paulo, and all participants signed an informed consent form. This study is registered on the Clinical Trials platform (NCT05987891).

Treadmill exercise test

Initial variables such as BP and heart rate (HR) were collected at rest, with the participant standing on the treadmill and electrodes positioned on the chest (Inbramed®, Porto Alegre, Brazil). Systolic (SBP) and diastolic blood pressure (DBP) were assessed using the auscultatory method. All equipment undergoes annual preventive maintenance to ensure data quality. HR, SBP, and DBP were measured at rest and at peak exercise. Peak effort was defined as the participant's inability to continue exercising at a given workload due to voluntary exhaustion, prompting the evaluator to stop the test and initiate the recovery phase on the treadmill. The treadmill protocols used were Bruce and Ellestad. All tests were interpreted and reported by the same cardiologists, with those showing positive results for myocardial ischemia (PMMD, LAD, and JPAD) excluded.

Ambulatory blood pressure monitoring (ABPM)

Ambulatory blood pressure monitoring was performed using devices from Cardios (São Paulo, Brazil), which are calibrated every six months. The ABPM setup was carried out by trained nurses (LRAS, JGO, and KOM). The purpose of ABPM is to continuously record blood pressure levels over a 24-hour period, during both daily activities and sleep. The procedure involves placing a pressure cuff on the patient's arm, connected to a portable electronic recorder. This device is programmed to automatically inflate and measure blood pressure at regular intervals – typically every 15 minutes during the day and every 30 minutes at night. The collected data are stored in the device's internal memory for later analysis.

During the monitoring period, patients were instructed to maintain their usual activities, avoiding only intense physical exertion and exposure to water to prevent damage to the equipment. Patients were also asked to record sleep times,

meals, physical activities, and symptoms in a dedicated diary to correlate with the recorded values. After 24 hours, the device was removed and the data were transferred to specialized analysis software, which generates graphs and reports containing the average blood pressure values over the 24-hour period.

Statistical analysis

The Kolmogorov-Smirnov test was used to assess data distribution and normality. Statistical analyses were performed using Student's t-test for normally distributed data, or the Mann-Whitney test for non-normally distributed data. A p-value < 0.05 was considered statistically significant. Data were expressed as mean $\pm$ standard deviation. GraphPad Prism software, version 5.0, was used for all analyses.

Results

Of the individuals eligible for the study during the data collection period, 18 were excluded due to having SBP ≥ 180 mmHg and/or DBP ≥ 110 mmHg prior to the exercise stress test, and six declined to participate. After the stress test, 83 individuals failed to reach at least the age-predicted submaximal heart rate, and 14 had electrocardiograms that were either uninterpretable or showed positive signs of myocardial ischemia (Figure 1). Thus, 190 patients were included in the final analysis, as shown in Table 1.

The comparison between performing ABPM and the exercise stress test on the same day versus on different days is presented in Table 2. No significant differences were observed in maximum SBP during wakefulness ($p = 0.5307$) or sleep ($p = 0.7383$), nor in maximum DBP during wakefulness ($p = 0.2691$) or sleep ($p = 0.3974$). Similarly, minimum SBP during wakefulness ($p = 0.4615$) and sleep ($p = 0.5584$), as well as minimum DBP during wakefulness ($p = 0.1289$) and sleep ($p = 0.8075$), did not differ significantly between the groups.

When comparing the intensity of physical effort among individuals who underwent both ABPM and the exercise stress test on the same day, no significant differences were observed in systolic blood pressure (SBP) during wakefulness ($p = 0.1029$) or sleep ($p = 0.2149$), nor in diastolic blood pressure (DBP) during wakefulness ($p = 0.2062$) or sleep ($p = 0.1851$) between the groups. Similar results were found for minimum SBP during wakefulness ($p = 0.7964$) and sleep ($p = 0.8991$), as well as for minimum DBP during wakefulness ($p = 0.8864$) and sleep ($p = 0.4892$), as shown in Table 3.

Following ABPM, 142 patients (75% of the sample) were diagnosed with arterial hypertension. Additionally, none of the participants in the study exhibited a hyper-reactive blood pressure response to exertion during the exercise stress test. ABPM data were also analyzed according to age groups (< 65 years and ≥ 65 years) and sex, as presented in Table 4 of the supplementary material. Individuals aged ≥ 65 years showed significantly lower diastolic blood pressure during wakefulness (103 ± 13 vs. 96 ± 13 mmHg; $p = 0.0015$) compared to those under 65 years of age. No other variables showed significant differences between the groups analyzed.

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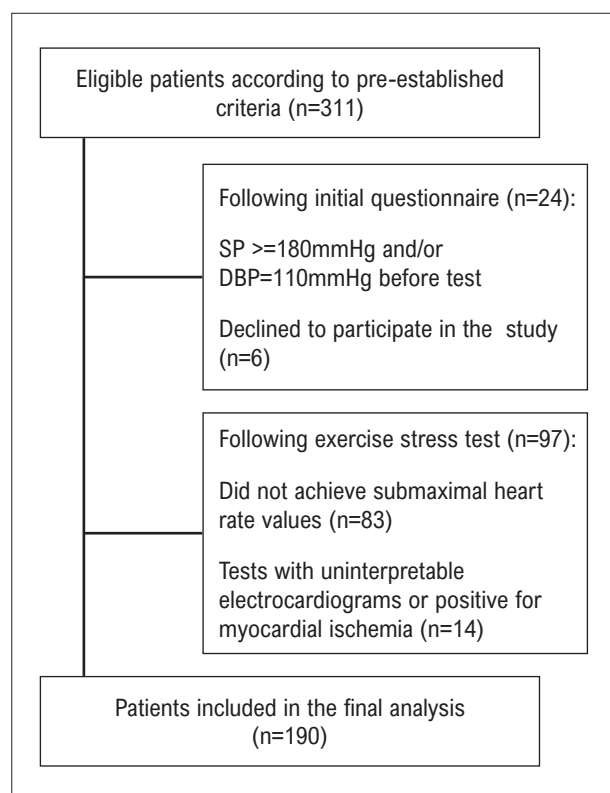


Figure 1 – Flowchart of patients; DBP: diastolic blood pressure; SBP: systolic blood pressure.

Regarding sex differences, female participants showed lower diastolic blood pressure values compared to males in several parameters: maximum diastolic pressure during wakefulness (104 ± 13 vs. 99 ± 13 mmHg; $p = 0.0053$), maximum diastolic pressure during sleep (91 ± 14 vs. 84 ± 13 mmHg; $p = 0.0012$), minimum systolic pressure during wakefulness (101 ± 15 vs. 96 ± 12 mmHg; $p = 0.0064$), and minimum diastolic pressure during wakefulness (60 ± 12 vs. 55 ± 10 mmHg; $p = 0.0019$). The isolated analysis of ABPM within the same sex, comparing different days or the same day as the exercise stress test, did not show significant differences in the variables studied, as presented in Table 5 of the supplementary material.

Discussion

Performing the treadmill test on the same day or on different days from ABPM did not influence blood pressure values in the studied sample, which consisted of non-hypertensive and physically inactive individuals. This finding supports the feasibility of conducting both the exercise stress test and ABPM on the same day, enhancing cardiological clinical practice by improving patient retention in the clinical setting and reducing dropout and discontinuity in clinical investigation.

The hypothesis, supported by a robust body of evidence, suggests that acute aerobic physical exercise reduces systolic and diastolic blood pressure, and that this effect may depend on the intensity of the exercise.³⁻⁶

Table 1 – Anthropometric and exercise stress test characteristics of the study sample

Variable	Sample (n=190)
Sex (F/M)	88/102
Age (years)	53 ± 13
Weight (kg)	84.7 ± 18.3
Height (m)	1.70 ± 0.10
BMI (kg/m ²)	29.2 ± 5.1
Exercise stress test	
Heart rate (bpm)	
Resting	77 ± 15
Maximum	154 ± 21
Blood pressure (mmHg)	
Resting systolic blood pressure	131 ± 12
Maximum systolic blood pressure	161 ± 17
Resting diastolic blood pressure	82 ± 4
Maximum diastolic blood pressure	83 ± 7
Test duration (seconds)	333 ± 98

BMI: body mass index; bpm: beats per minute.

In treated hypertensive patients, physical exercise has been shown to reduce blood pressure for up to 24 hours, reaching values considered normal.⁶ However, in the present study, this effect was not observed – possibly because the population consisted of individuals who, although in the process of being diagnosed with hypertension, were not yet undergoing treatment. Additionally, the absence of this effect may be related to the low volume of exercise performed, with an average duration of five and a half minutes, corresponding to the length of the test.

Moreover, aside from the treadmill test, no participant engaged in any other form of physical exertion, there were no reports of alcohol consumption in the diaries, and the sample did not include night-shift workers, which could have introduced confounding factors into the results.

Following the age-based analysis (<65 years vs. ≥ 65 years), as expected, the heart rate achieved was lower in the older group due to the decline in cardiac function associated with aging.^{7,8} Regarding male participants, higher hemodynamic values and longer test durations were observed.⁹ This finding is explained by greater physical capacity, resulting from higher testosterone levels and greater lean muscle mass.

The limitations of the present study include the absence of a group of hypertensive individuals and a group with hyper-reactivity to physical exertion, which would have allowed for more comprehensive comparisons and deeper exploration of the topic. The limited number of older participants, particularly

Table 2 – Hemodynamic variables from ambulatory blood pressure monitoring in individuals who underwent the treadmill test on the same day or on different days

Parameters/ groups	Same day (n=145)	Different days (n=45)	p
Blood pressure values (mmHg)			
Maximum systolic pressure during wakefulness	152 ± 17	155 ± 23	0.5307
Maximum systolic pressure during sleep	133 ± 16	134 ± 14	0.7383
Maximum systolic pressure during wakefulness	101 ± 13	104 ± 15	0.2691
Maximum systolic pressure during sleep	87 ± 13	89 ± 15	0.3974
Minimum systolic pressure during wakefulness	98 ± 13	100 ± 16	0.4615
Minimum systolic pressure during sleep	99 ± 13	100 ± 16	0.5584
Maximum systolic pressure during wakefulness	59 ± 10	56 ± 13	0.1289
Maximum systolic pressure during sleep	56 ± 10	58 ± 13	0.8075

Table 3 – Hemodynamic variables from ambulatory blood pressure monitoring in individuals who reached submaximal and maximal heart rate during the exercise stress test

Parameters/ groups	Submaximal (n=95)	Maximum (n=50)	p
Blood pressure values (mmHg)			
Maximum systolic pressure during wakefulness	155 ± 19	150 ± 15	0.1029
Maximum systolic pressure during sleep	134 ± 17	131 ± 15	0.2149
Maximum systolic pressure during wakefulness	103 ± 12	100 ± 13	0.2062
Maximum systolic pressure during sleep	89 ± 12	86 ± 14	0.1851
Minimum systolic pressure during wakefulness	98 ± 13	98 ± 13	0.7964
Minimum systolic pressure during sleep	98 ± 13	98 ± 13	0.8991
Maximum systolic pressure during wakefulness	59 ± 11	59 ± 11	0.8864
Maximum systolic pressure during sleep	57 ± 10	56 ± 10	0.4892

those aged 65 and above, also restricts more detailed analyses, especially secondary analyses by sex, which could have enriched the discussion around a predominantly hypertensive population that requires specific cardiological care.

Conclusion

Performing the exercise stress test prior to ABPM, both conducted on the same day, did not influence blood pressure values when compared to individuals who underwent the tests on different days. Furthermore, in treadmill tests performed on the same day as ABPM, the intensity of effort, whether maximal or submaximal, did not affect the ABPM results.

Given the ability of physical exercise to reduce blood pressure, one of the objectives of this investigation was to determine whether this phenomenon could mask hypertension in adults. However, this effect was not observed, which aligns with the study's hypothesis.

Therefore, the findings of this study reinforce clinical practice by demonstrating that physical exertion during the exercise stress test, whether submaximal or maximal, does not influence ABPM results, allowing both tests to be performed on the same day.

Acknowledgments

PCSB: To the Ministry of Education – MEC / Coordination for the Improvement of Higher Education Personnel – CAPES – process number: 88887.102383/2025-00.

Author Contributions

Conception and design of the research: Dourado PM, Hajjar LA, Braga PGS; Acquisition of data: Dourado PM, Silva LRA, Oliveira JG, Matos KO; Analysis and interpretation of the data: Dourado LA, Silva LRA, Oliveira JG, Matos KO, Dourado JPA, Hajjar LA, Braga PGS; Statistical analysis: Braga PGS; Obtaining financing: Dourado PM, Dourado JPA; Writing of the manuscript: Dourado LA, Braga PGS; Critical revision of the manuscript for content: Dourado PM, Dourado LA, Hajjar LA, Braga PGS.

Potential conflict of interest

No potential conflict of interest relevant to this article was reported.

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Sources of funding

There were no external funding sources for this study.

Study association

This article is part of the thesis of post doctoral submitted by Pedro Gabriel Senger Braga, from Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo.

Ethics approval and consent to participate

This study was approved by the Ethics Committee of the Faculdade de Medicina da Universidade de São Paulo under the protocol number 6.258.413. All the procedures in this

study were in accordance with the 1975 Helsinki Declaration, updated in 2013. Informed consent was obtained from all participants included in the study.

Use of Artificial Intelligence

The authors did not use any artificial intelligence tools in the development of this work.

Data Availability Statement

All datasets supporting the results of this study are available upon request from the corresponding author (Pedro Gabriel Senger Braga).

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