Effect of Premeasurement Rest Time on Systolic Ankle Pressure

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***Background*—**Systolic ankle pressures are routinely measured as part of an ankle-brachial index to screen for lower extremity peripheral arterial disease. Despite widespread use of this measurement, the effect of premeasurement duration of rest on the magnitude, or reliability of the ankle systolic pressure measurement is unknown. This study assessed the effect of premeasurement rest duration on systolic ankle pressures.

***Methods and Results*—**One hundred and forty participants meeting guidelines for peripheral arterial disease screening volunteered for this study. Following 5 minutes of rest in the supine horizontal position, ankle systolic pressures of the lower extremity were taken. Measurements were repeated at 10 and 15 minutes. Testing was repeated 7 to 10 days later. A significant drop in ankle pressure of 5.02 mm Hg occurred between 5 and 10 minutes (P=0.004). No significant change occurred between 10 and 15 minutes (mean change 0.15 mm Hg, P=0.99). Presence of diabetes was associated with a smaller drop between 5 and 15 minutes (mean change 1.85 mm Hg) and predicted 13.4% of the variance in change in ankle pressure ($\beta=-3.61$, P=0.0001). Test-retest reliability after 5 minutes was excellent (intraclass correlation coefficient: 0.84, 95% CI: 0.76 to 0.91) however increased for measurements taken at 10 and 15 minutes (intraclass correlation coefficient: 0.89 95% CI: 0.83 to 0.94 and 0.89 95% CI: 0.82 to 0.93).

***Conclusions*—**Results suggest ankle systolic pressures stabilise after 10 minutes of rest. Longer periods of premeasurement rest did not improve reliability significantly. Though diabetes affects ankle pressure changes after rest, further investigation is required to identify the cause. **(*J Am Heart Assoc.* 2013;2:e000203 doi: 10.1161/JAHA.113.000203)**

Key Words: blood pressure • diabetes mellitus • peripheral arterial disease

Peripheral arterial disease (PAD) affecting the lower extremity involves stenosis of arteries through atherosclerotic plaque formation. PAD has been demonstrated to affect from 8% to 12% of adults ≥50 years[1,2] and 21% of adults ≥65 years.[3] PAD commonly coexists with significant systemic atherosclerosis, increasing the risk of cardiac-related morbidity and mortality in conjunction with lower extremity complications including ulceration and amputation.[4,5]

Representing the ratio of ankle systolic pressure to brachial systolic pressure, the ankle brachial index (ABI) is a simple noninvasive screening tool for detecting the presence of subclinical PAD and subsequently monitoring disease progression.[6,7] The ABI has generally been found to be sensitive and highly specific to the presence of PAD[8] and is currently recommended as a screening test for the disease in people over the age of 50 with a history of diabetes or smoking, people over the age of 65, and in the presence of nonhealing wounds or exertional leg pain.[9]

A number of external factors have been found to influence the pressures used in the ABI measurement and have led to the development of a premeasurement protocol including avoiding exercise, caffeine, and tobacco for 30 minutes prior to testing and having the patient in a supine position.[10] However, the recommended duration of premeasurement rest prior to undertaking an ABI is highly variable. Current recommendations for 5 to 10 minutes of rest are not evidence-based and a range of rest times from 5 to 30 minutes are used in clinical research.[6,11–14] Investigation of the effect of the length of premeasurement rest prior to taking brachial pressures in a seated position demonstrate there are significant differences in systolic pressures when measured at 2-minute intervals up to, but not beyond, 10 minutes.[15] Systolic pressure of large arteries in the ankle used in the calculation of the ABI may also be affected by these changes, with inadequate rest time potentially resulting in measurement error. To the authors' knowledge the effect of the premeasurement rest time on systolic ankle pressure has not been evaluated.

Determining the appropriate rest time prior to undertaking systolic ankle pressure measurement may improve the clinical

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efficiency of calculating the ABI. The aim of this study is to investigate the effect of 5, 10, and 15 minutes of rest prior to systolic ankle pressure measurement on the value of the ankle pressure and subsequent test-retest reliability.

Methods

This study was undertaken at the University of Newcastle Podiatry Clinic on the New South Wales Central Coast. Ethical approval was obtained from the University of Newcastle Human Research Ethics Committee. Informed written consent was given by all participants prior to their participation in this study. Participants were recruited on a volunteer basis from patients attending the clinic and the local community via flyer advertising. Inclusion criteria were set in accordance with the current American Heart Association (AHA) recommendations for PAD screening using a resting ABI[9] (ie, people aged ≥65 years and ≥50 years, with a history of diabetes or smoking or with exertional leg pain or nonhealing wounds). Exclusion criteria were contraindications to ankle pressure measurement including history of deep vein thrombosis, lymphoedema, or current leg ulceration. Participant medical history was obtained following collection of ankle pressure measurements to confirm diagnosis of diabetes.

Equipment

Systolic ankle pressures were measured using an 8 Hz Bidop ES-100V3 hand-held Doppler (Hadeco), an adult standard, adult large or adult extra-large inflatable cuff (Liberty Health Care) and an ERKA aneroid sphygmomanometer (Kallmeyer Medizintechnik GmbH & Co). Size of the cuff used was determined in accordance with the AHA recommendations for cuff width and length.[6] All blood pressure gauges were newly calibrated.

Procedures

Data collection was performed at the University of Newcastle Podiatry Clinic. All testing was performed by the same clinician, a podiatrist with >10 years clinical experience. Participants were asked to avoid alcohol, exercise, and caffeine for 1 hour prior to participating in the study. Testing was performed in a controlled environment with room temperature maintained at 24 to 25°C. Measurements were taken following 5, 10, and 15 minutes of rest with the participant in a horizontal supine position. Systolic ankle pressure was measured at either the posterior tibial artery or the anterior tibial artery (at dorsalis pedis) for the left or right lower extremity. Extremity and artery selection was predetermined using a computer generated random allocation function.

Participant medical history was obtained to determine diagnosis of diabetes. Several disease-specific complications associated with diabetes including the presence of medial arterial calcification (MAC) and autonomic neuropathy have been suggested to affect the accuracy of the ankle pressure measurement and to potentially cause altered blood pressure regulation.[16–18] Diabetes may, therefore, impact the effect of premeasurement rest time on ankle pressures.

A subset of participants from those enrolled in this study selected using computer-generated random allocation attended the clinic 7 to 10 days after the initial testing session at a similar time of day (ie, morning or afternoon). The pretesting protocol used in the first testing session was followed prior to the second testing session. The testing protocol was identical to the first session, with repeated measurements taken at 5, 10, and 15 minutes for the same artery. The clinician was blinded to the results from the first testing session.

Statistical Analysis

Statistical analysis was performed using the Statistical Package Social Science software version 19.0 (SPSS). A one-way repeated measures ANOVA with Bonferroni adjustment was used to determine significant differences between pressure measurements recorded for the ankle pressure following 5, 10, and 15 minutes of rest. Significance was set at 0.017. An independent samples *t* test was used to compare mean change in ankle pressure in people with and without diabetes.

Sequential regression analysis was used to examine the ability of presence of diabetes to predict variance in change in ankle pressure between 5 and 15 minutes after controlling for age, gender, history of smoking and body mass index (BMI). Preliminary analysis was conducted to ensure no violations of assumptions for normality, linearity, multicollinearity and homoscedasticity. Age, gender, history of smoking and BMI were entered at Step 1. Presence or absence of diabetes was entered at Step 2.

Intraclass correlation coefficients (ICC) with 95% CI were calculated to determine level of agreement between test and retest for the measured ankle pressure following 5, 10, and 15 minutes of rest after a 7-day interval. All ICC values for intra-tester reliability were interpreted according to cut-offs suggested by Fleiss.[19] Paired *t* tests were performed for the test and retest pressures to determine whether a statistically significant difference existed between scores. Standard error of measurement (SEM) was calculated to estimate the precision of each measurement, and to give an indication of test-to-test variability in the blood pressure values.

Results

One hundred and forty participants were recruited to this study. Sixty-two participants attended the clinic 7 to 10 days later for repeat ankle pressure testing. Participant characteristics are reported in Table 1.

Effect of Premeasurement Rest Time

Mean ankle pressures were significantly affected by duration of premeasurement rest time (P=0.0009). Post-hoc testing demonstrated mean ankle pressures were significantly higher following 5 minutes of rest then after 10 minutes of rest (P=0.004). Between 5 and 10 minutes of rest the mean ankle pressure dropped by 5.02 mm Hg from 135.13 to 130.11 mm Hg. Between 10 and 15 minutes of rest results indicated ankle pressures had stabilized with a nonsignificant mean reduction of 0.15 mm Hg (Table 2).

Analysis of Change in Pressure by Disease Status

Preliminary analysis demonstrated no violation to assumptions of normality, linearity, multicollinearity, and homoscedasticity. Age, gender, history of smoking, and BMI were entered at Step 1 accounted for 4.9% of the variance in change in ankle pressures. After entry of diabetic status at Step 2, the model predicted 15.8% of the total variance (P=0.0001). Therefore, presence of diabetes predicted 15.8% of the variance in change in ankle pressure between 5 and 15 minutes. The presence of diabetes explained an additional 13.4% of variance in change in ankle pressure after controlling for age, gender, history of smoking, and BMI. In the final model diabetes was the only statistically significant measure (β=−3.61, P=0.0001). Mean change in ankle pressure between 5 and 15 minutes in people with diabetes(−1.85 mm Hg, SD 8.39 mm Hg) was significantly less than the mean change for all other participants (−5.10 mm Hg, SD 7.72 mm Hg, P=0.001).

Table 1. Participant Characteristics

Characteristic	Premeasurement Rest Time	Reliability
Total participants	140	62
Age, y	67.42 (SD 4.62)	64.56 (SD 4.93)
Gender	81 males (58%)	35 males (56%)
	59 females	27 females
Body mass index	26.85 (SD 1.98)	
Smoking history (current and past history)	67 (48%)	26 (42%)
Diabetes	64 (46%)	32 (52%)

SD indicates standard deviation.

Table 2. Effect of Premeasurement Rest Time on Systolic Ankle Pressure (N=140)

Ankle Pressure	N	Mean and SD	*P* Value
5 to 10 min	140	135.13 (16.59): 130.11 (17.58)	0.004
5 and 15 min	140	135.13 (16.59): 129.98 (17.60)	0.002
10 and 15 min	140	130.11 (17.58): 129.98 (17.60)	0.99

SD indicates standard deviation.

Test-Retest Reliability

All pressure testing demonstrated excellent test-retest reliability, indicated by ICCs over 0.80 (Table 3). ICCs that demonstrated test-retest reliability of ankle pressure were slightly higher following 10 minutes of rest compared to 5 minutes of rest (ICC: 0.84, 95% CI: 0.76 to 0.91 and ICC: 0.89, 95% CI: 0.83 to 0.94, respectively). Paired samples t tests demonstrated no significant differences between test and retest pressures at each time interval. The SEM calculated for ankle pressures were low, ranging from 2.22 to 3.05 mm Hg indicating adequate precision of the measurement (Table 3).

Discussion

There is currently no consensus on appropriate rest time prior to undertaking an ankle pressure measurement to use in calculating an ABI. The results of this present study suggest that in a community-based population the systolic ankle blood pressure falls by ≈5 mm Hg during the first 10 minutes of rest, but between 10 and 15 minutes further reductions are marginal. Only ankle systolic pressures were measured in this study to ensure that each measurement could be made exactly at each time point. Had brachial pressures also been included, the time taken to perform the measurements would mean that both measurements could not be taken at each specific time interval. However, our findings are consistent with literature relating to the effect of premeasurement rest time on systolic brachial pressures which have been demonstrated to drop over the first 10 minutes of rest in both seated and supine positions.[15,20] The total drop in systolic ankle pressure between 5 and 10 minutes of 5 mm Hg is a relatively small change in pressure and similar drops have been reported in systolic brachial pressures over the same time, meaning a ratio measurement such as an ABI may be less affected by this change if both pressures are taken following a similar amount of premeasurement rest. However,

Table 3. Test-Retest Reliability of Ankle Pressure Measurements After 5, 10, and 15 Minutes of Premeasurement Rest (N=62)

	Test Mean (mm Hg)	Retest Mean (mm Hg)	ICC	95% CI	Paired *t* Test *P* Value	SEM (mm Hg)
5 min	137.61	136.66	0.84	0.76 to 0.91	0.33	3.05
10 min	131.59	131.98	0.89	0.83 to 0.94	0.65	2.22
15 min	131.89	131.58	0.89	0.82 to 0.93	0.90	2.23

ICC indicates intraclass correlation coefficient; SEM, standard error of measurement.

given that the time implication of taking each measurement makes this difficult, the results of our study combined with previous investigations of brachial pressure[15,20] suggest the most accurate method of performing the ABI is following a 10-minute rest time.

Diabetes was demonstrated to have a significant effect on the amount of change between 5 and 15 minutes. The mean change in ankle pressure in this subset of the population was smaller than for the entire cohort. Potential presence of diabetes-related autonomic neuropathy may account for this finding as this has been suggested to affect blood pressure regulation in the lower extremity due to sympathetic denervation.[21,22] Christensen[21] demonstrated reduced variability of blood flow to the feet of people with diabetes suggesting this may cause impairment of thermoregulation and contribute to the development of orthostatic hypotension. Impaired sympathetic activity has been demonstrated to cause subsequent lack of vascular resistance during standing, leading to decreases in blood pressure in the diabetic-versus-nondiabetic cohort,[22] indicating altered sympathetic response to positional change. In this present study, altered sympathetic control in people with diabetes may have affected the amount of change seen in ankle pressures following a positional change (from standing to supine) when compared to the entire cohort. These findings suggest further investigation on the impact of specific diabetes- related comorbidities on ankle pressure regulation is required to determine their impact on current clinical testing procedures. It should also be considered that a number of other variables, including baseline ankle pressure, presence of hypertension, and significant PAD, may also affect systolic ankle blood pressure change with rest and are worthy of further investigation.

Reliability of the ankle pressure testing between test and retest was found to be excellent at 5, 10, and 15 minutes with only marginal increases in reliability following stabilization of systolic ankle pressure at 10 minutes (ICC range: 0.84 to 0.89) and greater precision of the measurement following 10 minutes of rest (SEM 3.05 mm Hg vs 2.22 mm Hg). The lack of significant change in mean systolic ankle pressure between test and retest at each time point indicated by the nonsignificant results of paired samples *t* tests suggest that overall the response of systolic ankle pressure to supine positioning and duration of rest was replicated at the second testing session. The results of our study are consistent with previously reported test-retest reliability of ankle systolic pressures taken with a 8 MHz Doppler probe 7 days apart following 15 minutes of rest (ICC range 0.85 to 0.99).[11] High reliability may have been due to strict control of external factors such as caffeine and exercise, which are known to affect blood pressure measurements, the retest occurring at a similar time of day to the first test, and the experience level of the clinician taking the measurements. These findings indicate that measurement of systolic ankle pressure with a handheld 8 MHz Doppler and aneroid sphygmomanometer is a clinically reliable method of assessing peripheral arterial flow.

Limitations

This study did not utilize a baseline measurement (taken at 0 minutes), therefore the total drop in systolic pressure between 0 and 15 minutes is unknown. The first measurement was taken at 5 minutes as this was the shortest duration of premeasurement rest time found to be reported in the literature.[13] The overall change in pressure between 0 and 15 minutes may therefore have been >5 mm Hg or <5 mm Hg depending on the direction of the change in the first 5 minutes. Previous research assessing brachial pressures in the supine position suggests that this is likely to have been an additional reduction. However, this needs to be determined in relation to ankle pressures.

The results of this study are relevant to an older community-based population which is likely to have higher rates of hypertension, diabetes, and PAD than the general population. This participant group was chosen for clinical relevance as all participants met the criteria to undergo routine screening with an ABI according to current guidelines. However, results from this study may not be reflective of changes occurring in a younger cohort free from risk factors for, or signs and symptoms of, PAD.

Conclusion

The results of this study suggest that systolic ankle pressure falls by ≈5 mm Hg between 5 and 10 minutes of rest time in a horizontal supine position. Fifteen minutes of rest does not appear to produce any further significant change in pressure. Test-retest reliability of ankle pressure measurement is also slightly higher following 10 minutes of rest than following 5 minutes of rest. Based on these results the most accurate measurement of ankle pressures for use in an ABI should be performed after 10 minutes of premeasurement rest in the horizontal supine position. Findings of this study also indicate that diabetes affects ankle pressure changes subsequent to assuming a horizontal supine position. However, the cause of the difference in ankle pressure requires further investigation.

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Disclosures

None.

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