Blood Pressure Assessed through Oscillometric and Auscultatory Method Before and After Exercise in the Elderly

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Abstract

Background: Different methods of measuring blood pressure (BP) have been used in clinical and scientific evaluations. However, the methods employed have constraints and peculiarities to be considered.

Objective: To evaluate whether similar BP values are obtained in elderly hypertensive patients undergoing resistance exercises when using the oscillometric (Omron-HEM-431) and auscultatory methods (mercury sphygmomanometer).

Methods: Sixteen elderly hypertensive patients underwent three randomized experimental sessions with different volumes: control (C: 40 minutes), exercise 1 (E1: 20 minutes) and exercise 2 sessions (E2: 40 minutes). BP was measured simultaneously through two methods every 5 minutes for 20 minutes before the sessions and during 60 minutes after them.

Results: In the pre-intervention period, there was concordance between systolic blood pressure (SBP) and diastolic blood pressure measurements (DBP) obtained through two methods, as well as a high overall concordance after the sessions (Lin’s concordance coefficient = 0.82 and 0.81, respectively). Greater concordance in DBP was found after the control session than after exercise sessions. The difference between the measurements obtained between the two methods was greater for DBP than for SBP after all sessions (p < 0.001). Regardless of the method, SBP and DBP fell in the first 60 minutes after the exercises.

Conclusion: The auscultatory and oscillometric methods were consistent before and after the control and exercise sessions. However, greater differences were found in DBP than in SBP. The latter was very similar between methods.

Key words: Blood pressure; oscillometry/methods; exercise; aged.

Introduction

Blood pressure measurement, widely used in routine clinical and scientific assessments, can be performed through different methods and the auscultatory method is the most used before, during and after exercise. However, the oscillometric method (through automatic or semiautomatic devices), which is not influenced by the observer, is inexpensive and easily handled. It also has been growing, both within research and in clinical and residential environments. This is due to the global trend of abandoning the mercury sphygmomanometer, due to pollution caused by this metal and ease of use of automated instruments, promoting greater involvement of hypertensive patients in BP control and acceptance of therapies prescribed.

However, due to the large number of devices offered in the market for this purpose, these should be similar to conventional methods (auscultatory and/or intra-arterial measurement), and are validated for special populations (elderly, pregnant women, children etc). Different studies have considered Omron monitors useful and valid for hospitals and home care because there is a satisfactory correlation with the values obtained with traditional indirect method.

Evaluations of these semi-automatic monitors, before and after exercise, are scarce. These devices should be used in practice in places such as clubs, gyms, schools, industries (workplace fitness programs), sports centers and public places including parks, where the sound of music, machinery and voices are very common. On auscultation, in order to identify BP values, it is necessary to hear heartbeats usually in the brachial artery. This feature is adversely affected by the environment, which impairs the accuracy of the measurement. On other hand, the oscillometric method has the advantage of being less susceptible to external noise.

Despite the clinical relevance of aerobic exercises, due to its benefits on BP in elderly hypertensive patients, resistance exercises have been recommended as a complement to aerobic exercises in prevention, treatment and control of hypertension. Added to this, the health professionals are increasingly interested in resistance exercises (RE) due...
to beneficial effects on the musculoskeletal system and other body systems, especially in the elderly\(^1\), in order to mitigate reductions to strength and muscle mass, reduce susceptibility to falls and some cardiovascular risk factors\(^2\). However, BP responses to dynamic resistance exercises are still controversial because further research is required to ensure the accuracy of BP measurement through the oscillometric method in these situations and, consequently, patient’s safety and the correct interpretation of the data. Thus, this is a cross-sectional study aimed at evaluating the correlation between the two BP assessment methods (auscultatory vs. oscillometric) in elderly patients undergoing resistance exercise sessions.

**Methods**

We studied 16 female and male elderly hypertensive patients under regular use of drugs, including seven men and nine women aged 61 to 75 (68 ± 5). This study employed the definition of elderly provided in Article 2 of Law No. 8842/94: “individuals aged 60 or older”\(^15\), nonsmoking, asymptomatic and not physically active more than twice a week. Inclusion criteria for this study, in addition to age smaller than 60, was regular use of the same antihypertensive drug for at least two months, including: angiotensin-converting enzyme inhibitors and calcium channel blockers and diuretics; as well as body mass index (BMI) between 20 and 34.9 kg/m\(^2\). The volunteers were selected after the analysis of 1.236 medical records from the Centro de Saúde Escola (School Health Center - CSE) and five Núcleos de Saúde da Família (Family Health Divisions), which belong to the area covered by the CSE - FMRP/USP.

Then, the patients were contacted by telephone and invited to participate in the study after receiving a detailed description of the procedures contained therein, including the benefits and possible risks. The study protocol was approved by the Research Ethics Committee of the CSE - FMRP/USP. The individuals signed a written consent and were evaluated for weight and height to calculate BMI. Before the first BP evaluation, elderly arm circumferences were measured in order to follow the width/length rubber bag recommendations. BP was measured at rest during two assessments on different days. At each assessment, three measurements were taken on each arm and from the last two measurements on the upper right limb on each day, we calculated BP baseline averages\(^16\). We excluded volunteers with mean BP greater than or equal to 160 x 100 mmHg and those with significant differences between measurements in both upper limbs, indicating that there could be arterial obstruction.

A questionnaire was administered to exclude patients with harmful use of ethanol (more than 168 g of ethanol per week), individuals with heart problems that contraindicated resistance exercise; individuals with apparent degenerative joint impairments; volunteers with prior experience with resistance exercises, and patients who worked during period of the study. After initial clinical evaluation, the individuals underwent laboratory tests, electrocardiogram (ECG) at rest and effort, fundoscopy and echocardiography, in order to exclude patients with diabetes (blood glucose > 126 mg/dl), renal insufficiency (creatinine > 1.4 mg/dl), hypo or hyperthyroidism, coronary artery disease, hemorrhagic lesions on fundoscopy, left ventricular systolic failure (ejection fraction < 50%) or moderate or severe left ventricular diastolic failure. Then, the patients selected had four sessions to adapt to the exercises, two test days to assess maximum dynamic strength and three single experimental sessions, control (C), 1-lap circuit (C1) and 2-lap circuit (C2) performed in the morning. These sequences were randomly selected with one-week intervals between them. The exercise sessions were composed of circuits made with one lap (C1) and two laps (C2), consisting of one series per circuit of 10 exercises (stations) each, with 20 repetitions and the intensity of 40% of one-repetition maximum (1RM) and 1 min interval between exercises and circuits.

Blood pressure measurements were performed simultaneously in different arms in all three sessions (C, E1 and E2), at every 5 minutes through the oscillometric method using a semi-automatic monitor (OMRON - HEM-431), and the auscultatory method using mercury sphygmomanometer for 20 min before and 60 min after the sessions. The individuals were instructed not to perform physical activities in the 48 hours preceding the session and maintain similar patterns of sleep, drug intake, activities and eating habits on the days of experimental sessions. After the random selection of sessions, the examiners of blood pressure were aware of the sessions that volunteers would do.

During the control session, the elderly remained seated at rest for 40 minutes precisely where the RE sessions were conducted.

The maximum load was determined for all of the 10 exercises: leg press 45 degrees; bench press, biceps curl, leg extension, pull down, triceps curl, pec deck, leg curl, row and fly. The proper mechanics for execution of movements was based on standards set by Everett Aaberg\(^17\) and Uchida et al\(^18\). Five attempts were allowed for each exercise in order to enable individuals to find their individual maximum load (1RM). The individuals were instructed to exhale once during concentric contraction and inspire once during eccentric contraction, on each repetition, to avoid the Valsalva maneuver.

To analyze blood pressure through auscultatory and oscillometric methods, we calculated the mean of the last three pre-intervention measurements and in the post-intervention periods we analyzed the averages at every 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55 and 60 minutes using a mixed model (random and fixed effects), which considered the individuals as random effect and the activity performed by the individuals as fixed effect. For each circuit, the blood pressure before and after the exercise was analyzed based on the concordance analysis proposed by Lin, which measures the concordance degree between two instruments and the confidence intervals. The differences (deltas) between BP measurements obtained through the auscultatory and oscillometric methods were compared using Student’s paired t test.

**Results**

Table 1 shows the characteristics of individuals studied in the initial clinical evaluation. Mean values of blood
pressure obtained before and after the intervention using the auscultatory and oscillometric methods, are shown in Table 2.

Average BP values obtained before the sessions were similar comparing the pre-control, pre E1 and pre E2 periods (p > 0.05), using any of the two measurement methods, that is, all sessions started with similar BP. There was no difference between the BP deltas obtained through the auscultatory (Ausc) and oscillometric (Osc) method when comparing SBP and DBP after the E2 session (delta SBP = 0.5 ± 6.9 mmHg, delta DBP = 2.5 ± 3.9 mmHg, p = 0.30). However, in the periods preceding session E1 and pre-control, there was a greater delta (negative) between methods for DBP than for SBP (E1: -5.0 ± 4.9 mmHg vs -0.0 ± 4.8 mmHg, p = 0.01 and control: -4.0 ± 3.7 mmHg vs 0.4 ± 5.3, p = 0.03, respectively), showing that the oscillometric method revealed higher measurements than the auscultatory method in these two situations.

The significant BP drop in the first 60 minutes after the resistance exercise (E1: PAS Ausc, p < 0.01; Osc PAS, p < 0.01; Ausc DBP, p < 0.01; Osc DBP, p < 0.01 and E2: PAS Ausc, p < 0.01; PAS Osc, p < 0.01; Ausc DBP, p < 0.05; PAD Osc, p < 0.05) was equally demonstrated by the two methods. By comparing the mean BP deltas obtained through the two methods, it was found that, for all sessions, the delta for DBP was higher than for SBP (post control session: SBP delta = -0.3 ± 1.4 mmHg, DBP delta = 2.3 ± 0.8 mmHg, p < 0.001; post E1 session: SBP delta = -1.0 ± 0.9 mmHg, DBP delta = 4.6 ± 2.2 mmHg, p < 0.001; post E2 session: SBP delta = -1.8 ± 1.9 mmHg, DBP delta = 5.3 ± 1.4 mmHg, p < 0.001), revealing lower values through the oscillometric method than through the auscultatory method for DBP.

All deltas obtained during the study are collectively represented in Figure 1. The differences between the pressures simultaneously obtained through the two methods were distributed according to the average of these two measures, clearly revealing individual delta values close to zero, that is, indicating similar measurements, as well as large deltas of more than 20 mmHg.

In the pre-intervention period, all activities (C, E1 and E2) presented concordance between the measurements obtained through the two methods for SBP (0.85 to 0.88), while the concordance for DBP ranged from 0.78 to 0.91. In the post-intervention period, when overall concordance was assessed after each session, the SBP presented a 0.75 concordance for the C and E1 sessions, while for the E2 session, there was a concordance of 0.85. In relation to DBP there was a smaller concordance for the sessions E1 (0.77) and E2 (0.79) as compared to the control session (0.87) (Table 3).

Table 3 shows that, regardless of the experimental session, there was a general good concordance for both SBP (0.82) and for DBP (0.81). Figure 2 shows the distribution of SBP (A) and DBP (B) obtained through auscultatory and oscillometric methods.

**Discussion**

The findings from this study reveal that DBP measurements obtained with the oscillometric method in the OMRON - HEM-431 device may present higher values (pre-exercise) or smaller values (post-resistance exercise) than those measured through the auscultatory method in elderly hypertensive patients. As far as we know, there are no previous studies comparing the relationship between the measurement obtained through semi-automatic devices (oscillometric method) and mercury sphygmomanometers (auscultatory method), post-exercise.

The semi-automatic device was used to minimize the impact of individual-observer interaction in BP measurements9. Several factors can be reduced by utilizing the oscillometric method, such as preference for digits, rapid cuff deflation, or reading up or down due to influences from the patient’s condition20,21. Besides these, the individual-observer stress while recording BP may be even eliminated, when a validated digital device is programmed to perform measurements at a

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### Table 1 - Characteristics of volunteers (mean ± standard deviation)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBP sitting (mmHg) - oscillometric</td>
<td>130±15</td>
</tr>
<tr>
<td>SBP sitting (mmHg) - auscultatory</td>
<td>128±10</td>
</tr>
<tr>
<td>DBP sitting (mmHg) - oscillometric</td>
<td>76±8</td>
</tr>
<tr>
<td>DBP sitting (mmHg) - auscultatory</td>
<td>80±8</td>
</tr>
<tr>
<td>Arm circumference (cm)</td>
<td>29.7±2.0</td>
</tr>
<tr>
<td>Resting HR (bpm)</td>
<td>73±11</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>70.6±10.4</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.59±0.1</td>
</tr>
<tr>
<td>BMI (kg/m^2)</td>
<td>27.5±2.6</td>
</tr>
<tr>
<td>Max VO2 (ml/kg/min)</td>
<td>29.1±7</td>
</tr>
</tbody>
</table>

### Table 2 - Systolic blood pressure (SBP) and diastolic blood pressure (DBP) values obtained with the oscillometric (Osc) and auscultatory (Ausc) methods, pre and post-intervention in the three experimental sessions: control (C), one-lap circuit (E1), two laps (E2)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Control</th>
<th>Control</th>
<th>E1</th>
<th>E1</th>
<th>E2</th>
<th>E2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre exercise</td>
<td>Post exercise</td>
<td>Pre exercise</td>
<td>Post exercise</td>
<td>Pre exercise</td>
<td>Post exercise</td>
</tr>
<tr>
<td>SBP-Osc (mmHg)</td>
<td>124±11*</td>
<td>127±11</td>
<td>122±11</td>
<td>119±11</td>
<td>122±13</td>
<td>117±16</td>
</tr>
<tr>
<td>SBP-Ausc (mmHg)</td>
<td>124±10*</td>
<td>127±9</td>
<td>123±9</td>
<td>118±11</td>
<td>124±12*</td>
<td>115±14</td>
</tr>
<tr>
<td>DBP-Osc (mmHg)</td>
<td>73±9*</td>
<td>77±9</td>
<td>73±9</td>
<td>71±9</td>
<td>74±10</td>
<td>70±10</td>
</tr>
<tr>
<td>DBP-Ausc (mmHg)</td>
<td>77±10*</td>
<td>80±9</td>
<td>77±10</td>
<td>76±11</td>
<td>76±12</td>
<td>75±11</td>
</tr>
</tbody>
</table>

* Different from the post-intervention period (p < 0.03).
specific time interval without the presence of the observer, which was not performed in this study.

The mean differences (deltas) of SBP and DBP between auscultatory and oscillometric methods for the control sessions (rest) were similar to those reported by other authors\[22\], who found greater magnitude on the mean difference for DBP as compared to the SBP in the sitting position.

According to Myers et al\[23\], when taken in similar conditions, automatic readings are close to the data obtained using mercury sphygmomanometer. As to the good concordance level observed between the devices in the pre-exercise phase, in the three sessions, our results corroborate those of Czarkowski et al\[24\] and Basso et al\[25\], confirming the validity of the oscillometric method for the rest condition, with greater concordance for SBP than for DBP. Such equipment is usually validated using comparisons with the auscultatory\[26\] or intra-arterial\[27\] measurement.

When our data were evaluated independently from the experimental session, a good overall concordance both for SBP (0.82) and for DBP (0.81) after the exercises. However, when we consider the session involved, the coefficients relating to DBP are smaller after the exercise than after the control session.

In fact, Czarkowski et al\[5\] found that the accuracy of Omron equipment changes according to the redistribution of blood flow, and this may limit its use in different rest situations. The validity of using these devices during and after the exercise is not yet defined.

Considering the differences between the blood pressures obtained through two methods for each measurement taken individually, we observed that the accuracy of measurements obtained through the oscillometric method was not suitable. It is important that measurements be carried out repeatedly and that their mean values be used in studies or in clinical practice.

The benefits of taking the readings using a semiautomatic device are generally applicable to population follow-ups\[28\] and suggested in places such as sports centers, pharmacies, shopping malls etc\[29\]. In the Ontario survey, mean BP obtained with the automated device were smaller comparing to manual

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Table 3 - Degree of concordance between systolic blood pressure (SBP) and diastolic blood pressure (DBP) measurements, pre and post-intervention, obtained with the auscultatory and oscillometric methods in the three experimental sessions: control, one-lap circuit (E1), two laps (E2)

<table>
<thead>
<tr>
<th>Activity</th>
<th>SBP Lin's coefficient (Pre)</th>
<th>SBP Lin's coefficient (Post)</th>
<th>SBP CI 95% (Post)</th>
<th>DBP Lin's coefficient (Pre)</th>
<th>DBP Lin's coefficient (Post)</th>
<th>DBP CI 95% (Post)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0.86</td>
<td>0.75</td>
<td>0.69;0.80</td>
<td>0.84</td>
<td>0.87</td>
<td>0.83;0.90</td>
</tr>
<tr>
<td>E1 session</td>
<td>0.88</td>
<td>0.75</td>
<td>0.69;0.80</td>
<td>0.78</td>
<td>0.77</td>
<td>0.72;0.82</td>
</tr>
<tr>
<td>E2 session</td>
<td>0.85</td>
<td>0.85</td>
<td>0.80;0.88</td>
<td>0.91</td>
<td>0.79</td>
<td>0.74;0.83</td>
</tr>
<tr>
<td>General coefficient</td>
<td>-</td>
<td>0.82</td>
<td>0.80;0.85</td>
<td>-</td>
<td>0.81</td>
<td>0.79;0.84</td>
</tr>
</tbody>
</table>

CI - confidence interval.
readings\textsuperscript{21}. Automatic readings, if not obtained simultaneously and carried out without the presence of the observer, may reflect the true status of hypertension in the population because it minimizes the white coat effect, as there is a close proximity between the automatic readings with the average ambulatory blood pressure monitoring, which is the current standard to assess cardiovascular risk\textsuperscript{29}.

With aging, the increase in blood pressure occurs primarily in SBP as a result of structural and functional changes, whereas DBP tends to decrease with increasing age. Artery hardening, with the loss of elastin fibers, calcium and collagen deposits and vascular wall thickening, promotes changes, particularly in large arteries, increase in SBP and cardiovascular risk closely associated with target-organ injury\textsuperscript{30}.

Thus, to assess SBP before the exercise session to ensure a safe execution, the elderly are prioritized because SBP is a greater predictor of cardiovascular events than DBP\textsuperscript{31}. The oscillometric method, using the semiautomatic monitor Omron HEM-431, can be considered a valid low-cost option\textsuperscript{32} for measuring systolic blood pressure at rest and may be useful in well-trafficked places, especially in places of physical activity, because it prevents manipulation of results and difficulties in auscultating heartbeats, and it provides data that are close to the auscultatory method, especially in relation to systolic blood pressure.

Despite the good concordance obtained after the sessions, the comparison of the oscillometric method with auscultatory and intra-arterial methods post-exercise still needs to be better assessed by other studies with larger sample sizes and diverse populations, including non-elderly and elderly with no hypertension, so that definitive conclusions can be obtained.

Conclusions

There was a good concordance between auscultatory and oscillometric methods in the pre-exercise period, with very similar SBP values and a greater difference between DBP than SBP values. The blood pressure reduction after resistance exercise, with different volumes, was found by the two methods studied, i.e., auscultatory and oscillometric. A good concordance level for SBP and DBP after the sessions was found. However, the difference in mmHg between the two methods was higher for DBP and the concordance between methods was smaller after exercise sessions than after the control session (rest). Therefore, the oscillometric method with Omron HEM-431 monitor can be considered useful, particularly in carrying out SBP measurements in the elderly at rest, where it is associated with increased cardiovascular risk and target-organ injuries.

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Potential Conflict of Interest

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

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Study Association

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