



## **Comparison of Systolic Blood Pressure Measurements by Auscultation and Visual Manometer Needle Jump**

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### ABSTRACT

*International Journal of Exercise Science* 12(2): 214-220, 2019. Purpose: This study was designed to investigate differences in systolic blood pressure measurements as obtained through auscultation and observation of the visual jump on the manometer. Methods: Men (n = 21; 26.9 ± 7.4 yrs) and women (n = 22; 29.3 ± 13.9 yrs) volunteered to have resting systolic blood pressure (SBP) assessments. During the same cardiac inflation-deflation cycle of traditional sphygmomanometry, the initial visual jump of the manometer needle and first Korotkoff sound heard were recorded. Duplicate assessments were made in each arm with 30 sec between intra-arm trials. Results: Paired t-test results indicated there were no within-method differences between arms for visual jump (R: 132.1 ± 11.3; L: 131.8 ± 10.5 mmHg) or auscultation (R: 116.8 ± 9.0; L: 113.5 ± 8.8 mmHg). There were methodological differences within arm with visual jump being the higher of the two (right: t(42) = -12.69; left: t(42) = -11.37; p < .001). Conclusion: If visual jump determination of SBP cannot be avoided, re-assessment using a more traditional method (i.e. auscultation) is recommended.

**KEY WORDS:** Korotkoff sound, manual sphygmomanometry, pressure oscillations

### INTRODUCTION

Blood pressure is a significant indicator of many diseases and disorders and, globally, is the most influential of the modifiable risk factors for cardiovascular disease (11). In the US, one in three adults has high blood pressure; the prevalence of American adults with hypertension is highest for non-Hispanic blacks (approximately 45%) and lowest for non-Hispanic Asians (approximately 29%) (3). As reported by the World Health Organization, hypertension is estimated to be at the root of 7.5 million deaths worldwide (17). Fortunately, blood pressure is a plastic phenotype meaning that high blood pressure can be prevented and reduced over time via suitable mechanisms including exercise (16) and medication (7, 8). However, appropriate action can only take place once blood pressure has been measured in an individual, and as high

blood pressure is symptomless (often termed the "silent killer") the actual recordings are extremely important.

Blood pressure measurements are important for gauging the health of an individual and occur in many settings. Such measurements take place at different frequencies depending on the individual, but the American Heart Association (1) suggests that blood pressure screenings should occur at least once every two years starting at age 20 if blood pressure is less than the standard 120/80 mmHg, with more frequent visits being required when over the standard reading. These recordings allow the individual and their doctor to monitor blood pressure over time.

While automated blood pressure assessment is growing in popularity in doctors' offices and in-home settings, the most common method of measuring blood pressure involves the use of a blood pressure cuff and stethoscope (14). This method, known as auscultation, requires the practitioner to listen to the artery (usually brachial artery) for sounds that indicate the point of systolic and diastolic blood pressure. When these Korotkoff sounds are heard, the practitioner observes the manometer and records the reading. Nurses and other practitioners have been observed using a method where auscultation is not used; instead, the needle/gauge of the manometer is observed with a visual jump of the needle indicating the point of systolic blood pressure (SBP); diastolic blood pressure (DBP) cannot be measured with this method.

While there is minimal literature (2) that even references using a "needle bounce manometer," online forums and primary research (personal communications with and observations of athletic trainers, nurses, etc.) indicate that the method is not uncommon. That this method is occasionally used and that there is no research supporting or comparing the method with an accepted BP assessment method is concerning. Online forums suggest the method can be as far as 20 mmHg different from a reading made using auscultation. If the method is commonly used (as suggested by primary research) and taught in degree programs and clinical settings, it is important that the method is analyzed for its validity and reliability. If the inaccuracy of the method is as extreme as some sources suggest, it could have potentially detrimental effects - the risk of developing cardiovascular disease for example, doubles with every 20/10 mmHg increment above 115/75 mmHg (5). This would mean that an inaccurate reading could result in an inappropriate course of treatment.

This study was designed to compare visual jump and auscultated SBP values obtained within the same cuff inflation-deflation cycle for a sample of adults. The visual jump SBP values were hypothesized to be significantly higher than those heard via auscultation in the same cuff inflation-deflation cycle.

## METHODS

### *Participants*

A convenience sample of English-speaking men ( $n = 21$ ;  $26.9 \pm 7.4$  yrs) and women ( $n = 22$ ;  $29.3 \pm 13.9$  yrs) between the ages of 18 and 65 yrs volunteered. To participate in the study as approved by the university's Institutional Review Board, volunteers had to be free of all

exclusion criteria: inability to consent, age outside designated range, pregnancy, missing all or part of an arm. An *a priori* power analysis (G\*Power 3.1.9.2) (6) was performed to estimate sample size with a power of .95, alpha value of .05, and effect size of .70, we determined that a total of 13 participants were needed. To compare possible differences by sex, we sought to recruit 25 men and 25 women to account for exclusion criteria found during screening, missing data, or attrition.

#### *Protocol*

Recruitment was conducted via word-of-mouth and posted flyers. Interested persons contacted a research team member and were given the opportunity to review the approved Informed Consent at their leisure prior to undergoing screening for inclusion criteria. Those screening into the study were scheduled for an assessment appointment and given instruction on the importance of wearing a shirt with short sleeves so blood pressure was not taken over clothing. No other pretest guidelines were provided as the sole interest was in how closely SBP values determined via visual jump and auscultation would be.

At the scheduled appointment, the participant met with a research team member who instructed the participant to sit in a chair with a supportive back and place their feet flat on the floor. Participants asked any questions they had, gave written consent, and completed a brief health history questionnaire. Participants bared their upper arm, and the researcher positioned an appropriately sized blood pressure cuff in accordance to standard procedure (12). Approximately 5 min after the client had been sitting, the researcher palpated the brachial artery. With stethoscope earpieces and participant's arm properly positioned, the researcher quickly inflated the cuff to 200 mmHg, released the pressure to allow deflation at a rate of 2 to 3 mmHg/s, mentally noted when the needle of the aneroid gauge deviated from its downward fall with a rhythmic jump, and continued to deflate the cuff while listening for the first (auscultated SBP) Korotkoff sound. The researcher continued listening for another 10 mmHg beyond the last (auscultated DBP) Korotkoff sound before releasing the remaining pressure in the cuff. These values were recorded and, 30 sec later, the process was repeated on the same arm with inflation stopping at 20 mmHg above where the visual jump had been observed in the first trial. The same procedure was used on the arm contralateral to the initial arm assessed, resulting in two blood pressure assessment cycles per arm, a total of four measurements being recorded per participant. The arm (right or left) in which the first assessment was taken was randomly selected.

The same trigger-style palm aneroid sphygmomanometer (American Diagnostic Corporation, Hauppauge, NY, USA) and stethoscope (3M Littmann, Maplewood, MN, USA) were used throughout the study. Three technicians, all of whom had been similarly trained over the course of a semester, performed the blood pressure assessments. Intertester reliability for visual jump and auscultated SBP was determined to be  $r = .99$ .

### Statistical Analysis

Using Microsoft Excel, the mean of each arm's visual jump and auscultated SBPs were computed and compared via paired *t*-tests;  $p \leq .05$  denoted significance. The differences between methods were evaluated via frequency counts in 10 mmHg increments.

## RESULTS

As indicated in Table 1, there were no significant between-arm differences for the sample (visual jump:  $t(42) = .63$ ; auscultation:  $t(42) = .30$ ;  $p > .05$ ) or the women (visual jump:  $t(21) = -.526$ ; auscultation:  $t(21) = .02$ ;  $p > .05$ ) when the assessment methods were evaluated separately. For the men, the between-arm differences were significant for auscultation ( $t(20) = 2.20$ ;  $p = .04$ ) but not visual jump ( $t(20) = -.1115$ ;  $p > .05$ ).

There were significant within-arm differences for the sample with the visual jump method producing higher values compared to auscultation (right:  $t(42) = -12.69$ ; left:  $t(42) = -11.37$ ;  $p < .001$ ). This pattern of within-arm differences was also noted for the women (right:  $t(21) = -8.62$ ; left:  $t(21) = -7.94$ ;  $p < .001$ ) and men (right:  $t(20) = -9.17$ ; left:  $t(20) = -8.00$ ;  $p < .001$ ).

**Table 1.** Methodological comparison of mean systolic blood pressure values in right and left arms by sex.

	Visual jump (mmHg)	Auscultation (mmHg)	Difference (mmHg)
Right arm	132.1 ± 11.3	116.8 ± 9.0*	15.3
Men	131.7 ± 10.9	116.3 ± 9.9*†	15.4
Women	132.5 ± 12.3	117.2 ± 8.3*	15.3
Left arm	131.8 ± 10.5	117.5 ± 9.8*	14.0
Men	131.6 ± 9.7	117.7 ± 11.3*	13.9
Women	132.0 ± 12.1	117.2 ± 8.3*	14.8

\* significantly different from Visual Jump technique;  $p < .001$

† significantly different from corresponding left arm auscultation;  $p = .04$

Frequencies of the mean SBP values were stratified based on the SBP assessment method, sex, and new hypertension guidelines (15). As seen in Table 2, classifications of SBP are notably different and shifted into higher mmHg ranges when using the visual jump of the manometer needle.

**Table 2.** Frequencies of SBP mean values stratified by method, sex, and SBP category

	< 120 mmHg	120 - 129 mmHg	130 - 139 mmHg	≥ 140 mmHg
Visual jump				
Men	0	10	7	4
Women	4	6	5	7
Auscultation				
Men	12	7	2	0
Women	14	6	2	0

## DISCUSSION

The results of this study are the first to formally document that SBP values are higher when relying on the first visual jump of the manometer needle as opposed to the standard auscultation assessment of systolic blood pressure. Additionally, the individual difference between assessment methods ranged from 2.5 to 38.0 mmHg, with the mean difference being approximately 15.3 mmHg for men and 14.2 mmHg for women in the current sample. Although these methodological differences are slightly lower than the previously mentioned 20 mmHg, the individual differences varied widely with only 17 of the 43 participants having a mean methodological difference between 15.0 and 25.0 mmHg.

Auscultated SBP is defined as being the first Korotkoff sound heard during cuff deflation and is dependent on the technician's ability to hear the onset of blood flow turbulence when the pressure in the occluded artery exceeds that in the inflated cuff (4, 12). The 1.4 mmHg difference for the men's between-arm SBP auscultation values in the current study is statistically significant ( $p < .04$ ) but may not be clinically significant. Recently, a between-arm difference in SBP that is  $\geq 5$  mmHg has been suggested as the criterion for predicting future cardiovascular events (10). The source of the men's inter-arm difference for auscultation may be due to normal hemodynamic variation, preponderance of right-arm dominance, starting arm selection, and/or measurement error.

The visual jump of the manometer needle may represent a sub-auditory volume of blood flowing through the monitored artery beneath the stethoscope. Alternatively, the jump may represent pressure changes transmitted through the cuff to the manometer as the pulsatile blood flow arrives in vessels at the point of vascular occlusion (4). These pulsations of pressure seen on the manometer describe the initial oscillations that precede the point of maximal oscillation corresponding to the "gold standard" of systolic blood pressure measures – intra-arterial systolic pressure (12). It was the initial, not maximal, jump (oscillation) that was recorded in the current study. Whereas, proprietary computer algorithms on which the oscillometric blood pressure assessment technique is based differ in regard to which magnitude of oscillation is determined as the SBP (4, 12).

Proper and accurate assessment of resting blood pressure is an important skill taught in most exercise science programs. During that training, it is important that students learn that the auditory/auscultated SBP values are more accurate than the visual jump in all instances. Client safety relies on accurate blood pressure assessment before, during, and after aerobic capacity testing. Systolic blood pressure is expected to increase from baseline in response to increasing exercise intensities and decrease toward baseline as the workload is reduced and the test stopped. Relative blood pressure-related contraindications to maximal exertion exercise need to be ruled out before testing begins (13). Likewise, a drop in SBP during a maximal exertion exercise test may warrant test termination. This determination relies on the baseline blood pressure values taken with the client in the posture required for the exercise test (i.e. seated for cycling) (13). Personal trainers and fitness professionals who periodically assess their client's blood pressure can determine if the prescribed exercise program is having the desired effect or

is in need of modification. Therefore, it is recommended that students repeatedly practice with trained and skilled technicians until accurate auscultation of blood pressure is mastered (9). Use of visual jump SBP should be avoided except in emergency situations that impair ability to hear or to alert the technician that the auscultation value is not far away time-wise.

Limitations of the current study could be reduced by using a teaching stethoscope with two sets of ear pieces and scheduling appointments so simultaneous determinations could be made by two of the similarly-trained technicians. The American College of Sports Medicine recommends a minimum of 1 minute elapse between inflation-deflation cycles (13), but our inter-trial assessment time lapse was shorter. Thus, there is a possibility that this may have introduced some error in the second reading within each arm.

Ultimately, in the situations in which the visual jump of the manometer needle might be used to identify SBP (e.g. riding in back of an ambulance, loud environment, poor hearing acuity, lack of functioning stethoscope), the value recorded should be identified as an estimate only and in need of reassessment via a more precise method such as auscultation.

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