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Influence of Resting Blood Pressure on Functional Fitness: An Experimental Study Comparing Hypertensive and Normotensive Older Women

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Abstract: Hypertensive older adults have reduced blood flow and oxygen supply as compared to normotensive individuals. These negative adaptations can negatively impact muscle function. Although the vascular consequences of systemic arterial hypertension (SAH) have been extensively discussed, the literature on functional fitness (FF) in hypertensive older persons is limited. The objective of the present study was to investigate the influence of resting blood pressure (BP) on functional fitness in hypertensive as compared to normotensive older women. A total of 48 older women were included according to their resting BP: 24 from the normal BP group (GNBP, 70.5 ± 7.4 years) and 24 from the high BP group (GHBP, 71.0 ± 6.8 years). Anthropometric measurements and FF (30s Chair Stand, Arm Curl, Chair Sit and Reach and 8-Foot Up-and-Go) were investigated. The comparison between groups revealed that the GNBP had a higher number of repetitions in the 30s chair stand test (p=0.007, d=0.618) as compared to the GHPB. Hypertensive older women have lower values of lower limb muscle strength compared to normotensive older women. Therefore, functional tests that measure muscle strength of lower limbs may be adapted for this population.

Keywords: Functional Capacity; Geriatrics; Hypertension; Muscle Strength; Older persons.

1. Introduction

Systemic arterial hypertension (SAH) affects more than 25% of the world population, being considered as a primary risk factor for the development of atherosclerosis, coronary artery disease, myocardial infarction and kidney disease (American College of sports Medicine, 2004). The literature demonstrates that the prevalence of SAH increases with age, reaching more than half of those with 60 years old or over (American College of Sports Medicine, 2004; Chobanian et al., 2003; Malachias et al., 2016).

Previous studies have shown that higher levels of Blood Pressure (BP) seem to impact muscle function in hypertensive older adults (Williams et al. 2007; Greaney et al. 2014; Greaney, Edwards, Fadel & Farquhar, 2015). This is justified by the fact that hypertensive individuals may have an increased muscle sympathetic nerve activity and increased vasoconstriction (Greaney, Edwards, Fadel & Farquhar, 2015; Gosker, Wouters, der Vusse & Schols, 2000) which may impact in the production of strength, power and performance levels.

In this context, the functional capacity, which is defined as the ability to perform activities of daily living independently and without fatigue, is significantly lower with advancing age (Rikli & Jones, 2013). The Senior Fitness test is one of the most used protocols in the world to assess functional fitness in older people (Rikli & Jones, 2013; Vasconcelos, Cardozo, Luchetti & Luchetti, 2016; Cardozo et al., 2019) presenting a good correlation with other more sophisticated methods of physical evaluation (Rikli & Jones, 2013) and has the advantage of analyzing different physical valences, such as strength, endurance, agility, flexibility, and aerobic capacity that are essential for carrying out the physical activities of daily living. Although the vascular consequences of systemic arterial hypertension (SAH) have been extensively discussed (American College of Sports Medicine, 2004, Williams et al. 2007; Aronow et al. 2011), the literature on functional fitness (FF) in hypertensive older persons is limited.

For this reason, the objective of the present study was to investigate the influence of resting blood pressure on functional fitness in hypertensive as compared to normotensive older women. To our knowledge, this is the first study aimed at this analysis in older women. As an initial hypothesis, we expect that the tests that require greater strength and contraction speed will be lower in the group of hypertensive patients.

2. Materials and Methods

This is an experimental study carried out between October and November of 2019. Participants were selected from the FAMIDADE program in the city of Juiz de Fora, BRAZIL (Vasconcelos, Cardozo, Luchetti & Luchetti, 2016). This program is offered to the community with the aim of promoting education and health in this population by providing a range of activities, talks and social interaction.

Inclusion criteria adopted for participation in this study were: be older women (60 years old or over), not have any muscle and/or joint limitations that may affect the functional fitness test and be cognitively capable of understanding the tests proposed.

Participants were enrolled in two experimental groups until reaching the desired sample size, based on the values of the Joint National Committee Seven on the Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC7) (Chobanian et al., 2003): (a) the normal blood pressure group (GNBP), which consisted of participants who had SBP values <120 mmHg and DBP values <80 mmHg and make use of no antihypertensive drugs; and (b) the high blood pressure group (GHBP), which consisted of hypertensive and pre-hypertensive participants who presented SBP values ≥130 mmHg and DBP≥80 mmHg and may be using some antihypertensive drugs, such as diuretics, vasodilators, angiotensin-converting enzyme inhibitors, and beta-blockers.

The experimental procedures were approved by the local Ethics Research Committee under number 847.611. The study was conducted in compliance with the ethical principles of the Declaration of Helsinki and participants signed a consent term.

Methodology— All volunteers were informed of the objectives and the procedures of this study. All data were collected on the same day. After agreeing to participate, participants had their resting blood pressure and anthropometric data measured and were submitted to the functional fitness test as reported below:

Resting blood pressure — Resting blood pressure (BP) was determined according to the American Heart Association (Pickering et al., 2005). After a period of 10 minutes at rest, with a sphygmomanometer positioned on the right arm, sitting position, legs uncrossed, with feet flat on the floor and back supported, resting BP readings were performed. Two readings were taken, with an interval of 5 minutes between readings. If there was a difference greater than 5 mmHg between the first and the second reading, a third reading would be performed. It was considered as resting BP the lowest value found between readings (Pieckering et al., 2005; Blanchard et al., 2018).

Anthropometric measurements — Body weight was performed on a calibrated scale and height was measured using a tape measure on the wall with the volunteers wearing light clothes and barefoot.

Assessment of Functional Fitness — The assessment of functional fitness was based on the Senior Fitness Test (Rikli & Jones 1999; Rikli & Jones 2013). All tests were performed in the same sequence as described below:

a) 30s Chair Stand - Number of times the subject gets up from the chair for a period of 30 seconds. This test was performed once and is indicated to measure the dynamic strength of the lower limbs;

b) Arm Curl - Number of elbow flexion in which the subject performs for a period of 30 seconds. This test was performed once and is indicated to measure the dynamic strength of the upper limbs;

c) Chair Sit and Reach - Number of centimeters reached with one leg extended. This test was performed twice and considered the best result of 2 trials. This test is indicated to measure the flexibility of the lower limbs;

d) 8-Foot Up-and-Go - Number of seconds required to get up from the chair, walk 2.44 meters and return to the initial position. This test was performed twice and considered the best result of 2 trials. This test is indicated to measure the muscle power, agility and balance.

Statistical Analysis — Sample size was determined using the software G*Power 3.1. Based on a previous meta-analysis on effect sizes in training programs, small effect sizes for untrained individuals range from d=0.50 to 1.25 (Rhea, 2004). Thus, using an effect size of d=0.87, alpha of 0.05, 1-Beta of 0.80, two-tailed, allocation ratio=1, the sample size would be at least 44 participants (22 per group) to detect clinical relevant differences between groups.

Since the GHBP tended to be older and having a higher weight as compared to the GNBP, a stratification of participants was carried out based on their age and weight. This procedure was performed in order to increase the homogeneity of the samples. The comparison between the GNBP and GHBP was then assessed using descriptive statistics (mean and standard deviation) and inferential statistics (independent t-tests). For these comparisons, effect sizes were reported using Cohen-d. The values used were: 0.20-0.30 small; 0.40-0.70 moderate and ≥ 0.80 large (Cohen, 1988). A significance level of p≤0.05 was adopted. All analyzes were performed using the SPSS 20.0 software.

3. Results

In order to achieve homogenous groups of participants, a total of 74 older women were invited to participate. However, 26 volunteers were excluded due to imbalances in the stratification of groups (not matching weight and age parameters between groups). Thus, the present study had a total of 48 participants, 24 participants for each group.

The comparisons between groups are reported in Table 1. There were no significant differences between groups concerning age (p=0.793), weight (p=0.759) and BMI (p=0.624). As expected, there were differences concerning the levels of Diastolic BP (p<0.001), Systolic BP (p<0.001) and Mean BP (p<0.001).

Regarding functional fitness (Table 1 and Figure 1), the GNBP had a higher number of repetitions in the 30s chair stand test (p = 0.007, d=0.618) as compared to the GHPB. However, there were no differences in the other fitness tests: arm curl (p=0.304, d=0.290), chair sit and reach (p=0.984, d=0.010) and 8-foot up-and-go test (p=0.455, d=0.201).

Table 1 Comparison between normotensive and hypertensive participants (Values expressed as mean and standard deviation).

Variables	GNBP (n=24)	GHBP (n=24)	p-values	Cohen's d
Age (years)	70.5 ± 7.4	71.0 ± 6.8	0.793	0.070
Weight (kg)	66.8 ± 11.2	65.8 ± 10.9	0.759	0.090
BMI	26.4 ± 3.3	26.9 ± 4.5	0.624	0.126
SBP (mmHg)[a]	110.9 ± 4.6	136.7 ± 10.0*	0.001	3.314
DBP (mmHg)[b]	67.7 ± 8.3	85.3 ± 7.0*	0.001	2.292
MBP (mmHg)[c]	82.1 ± 5.9	102.4 ± 7.0*	0.001	3.135
30s Chair Stand[d]	12.7 ± 2.0	11.4 ± 2.2*	0.007	0.618
Arm Curl[d]	15.7 ± 2.8	14.9 ± 2.7	0.304	0.290
CSR (cm)[e]	-2.5 ± 9.4	-2.4 ± 8.8	0.984	0.010
8-Foot Up-and-Go[f]	6.8 ± 1.1	7.1 ± 1.8	0.455	0.201

a=systolic blood pressure; b= diastolic blood pressure; c= mean blood pressure; d= repetitions; e= chair sit and reach; f= seconds; BMI= body mass index; GNBP= normal blood pressure group; GHBP= high blood pressure group; *Indicates statistical difference in relation to GNBP (p≤0.05).

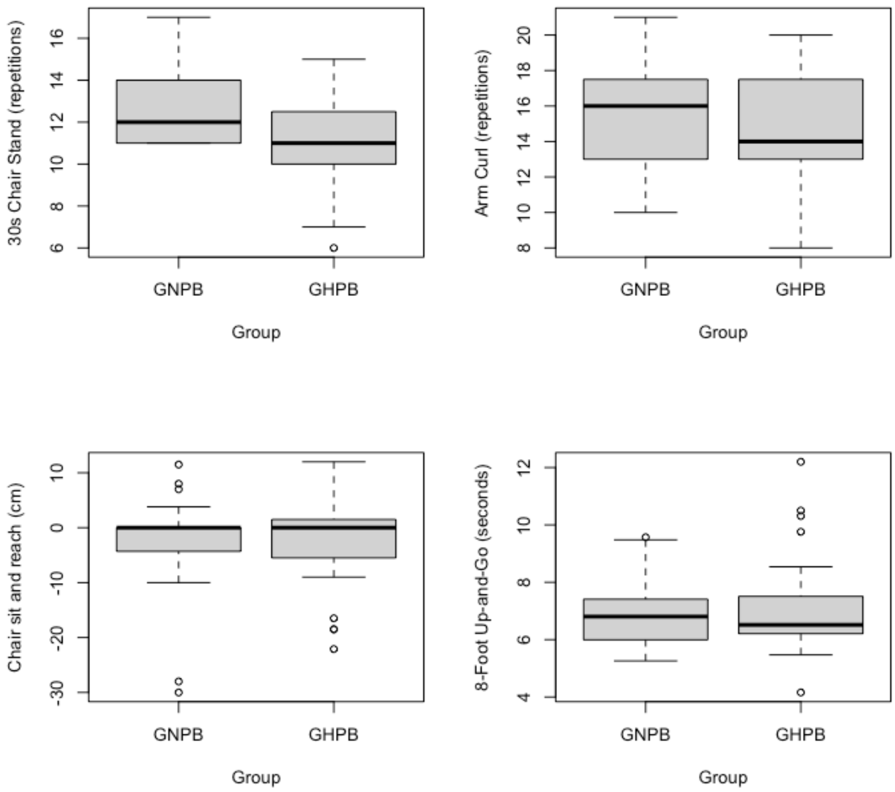

Figure 1 Comparison between 30s Chair Stand, Arm Curl, Chair sit and reach and 8-Foot Up-and-Go between normotensive and hypertensive participants (Values expressed as mean and standard deviation).

4. Discussion

The present study found that hypertensive older women have lower values of lower limb muscle strength as compared to normotensive older women. This lower capacity to produce strength reflected in a lower volume of repetitions for the GHBP in the 30s chair stand test.

To our knowledge, this is the first study that was directed to this analysis and these results can be explained by the fact that previous studies have shown that hypertensive individuals tend to have greater muscle sympathetic nervous activity, vasoconstriction and less oxygen supply than normotensive individuals (Greaney, Edwards, Fadel & Farquhar, 2015; Vongpatanasin et al., 2011; Nyberg, Jensen, Thaning, Hellsten & Montersen, 2012). These physiological responses and negative vascular adaptations can affect muscle blood flow and consequently negatively impact the production of muscle strength levels due to hypoxia (Greaney, Edwards, Fadel & Farquhar, 2015).

This hypoxic environment can cause a greater production of metabolites (hydrogen ions), at rest and during physical exercise and potentiate the action of the chemoreceptors, which act quickly informing the cardiovascular control center, which in turn, responds by increasing the levels blood pressure (Greaney, Edwards, Fadel & Farquhar, 2015). Therefore, the responses to increased blood pressure can hinder the performance of hypertensive individuals during physical exercise sessions.

As the test of 30s Chair Stand involves a large muscle mass of the lower limbs to perform the squat movement, it may have provided greater production of hydrogen ions and consequently greater spikes in blood pressure during the exercise in the GHBP and for this reason, affected in the number of repetitions performed. The literature has already shown that large muscle groups activated during the practice of resistance exercises provide greater spikes in blood pressure (MacDougall, Tuxen, Sale, Moroz & Suton, 1985). Although the normotensive group showed a trend towards better scores, the arm curl, chair sit and reach and 8-foot up-and-go tests were not different between the groups. A hypothesis to justify such findings is the fact that the execution time of the exercise performed repeatedly at specific angulations (i.e movement of standing up and sitting down from a chair for 30 seconds) may have influenced these responses. Because in the chair sit and reach test, individuals maintained a specific position in isometrics for a few seconds (due to the characteristic of the test), the 8-foot up-and-go test involved different and non-repetitive movements (i.e getting up from a chair, walking a few meters, and returning to the start position) and the arm curl test involves small muscle mass and therefore may do not have a difference in blood pressure (Gotshall et al., 1999; Polito & Farinatti, 2009). However, the physiological mechanisms that explain these responses still need to be investigated for a better understanding.

Despite this evidence, other authors have shown that individuals who had higher blood pressure values at rest, exhibited higher levels of muscle strength in adults and middle-aged adults of all ages (Blanchard et al., 2018; Dong, Wang, Arnold, Song, Wang & Ma J, 2016). Perhaps this divergence of results can be attributed to the composition of the sample, as in our study, only older women were included. Therefore, it seems that have high resting blood pressure levels in the aged group seems to be potentially deleterious, impacting lower limb muscle strength and predisposing these older adults to falls and their consequences.

The present study has some limitations that should be considered, such as the lack of analysis of sympathetic nervous activity, blood flow measurements, and electromyography that could contribute with specific information on muscle recruitment during the tests. Likewise, this is not a randomized controlled trial and, for this reason, the sample was stratified in order to achieve homogeneity between groups. This study also did not evaluate the 6-minute test (test indicated to assess cardiorespiratory capacity) because there was not an appropriate space for this test. For this reason, future studies could include this measure in the comparison between normotensive and hypertensive individuals to verify whether the responses will be different between groups.

In conclusion, hypertensive older women have decreased muscle strength of lower limbs compared to normotensive older women. Future studies could be directed to confirm these findings, and if confirmed, investigate possible mechanisms and adaptations in the assessment of functional fitness in hypertensive older people.

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