Age and gender do not affect the ankle–brachial index

Matthew Austin, Herbert Jelinek, Kevin Cole, Simon McDonald

Introduction

The authors' clinical use of the ankle–brachial index (ABI) is based on normal values for all patients lying between 0.9 and 1.3. However, the evidence for these values, including physiological measures of blood pressure in the arm and ankle, is scarce in the general podiatry and diabetic foot literature. This paper attempts to utilise physiological findings together with the ABI to provide an evidence-based model for assessing ABI across gender and age groups.

The ankle–brachial index (ABI), which is a ratio of systolic blood pressure (SBP) of the arm to that of the leg, provides a simple, convenient, and non-invasive measure of lower-extremity vascular function. Reproducibility of the ABI is considered acceptable, with subsequent examinations on the same patient yielding a consistent result (Vowden and Vowden, 2001). According to the literature, normal values, independent of age and gender, should be above 0.9 (Rose, 2000; Brooks et al, 2001; McDermott et al, 2003). Results below this indicate varying levels of peripheral arterial disease. An ABI over 1.3 indicates arterial wall calcification and is unreliable in determining lower-limb perfusion (McDermott et al, 1998).

Effects of ageing and gender on arterial function

Ageing modifies vessel structure, particularly in elastic arteries; SBP increases because the vessel wall becomes less elastic and does not conform to blood pressure changes as readily (Vuong and Berry, 2002). Atrophy of large peripheral arterial smooth muscle cells also occurs in the ageing process, as does atherosclerosis, which thickens the vascular wall, reduces lumen size and therefore increases SBP (Vuong and Berry, 2002). In men, basal blood flow to the lower limb progressively declines throughout adulthood (Dinenno et al, 2001; Tanaka et al, 2001). Gender differences have been noted for brachial artery compliance, which has been found to be significantly higher in older women than older men (van der Heijden-Spek et al, 2000). These physiological findings certainly warrant an investigation of whether they influence the ABI.

Lower cut-offs for the ABI indicating normal blood pressure ranges have been reported from 0.8 to 1.1 (Hiatt et al, 1995; Moffatt and O'Hare, 1995; Rose, 2000; Brooks et al, 2001; Vowden and Vowden, 2001; McDermott et al, 2003), and angiographic evidence of peripheral vascular disease with an ABI of less than 0.90 has been stated to be 95% sensitive but between 50% and 99% specific for angiographically significant peripheral arterial disease (Applegate, 1993; Olin, 1998). In addition, cuff size, gender, daily stresses and age have been reported to influence the ABI measure (Walsh and Bower, 1993; Anderson, 2002; Austin et al, 2003). It is therefore vital that research be undertaken to identify any differences in ABI results due to physiological differences between age groups and between genders, in order to improve evidence-based practice and patient outcomes through earlier diagnosis.

ARTICLE POINTS

1. The ankle–brachial index (ABI) should be considered within the framework of vascular physiology to provide an evidence-based range of normal values.
2. The ABI is a function of the vascular physiology and structural attributes of the blood vessels.
3. This study assessed whether there were significant differences in the ABI based on age and gender.
4. Age and gender differences in the ABI were not statistically significant in this study.

KEY WORDS

- Ankle–brachial index
- Vascular physiology
- Gender
- Ageing
- Evidence-based practice

Matthew Austin is a Podiatry Honours student, Herbert Jelinek is a Lecturer in Biomedical Science, and Kevin Cole is a Lecturer in Podiatry, School of Community Health, Charles Sturt University, Albury, Australia. Simon McDonald is a Spatial Analysis Officer, Charles Sturt University, Albury, Australia.

PAGE POINTS

1. People aged <30 years or >40 years were recruited as part of the Charles Sturt University Allied Health Clinic diabetes complications screening programme.

2. Sixty-one participants (26 males and 35 females) were included in the data analysis.

Table 1. Blood pressure (mmHg) and ABI results by age group.

	Mean ± standard deviation		
Parameter	<30 years (n=45)	>40 years (n=16)	*P*-value
Left brachial	116 ± 9	130 ± 14	<0.001
Right brachial	118 ± 12	131 ± 15	<0.01
Left ankle	122 ± 13	139 ± 18	<0.001
Right ankle	121 ± 11	136 ± 18	<0.001
Left ABI	1.02 ± 0.1	1.04 ± 0.1	NS
Right ABI	1.01 ± 0.1	1.02 ± 0.1	NS

ABI, ankle–brachial index; NS, not significant

Methods

Participant recruitment

People aged <30 years or >40 years were recruited as part of the Charles Sturt University Allied Health Clinic diabetes complications screening programme. Exclusion criteria were the presence of cardiovascular disease, peripheral vascular disease, diabetes, kidney disease, smoking or excessive alcohol consumption. Participants' data were also excluded from the analysis if the participants were found to be taking any medications for hypertension, kidney function, autonomic nervous system neuropathy or cardiac pathology. Sixty-one participants (26 males and 35 females) were included in the data analysis.

To avoid the effect of outliers on statistical analysis, the data were ranked and the inter-quartile range was multiplied by 1.5 to determine the normal range. Values outside this range were excluded for purposes of this analysis as they were deemed to indicate a high probability of peripheral arterial disease or vessel calcification (Fowkes et al, 1988).

Procedures and instrumentation

The ABI was determined using an examination plinth with participants in a supine position. After a minimum of 5 minutes, SBP measurements were taken. Examination rooms were all of a comfortable temperature, with minimal noise during ABI measurement. Using a pressure cuff, a sphygmomanometer and a Doppler ultrasound unit (Hadeco ES-1000 SPII, Hayashi Denki Co., Kawasaki, Japan) with an 8 MHz probe, SBP measurements were obtained from each brachial artery and each dorsalis

Table 2. Blood pressure (mmHg) and ABI results by gender.

	Mean ± standard deviation		
Parameter	Females (n=35)	Males (n=26)	*P*-value
Left brachial	116 ± 11	125 ± 13	<0.01
Right brachial	119 ± 14	127 ± 12	<0.05
Left ankle	126 ± 16	128 ± 17	NS
Right ankle	124 ± 15	127 ± 16	NS
Left ABI	1.03 ± 0.1	0.99 ± 0.1	NS
Right ABI	1.02 ± 0.1	0.99 ± 0.1	NS

ABI, ankle–brachial index; NS, not significant

PAGE POINTS

1 Identifying age and gender trends with respect to the ankle–brachial index has implications for the evidence-based practice of patient management.

2 The literature has already highlighted physiological variations in systolic blood pressure between genders and age ranges.

pedis artery unless the dorsalis pedis artery showed no clear pulse, in which case the posterior tibial artery was used. The ankle SBP reading was then divided by the highest brachial SBP reading to give a numerical value: the ABI (Brooks et al, 2001).

Participants were divided into gender and age groups of <30 years and >40 years for the final data analysis.

Descriptive statistics and parametric statistical tests were used to observe characteristics of central tendency and variability within the data-set as appropriate for normative data collection.

To identify any statistically significant age and gender differences in the ABI and SBP, a standard two-sample t-test and fitted analysis of variance (ANOVA) were undertaken. The SBP and ABI values were the dependent variables and age and gender the independent variables to determine whether age and gender can predict a significant difference in SPB and ABI. Statistical significance was identified using α=0.05.

Results

The mean and standard deviation values for the two age groups are shown in *Table 1*. In all of the parameters the older age group had higher scores. The age differences for SBP values all reached a high level of significance. When this was translated into the ABI, although the older age group had a higher mean for both the left and the right reading, no such significance was reached.

Table 2 shows the results for the gender comparison. Our results indicate that a statistically significant difference exists between the brachial SBPs of males and females. No significant difference was noted for the ankle SBPs or for the ABIs.

Table 3 shows results by age group and gender. Comparison between genders within each age group indicated that in the <30 years group both brachial SBPs were significantly different (P<0.05), whereas in the >40 years group only the right brachial SBP was significantly different (P<0.05). Comparison between age groups revealed significant differences (P<0.05) for the brachial and ankle SPBs for each gender. No significant differences were noted for ABI measures when controlling for age or gender.

Discussion

Identifying age and gender trends with respect to the ABI has implications for the evidence-based practice of patient management. The literature has already highlighted physiological variations in SBP between genders and age ranges (Vuong and Berry, 2002). It is because of these differences, and the importance of

Table 3. Blood pressure (mmHg) and ABI results by age group and gender.

	Mean ± standard deviation			
	Females		Males	
Parameter	<30 years (n=24)	>40 years (n=11)	<30 years (n=21)	>40 years (n=5)
Left brachial	111 ± 7	126 ± 11	121 ± 8	140 ± 16
Right brachial	115 ± 14	126 ± 11	123 ± 6	143 ± 17
Left ankle	121 ± 14	134 ± 15	123 ± 11	148 ± 23
Right ankle	120 ± 13	132 ± 13	122 ± 8	145 ± 24
Left ABI	1.04 ± 0.1	1.05 ± 0.1	0.99 ± 0.1	1.01 ± 0.1
Right ABI	1.02 ± 0.1	1.02 ± 0.1	0.99 ± 0.1	0.99 ± 0.1

ABI, ankle–brachial index; significance testing described in text

PAGE POINTS

1 In this study, significance in systolic blood pressure differences between age groups did not equate to significance when converted to the ankle–brachial index (ABI).

2 The ABI differences between genders did not reach statistical significance.

3 We recommend that future research involves a larger cohort and uses 10-year increments for age to assess incremental changes in ABI.

using scientific evidence to base clinical decisions on, that further research into the ABI was warranted.

Age and ABI

Previous research on lower-limb blood flow has demonstrated a difference in leg blood flow between younger and older males (Dinenno et al, 2001). A variation in blood vessel morphology with age has also been shown in the brachial artery (van der Heijden-Spek et al, 2000). A statistically significant difference was observed in our study between age groups for the brachial and ankle SBPs. Significant differences in SBP were also found when comparing the two age groups within each gender. However, significance in SBP differences did not equate to significance when converted to the ABI. Despite this, the results for the two age groups shown in *Table 1* indicate a trend in the ABI, we feel, with the older age group having higher ABI scores.

Of interest are the results of the range variation in ABI results between age groups. Here the younger age group had a left ABI range of 0.78–1.24 (mean ± standard deviation, 1.02 ± 0.1) and a right ABI range of 0.73–1.2 (1.01 ± 0.1), while the older age group had a left ABI range of 0.92–1.33 (1.04 ± 0.1) and a right ABI range of 0.86–1.17 (1.02 ± 0.1). These results can be used as an indicator of normal range when testing patients in either of these two age groups. The range of ABI values suggests that a lower cut-off for normal values may be applicable, compared with the current accepted cut-off of 0.9. However, note that the upper limit remained fairly close to the current suggested upper limit of 1.3, whereas some authors (e.g. Resnick et al, 2004) have suggested an upper cut-off of 1.4.

Gender and ABI

Statistical tests comparing ABI scores between genders found no significant differences. The findings of this research support those of other studies (e.g. van der Heijden-Spek et al, 2000) that found a significant difference in the brachial artery SBP between genders. Results from the ankle SBP were not significantly different between genders. A difference in ABI was noted between age groups and gender in this study. The fitted ANOVA model indicated that both age and gender were able to predict significant differences for brachial SPB measures ($P<0.01$), but only age was able to predict significant differences for ankle SBP measures ($P<0.01$). The model was not applicable for identifying significant differences for the ABI values. The respective left and right ABI ranges were found to be 0.78–1.33 and 0.73–1.24 for females and 0.81–1.19 and 0.85–1.2 for males. These ranges again suggest that a lower normal ABI cut-off can be considered. While the ABI differences between genders, or age groups, did not reach statistical significance, we feel they do indicate that consideration of age and gender may be warranted for diagnosis of peripheral vascular disease using ABI.

Conclusion

Gender and age have been shown to influence normal function of blood flow by leading to an increase in vessel wall hardening and other structural changes. Some of these physiological changes are reflected by changes in the SBPs recorded from either the arm or ankle. However, age and gender differences in the ABI were not statistically significant in our study. We observed that the mean ABI for the younger age group (<30 years) was lower in both the female and male groups and that the mean male ABI was lower compared with the mean female ABI. We recommend that future research involves a larger cohort and uses 10-year increments for age to assess incremental changes in ABI. This may provide data similar to those reported for age and gender influence on blood pressure when assessing hypertension, where absolute values in blood pressure for different age groups or between genders are not significantly different but reflect a trend in the population. ■

'Identifying age and gender trends with respect to the ankle–brachial index has implications for the evidence-based practice of patient management.'

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