

# Autonomic response of older women to the submaximal effort in the six-minute walk test: a cross-sectional study

*Resposta autonômica de mulheres idosas ao esforço submáximo do teste de caminhada de seis minutos: um estudo transversal*

*Respuesta autonómica de ancianas al esfuerzo submáximo en la prueba de paso de seis minutos: un estudio transversal*

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**ABSTRACT** | This cross-sectional study aimed to evaluate the autonomic response of older women in the six-minute walk test. In total, 32 women aged 60 years or older without a diagnosed health problem were evaluated during the six-minute walk test. To monitor the autonomic response, the following variables were considered: heart rate, systolic and diastolic blood pressure, respiratory rate, and perceived exertion. These variables were compared during rest, effort, and recovery. This study also sought a correlation between autonomic function variables and performance in the test and perceived exertion. Results showed that the effort made by older women in the six-minute walk test induces an autonomic response resulting in increased heart rate and systolic and diastolic blood pressure; however, the respiratory rate remained unchanged during the test. Diastolic blood pressure remained high during recovery. No correlation was found neither between perceived exertion and cardiovascular physiological response nor between distance covered and variation of the autonomic response or level of physical conditioning. Therefore, the effort spent in the six-minute walk test promotes

an autonomic response in older women, increasing cardiovascular stress without increasing ventilation. In this context, the Borg scale was not representative of cardiovascular stress during the test.

**Keywords** | Walk Test; Aged; Aging; Autonomic Nervous System; Cardiovascular System.

**RESUMO** | O objetivo deste estudo foi investigar a resposta autonômica de idosas ao esforço do teste de caminhada de 6 minutos (TC6M). Realizou-se um estudo transversal a partir da avaliação de 32 idosas, sem problemas de saúde diagnosticados, com 60 anos ou mais, durante o TC6M. Para o monitoramento da resposta autonômica, foram consideradas as seguintes variáveis: frequência cardíaca, pressão arterial sistólica e diastólica, frequência respiratória e percepção de esforço. Essas variáveis foram comparadas durante o período de repouso, esforço e recuperação. Buscou-se também correlação entre as variáveis da função autonômica e o desempenho no teste e a percepção de esforço. Os resultados demonstraram que o esforço

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gerado no TC6M induz uma resposta autonômica que leva ao aumento da frequência cardíaca e da pressão arterial sistólica e diastólica em mulheres, porém a frequência respiratória permaneceu inalterada durante o teste. A pressão arterial diastólica permaneceu elevada durante a recuperação. Não houve correlação entre a percepção de esforço e a resposta fisiológica cardiovascular apresentada, nem entre a distância percorrida e a variação da resposta autonômica ou o nível de condicionamento físico. Concluiu-se que o esforço despendido no TC6M promove uma resposta autonômica em idosas, intensificando o estresse cardiovascular sem aumentar a ventilação. Nesse contexto, a escala de Borg não foi representativa do estresse cardiovascular durante o teste.

**Descritores** | Teste de Caminhada; Idoso; Envelhecimento; Sistema Nervoso Autônomo; Sistema Cardiovascular.

**RESUMEN** | El objetivo de este estudio fue investigar la respuesta autonómica de ancianas al esfuerzo en la prueba de paso de 6 minutos (6MWT). Se realizó un estudio transversal con la participación de 32 ancianas, de 60 años o más, sin problemas de salud diagnosticados durante la 6MWT. Para monitorear la respuesta autonómica, se consideraron las

siguientes variables: frecuencia cardíaca, presión arterial sistólica y diastólica, frecuencia respiratoria y esfuerzo percibido. Se compararon estas variables durante el período de reposo, esfuerzo y recuperación. También se buscó una correlación entre las variables de función autonómica y rendimiento en la prueba y el esfuerzo percibido. Los resultados mostraron que el esfuerzo producido en la 6MWT genera una respuesta autonómica que conduce a un aumento de la frecuencia cardíaca y de la presión arterial sistólica y diastólica en las mujeres, pero la frecuencia respiratoria se mantuvo sin cambios durante la prueba. La presión arterial diastólica se mantuvo alta durante el período de recuperación. No hubo correlación entre el esfuerzo percibido y la respuesta fisiológica cardiovascular presentada, tampoco entre la distancia recorrida y la variación de la respuesta autonómica o el nivel de condicionamiento físico. Se concluyó que el esfuerzo realizado en la 6MWT generó una respuesta autonómica en las ancianas al intensificar el estrés cardiovascular pero sin aumentar la ventilación. En este contexto, la escala de Borg no fue significativa para el estrés cardiovascular durante la prueba.

**Palabras clave** | Prueba de Paso; Anciano; Envejecimiento; Sistema Nervioso Autônomo; Sistema Cardiovascular.

## INTRODUCTION

The autonomic nervous system (ANS) is responsible for controlling the smooth muscles of internal organs and is divided into sympathetic and parasympathetic nervous systems<sup>1</sup>. These systems allow quick adjustments for blood pressure, heart rate (HR), and vascular reactivity<sup>2</sup>. However, aging is associated with structural and functional changes in the ANS<sup>3</sup>.

During physical exercise, the cardiovascular response is induced by mechanical and metabolic muscle signals that provide afferent stimuli that lead to physiological responses, including increased HR, contractility<sup>4</sup>, and cardiac output, which is proportional to oxygen uptake, maintaining or increasing blood pressure<sup>5</sup>. However, aging reduces the parasympathetic tone<sup>6,7</sup>.

Submaximal stress tests are widely used to assess functional capacity and response to therapeutic intervention<sup>8,9</sup>. Although the six-minute walk test (6MWT) was designed to evaluate patients with chronic obstructive pulmonary disease, its use has expanded to

other chronic diseases, since its assessment is in the scope of functional capacity<sup>10</sup>. Moreover, walking tests have an important correlation with functionality in older adults with and without chronic diseases<sup>11</sup>. However, to date, no published studies have evaluated the autonomic response to the effort spent in the 6MWT.

Considering the autonomic dysfunction inherent to aging<sup>3</sup>, evaluating how older adults respond to the 6MWT is necessary to provide scientific evidence that makes the test more applicable to them. Thus, this study aimed to investigate the autonomic response of older women to the 6MWT.

## METHODOLOGY

This quantitative cross-sectional study evaluated women aged 60 years or older without a diagnosed health problem. The sample was recruited in activity groups for older adults and 32 women were selected. Having a cardiopulmonary disease, motor impairment,

severe osteoarticular disease, and sensory-perceptual disorders were exclusion criteria.

Data were collected by trained researchers from the Universidade Estadual de Ciências da Saúde de Alagoas at the university or in places where the older women performed group activities, always before physical activities. All women underwent a preliminary clinical evaluation, in which information on their personal characteristics, such as lifestyle, health condition, and physiological and pathological background, was collected. Once the sample eligibility was established, all older women underwent the following evaluation processes.

### Baecke physical activity questionnaire

The physical activity questionnaire for the elderly, or the Baecke questionnaire, assesses the amount and intensity of weekly physical activity performed in the last 12 months at home and during leisure time. To classify the sample according to the level of habitual physical activity, the cut-off points established by Ueno<sup>12</sup> were considered.

### Six-minute walk test (6MWT)

This is a submaximal, validated, and standardized test to assess functional capacity<sup>13</sup>. In a 30-m-long hallway, delimited by cones and without flow of people, older women were instructed to walk as fast as possible for six minutes, without pause. Before the test, they remained seated for 10 minutes and during this time, systolic (SBP) and diastolic (DBP) blood pressure were measured using a properly calibrated sphygmomanometer and stethoscope, resting HR and oxygen saturation were evaluated by a portable pulse oximeter, respiratory rate (RR) was observed by counting visible respiratory incursions per minute, and perceived exertion (BORG) was measured using the Borg scale<sup>14</sup>. After the test, the distance covered was estimated and a new monitoring (HR, SBP, DBP, RR, and BORG) was performed immediately after the effort and after 10 minutes of rest.

### Estimation of the predicted distance for the 6MWT

The reference equation to predict distance in the 6MWT<sup>13</sup> allowed for the estimation of the predicted value for each older woman. The equation is described as

Estimated Distance=(2.11×height in cm)–(2.29×weight in kg)–(5.78×age)+667m and its result was used to estimate the percentage of the distance covered (= % predicted×100/distance covered).

### Data analysis

The variables SBP, DBP, RR, HR, and BORG were observed during rest (before the test), effort (immediately after the test), and recovery (10min after the test). For all periods, mean, standard deviation, and minimum and maximum values were estimated, as well as the HR variation ( $\Delta$ HR=effort HR–rest HR).

For all quantitative variables, data distribution analysis was performed using the D'Agostino-Pearson test to guide the choice of parametric or nonparametric tests. For the comparison of the rest, effort, and recovery periods, the analysis of variance (ANOVA) test with repeated measures and the Tukey post-hoc test were used.

For correlation analyses, the Pearson's correlation coefficient was estimated when two variables had normal distribution. When one or two variables did not have a normal distribution, the Spearman's correlation coefficient was used.

All statistical analyses were performed using the Prism GraphPad® 5.0 software and  $p \leq 0.05$  was considered significant.

## RESULTS

### Sample characteristics

We evaluated 32 women aged from 60 to 86 years, of which 59.37% practiced regular physical activity, mostly walking (43.36%). Gymnastics, water aerobics, and Pilates were other mentioned activities. However, the Baecke questionnaire showed that all older women had a low level of habitual physical activity, with a mean of 3.83 (Table 1). Based on an anthropometric perspective, the sample had short stature and high total body mass (Table 1), as well as a high prevalence of overweight (53.12%).

Regarding the performance of the sample in the 6MWT, the mean distance covered was 411.7m and the mean percentage based on the individual calculation of the predicted distance was 95.10% (Table 1).

Table 1. Characteristics of the sample

	Mean	Standard deviation	Minimum	Maximum
Age (years old)	70.62	7.11	60.00	86.00
Height (m)	1.54	5.32	1.41	1.68
Weight (kg)	65.80	13.09	38.10	90.50
BMI (kg/m <sup>2</sup> )	27.51	4.77	16.50	36.20
Baecke score	3.83	2.63	0.50	9.66
6MWT (m)	411.70	78.63	229.00	586.50
% Performed from the distance predicted for 6MWT (%)	95.10	19.70	54.90	133.30

Data from 32 older women. BMI: body mass index; 6MWT: six-minute walk test.

### Autonomic response to the 6MWT

The effort expended in the 6MWT increased SBP, DBP, HR, and PE compared with the rest period (Table 2), showing autonomic response during effort. In the recovery period, SBP, HR, and BORG decreased, although HR maintained high values compared with the rest period (Table 2). DBP remained high even 10 minutes after the test. RR remained similar during the three evaluated periods, with mean of 18 breaths per minute (Figure 1).

Table 2. Autonomic response and perceived exertion in response to the six-minute walk test

	Rest Mean±SD	Effort Mean±SD	Recovery Mean±SD
Systolic BP	132.78 (±13.99)	138.75 (±15.81)*	131.87 (±14.46)#
Diastolic BP	81.56 (±9.19)	87.50 (±11.63)*	86.87 (±13.78)*
HR	75.12 (±10.81)	90.59 (±14.40)*	78.06 (±10.57)*#
RR	18.00 (±3.42)	18.96 (±3.27)	18.43 (±3.91)
BORG	0.62 (±1.18)	2.50 (±2.27)*	0.60 (±1.26)*#

SD: standard deviation; BP: blood pressure; HR: heart rate; RR: respiratory rate; #: compared with rest (<0.0001); \*: compared with effort (<0.0001).

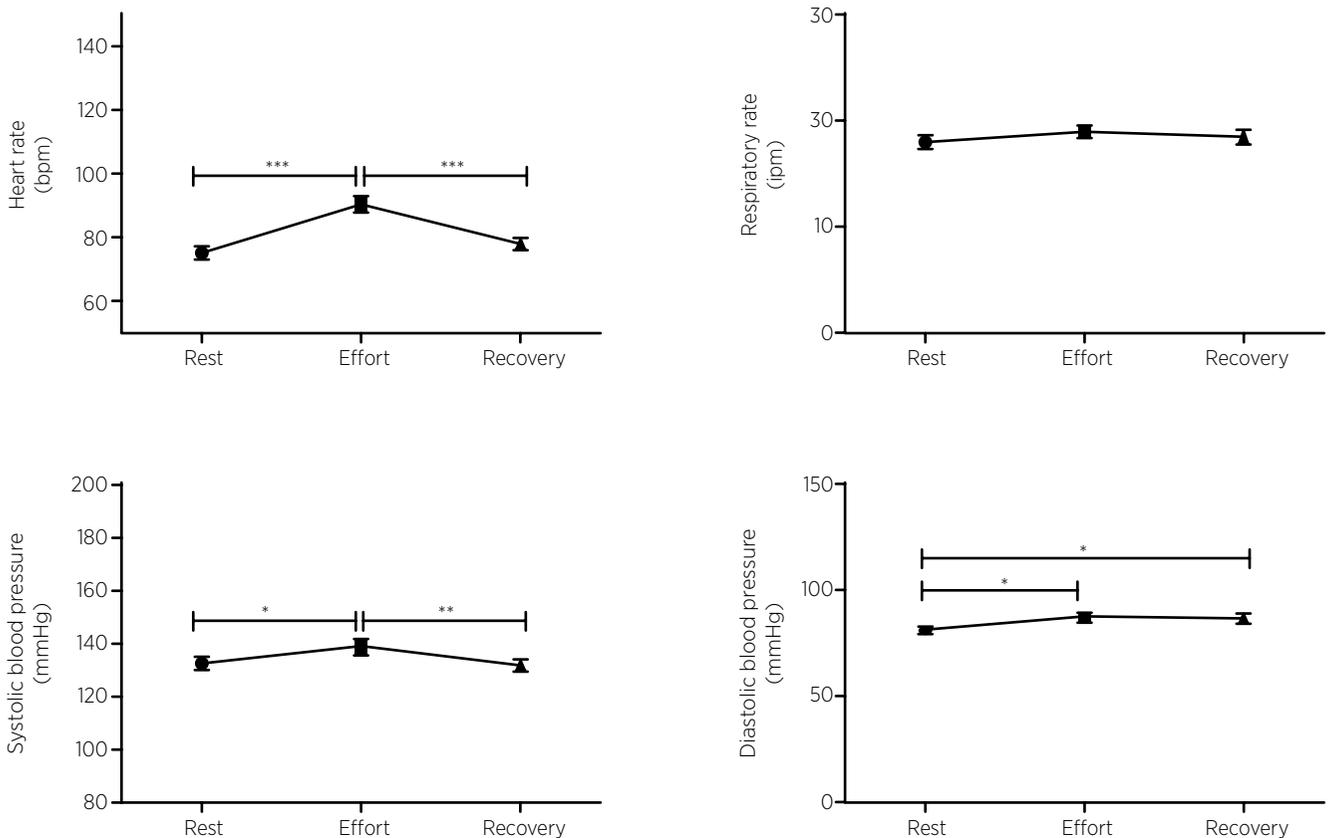


Figure 1. Autonomic response during the 6MWT.

#: p≤0.05; \*\*: p≤0.01; \*\*\*: p≤0.001.

### Correlation between physiological response to effort and perceived exertion

The evaluation of the correlation between the response of clinical markers of autonomic function and BORG

showed no correlation between the variables resting HR, delta HR, and HR and BORG during effort (Figure 2), thus, despite the physiological response to exercise, this is not expressed as perceived exertion.

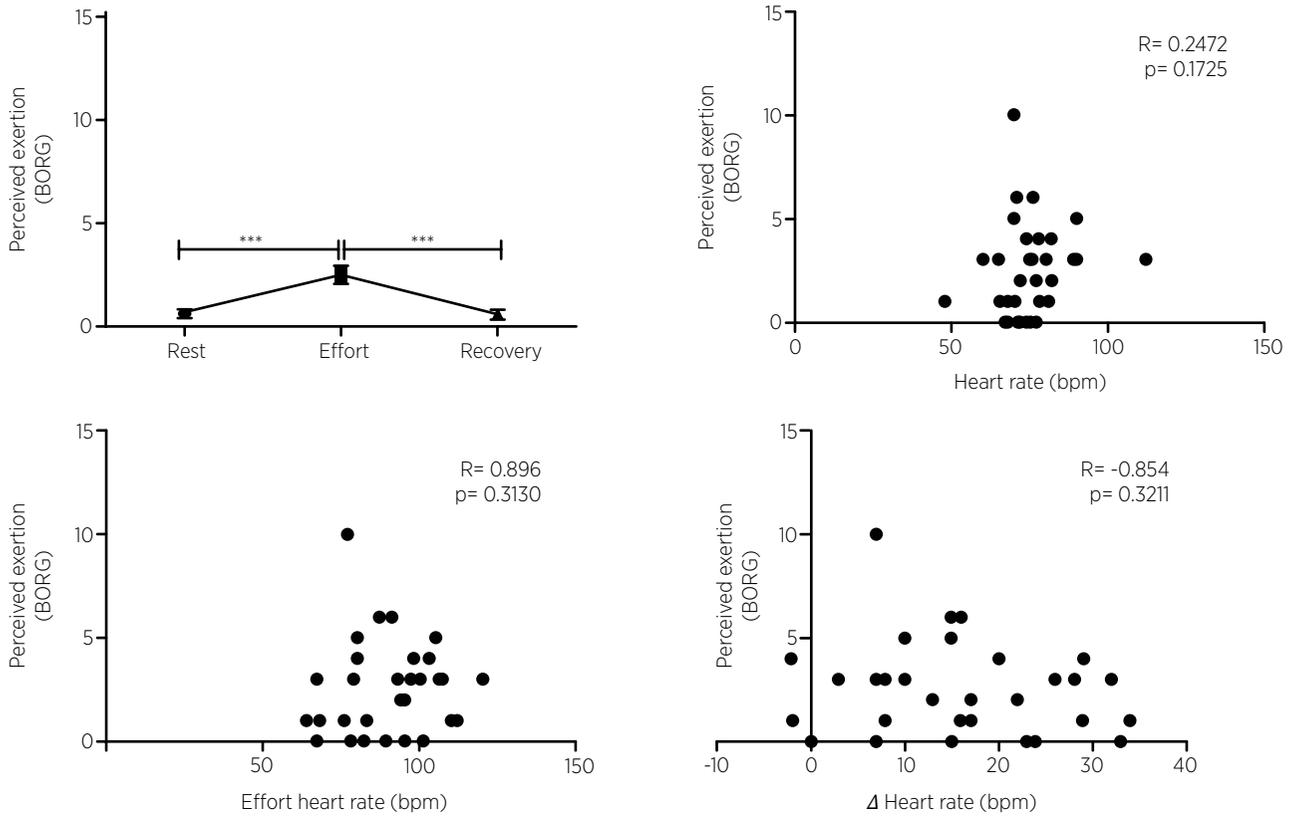


Figure 2. Correlation between the response of clinical markers of autonomic function and perceived exertion during effort  
 \*\*\*:  $p \leq 0.001$ ; R: correlation coefficient; p: p-value of the statistical test.

### Correlation between autonomic response and performance in the 6MWT

We found no correlation between delta and resting HR and performance in the 6MWT (Figure 3). Such

result suggests that in older women with low levels of habitual physical activity, resting HR or the HR variation during the test are not determining variables for their performance in the 6MWT.

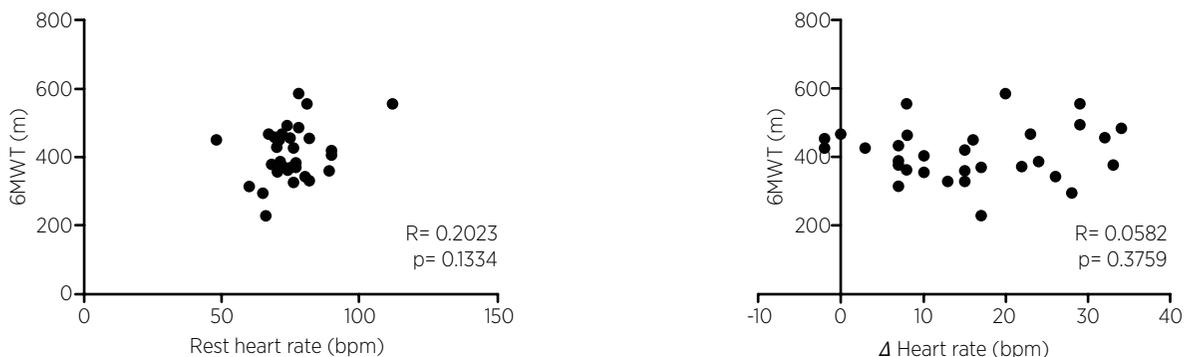


Figure 3. Correlation between autonomic response and performance in the 6MWT  
 R: correlation coefficient; p: p-value of the statistical test.

## DISCUSSION

Our results show that the effort expended by older women with low levels of habitual physical activity in the 6MWT induces an autonomic response resulting in increased HR, SBP, and DBP during the test. However, RR remained unchanged during the test. Although older women reported an increased sensation of effort during the 6MWT, we found no correlation between perceived exertion and this cardiovascular physiological response. Moreover, we found no correlation between distance covered and variation in the autonomic response or level of physical conditioning.

The cardiovascular and respiratory systems are regulated by the sympathetic and parasympathetic nervous systems. The aging process reduces the parasympathetic tone, which can result in impaired cardiovascular and respiratory response to effort<sup>6</sup>. During exercise, the parasympathetic activity is discontinued by sensory feedback, which is originated from the mechanical and metabolic muscle response, favoring the sympathetic activity that increases HR, stroke volume, and cardiac output<sup>15</sup>. Moreover, baroreceptors, cardiac receptors, and carotid body chemoreceptors contribute to the modulation of the ANS response during exercise, which results in an important control of HR, blood pressure, and respiratory activity<sup>6</sup>. In the recovery period, the sympathetic activity undergoes parasympathetic reactivation and deactivation, reducing HR and blood pressure<sup>6</sup>. In our study, the autonomic response to the 6MWT during effort increased HR, SBP, and DBP.

In the recovery period, our sample showed a deficiency regarding DBP normalization to baseline resting levels. Aging impairs the autonomic function, including the HR response to exercise and recovery<sup>16</sup>. Reduced cardiac vagal modulation and reduced parasympathetic activity in the heart may be correlated due to decreased baroreflex sensitivity<sup>17</sup>, which would explain the delayed DBP normalization in our study.

Moreover, Casonatto et al.<sup>18</sup> showed that DBP normalization was delayed even in young adults after test in a treadmill, decreasing only after 60 minutes. Tricott et al.<sup>19</sup> stated that the low level of physical activity contributes to the delayed normalization of autonomic variables after exercise. Therefore, the low level of physical activity in our sample may have contributed to the delayed DBP normalization during the recovery period.

Although the 6MWT caused cardiovascular stress, which is represented by high HR and blood pressure, RR remained similar throughout the test. Thus, the physiology of breathing results from a combination of mechanisms that involve the central nervous system (CNS), peripheral afferent feedback, and chemical actions<sup>20</sup>. In more strenuous exercises, in which the tidal volume reaches 50% to 60% of the vital capacity, forming a plateau, the minute volume increases due to increased RR<sup>20</sup>. However, the stimulus generated by the 6MWT may not be sufficient to promote such physiological responses in the studied population, since individuals perform this test with their maximum effort<sup>21</sup>.

RR is a valid marker of perceived exertion<sup>20</sup> and, although our sample reported increased perceived exertion during the test, the effort spent in the 6MWT was not sufficient to promote changes in the ventilatory response. When we evaluated perceived exertion using the Borg scale, the sample reported mild tiredness. Ribeiro et al.<sup>22</sup> and Alves et al.<sup>23</sup> evaluated women and they reported the same perceived exertion during a walking circuit-based exercise and resistance exercises, considering them easy.

Although the Borg scale is widely used in clinical studies<sup>24-27</sup> to monitor effort, in this study, perceived exertion was not correlated to cardiovascular stress during exercise, which is represented by HR during effort and the HR variation during exercise. This result suggests that the Borg scale is not representative of the autonomic response to exercise in older women with low levels of physical activity.

We found no correlation between the HR variation and performance in the 6MWT, suggesting that the autonomic response was not determinant for exercise capacity. Njemanze et al.<sup>28</sup> observed that in older women, the HR response to exercise reduced even in physically active women, showing that a high level of daily physical activity has a limited effect on age-related decline in cardiac autonomic function. Our findings corroborate this study, as they show that better exercise capacity in the 6MWT is not related to better autonomic response. This result shows that for older women, HR variability may not be an ideal parameter to monitor stress tests, since their autonomic response is delayed.

## CONCLUSION

The effort expended in the 6MWT results in increased HR, SBP, DBP, and perceived exertion in older women

with low levels of habitual physical activity. In this sample, DBP normalization was delayed and there are no effects on RR. Therefore, the walk test promotes an autonomic response in older women, increasing cardiovascular stress without increasing ventilation.

The Borg scale is not representative of cardiovascular stress during the test. Thus, its use to monitor effort requires attention. Moreover, considering the decreased autonomic response to exercise inherent to aging, HR variability may not be an ideal parameter to monitor older women during stress tests.

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