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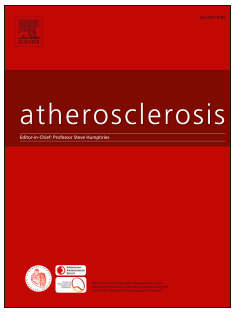

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Reliability of oscillometric central blood pressure and central systolic loading in individuals over 50 years: Effects of posture and fasting

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ABSTRACT

Background and aims: The between-day reliability of oscillometric pulse wave analysis has been demonstrated in a young, healthy population but not in an older sample. This study examined the between-day reliability of the SphygmoCor XCEL in individuals over 50 years. As blood pressure is measured in a range of postures and fasting states (supine/seated, fasted/non-fasted), this study also investigated the effect of these variables on central blood pressure and central systolic loading. *Methods:* Fifty-one adults (m=21; age 57 ± 6.4 y) were tested on three mornings in supine and seated conditions and in fasted and non-fasted states. Data was analysed as a whole and for normotensive (n=25) and hypertensive participants (n=26).

Results: SphygmoCor XCEL demonstrated strong reliability in the whole sample for central systolic and diastolic blood pressures, augmentation index (AIx) and AIx75 (ICC=0.77–0.95). Significant interaction effects were observed in central diastolic blood pressure, central pulse pressure, augmentation index (AIx) and AIx75 ($p < 0.05$; $\eta_p^2 = 0.10$-0.23). Fasting state had a greater influence on central pressures in a seated than supine posture, but a greater effect on central systolic loading measures in a supine posture.

Conclusions: The SphygmoCor XCEL is a reliable tool to assess central haemodynamic variables in an older population. It would be pertinent for clinicians and researchers to record central measures in a supine posture to minimise the effects of food consumption. Conversely, the assessment of central systolic loading should occur in a seated condition to minimise the influence of varying fasting states.

KEY WORDS

Arterial stiffness; Augmentation index; Posture; Fasting state; Reliability; Pulse wave analysis; SphygmoCor XCEL

ABBREVIATIONS: Aix, augmentation index; AIx75, augmentation index corrected to a heart rate of 75b-min$^{-1;}$ AP, augmented pressure; BP, blood pressure; cBP, central blood pressure; cDBP, central diastolic blood pressure; cSBP, central systolic blood pressure; cPP, central pulse pressure; DBP, diastolic blood pressure; ICC, intra-class correlation coefficient; SBP, systolic blood pressure.

INTRODUCTION

Globally, hypertension is the most common condition seen in primary care [1] and the major cause of death worldwide [2], with ≥ 29% of adults in the United Kingdom and United States presenting as hypertensive [3-4]. Although peripheral blood pressure (BP) measurement is traditionally used to monitor BP, central blood pressures may be more closely related to the pathophysiology of end-organ damage [5]. Systolic blood pressure (SBP) may be increased in the periphery by as much as 40 mmHg due to increased arterial stiffness away from the aorta [6]. Around 30% of peripherally normotensive males and 10% of peripherally normotensive females may share central pressures in common with those with stage I peripheral hypertension [6]. Central haemodynamic parameters may therefore be a superior measure for clinicians than traditional peripheral BP readings [7]. Before these readings are incorporated into clinical practice, the between-day reliability of these measures in normal operating conditions must be assessed.

Central pressures have previously been recorded invasively; a procedure usually contraindicated in healthy populations [8]. Recent technological advances mean these measures can now be estimated non-invasively using oscillometric-based pulse wave analysis. Although these devices have been shown to be valid [9-12], including with an older population sample [13], further work is needed to demonstrate the reliability and optimal operating conditions for the function of these devices. Recent research by Young et al. [7] demonstrated central haemodynamic parameters and systolic loading readings to be reliable in a young, healthy population (intra-class correlation coefficients [ICCs] of 0.73–0.89), particularly in a supine and fasted state, when using the SphygmoCor XCEL device. However, the between-day reliability of these measures has not been demonstrated in an older demographic, where hypertension is more commonly found. As BP measures frequently inform medication prescription, devices recording these measures must be reliable enough to make appropriate clinical decisions.

It is important to consider the effect of posture and fasting state in older individuals as BP is clinically measured in different postures and prandial states (i.e. within primary and secondary care), depending on individual circumstance. Both posture [14-15] and fasting state [16] are reported to influence brachial blood pressures but the influence these variables have on central measures is limited. Young and colleagues [7] suggested no significant difference in central pressures after food consumption but Ahuja, Robertson & Ball [17] reported a significant post-prandial drop in central pressures in a participant sample aged between 21 and 80 years.

This study examined whether between-day reliability of the SphygmoCor XCEL is influenced by posture and fasting state in an older participant sample (> 50 years), and whether the measurement precision is altered in normotensive and hypertensive individuals. These findings will be important when determining the SphygmoCor XCEL's suitability for clinical use and the optimal testing conditions in an aging demographic.

MATERIALS AND METHODS

This observation study was carried out in accordance with STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines [18].

Participants

Fifty-one participants (m=21; f=30; age 57 ± 6.4 y; age range = 32 [50-82]) were recruited to the study. Participant demographics can be observed in Table 1. Ethical approval was received from the University of Winchester Ethics Committee. The study conformed to the ethical guidelines of the 1975 Declaration of Helsinki. Participants provided written informed consent and maintained the right to withdraw at any time. Participants were recruited if they were over the age of 50 and excluded or were unable to give consent.

Experimental design

Participants were tested on three mornings (all three visits within three weeks; between the hours of 07:00 and 10:00) and had consumed only water for the 12 hours before and refrained from intense physical activity for 24 hours preceding testing. Participants were firstly allocated to either the supine or seated condition using a computerized random number generator. They then adopted the allocated posture for twenty minutes before a minimum of two pulse wave analysis measurements were taken using the SphygmoCor XCEL (AtCor Medical, Sydney, Australia) with a three-minute interval. If a difference of > 5 mmHg and a difference of > 4% AIx was noted under manufacturer guidelines, a third measure was taken and data were averaged. After twenty minutes in the other posture, these measures were repeated. A matched breakfast of either cereal (Weetabix), banana, milk, orange juice or two slices of toast with butter, marmalade and orange juice was then provided. The protocol was then repeated in both supine and seated non-fasted conditions in the same order as the fasted state, leading to final measures being approximately 45

minutes post-food consumption. This resulted in approximately 8 data points per session and a total of 1370 data points.

Sample size

A minimum sample of 25 participants per group was identified using G*Power [19] with *p* set at 0.05, a power of 0.80 and a moderate effect size (0.50) whilst accounting for a 10% drop-out.

Statistics

Statistical Package for Social Sciences v.22 (SPSS, Inc., Chicago, Illinois, USA) was used to analyse data. Statistical significance was set at $p < 0.05$. Analysis of variance for repeated measures with two within-participant factors (posture and fasting state) was used to assess differences in peripheral and central haemodynamic parameters (systolic blood pressure [SBP]; diastolic blood pressure [DBP]; pulse pressure [PP]; central systolic blood pressure [cSBP]; central diastolic blood pressure [cDBP] and central pulse pressure [cPP]; heart rate [HR]) and central systolic loading (augmentation index [AIx]; augmentation index @ 75 bpm [AIx75]). Effect sizes were reported using partial eta squared (η_p^2) with 0.01, 0.06 and 0.14 representing small, medium and large effects [20]. Intra-class correlation coefficient (ICC), standard error of measurement (SEM) and the Smallest Detectable Change (SDC) were used to assess the between-day reliability of the XCEL (see [7]). Identical analysis was performed with the sample split into two groups: normotensive (peripheral blood pressure <130/80 mmHg) and hypertensive (peripheral blood pressure ≥ 130/80 mmHg [21]).

RESULTS

Data was successfully collected from all participants in each condition.

Central and peripheral blood pressures

Whole sample

Table 2 summarises the mean values for central and peripheral haemodynamic measures for the whole sample. Significant interaction effects were reported for cDBP and cPP (p <0.05; η_p^2 = 0.10-0.23), with greater differences observed between fasted and non-fasted whilst seated than when supine. Fasting state was found to have a significant main effect on cSBP and HR. For all central blood pressure variables, ICC values were above the 0.75 criterion in each condition, demonstrating excellent between-day reliability (Table 3).

Normotensive group

Significant interaction effects were observed for cDBP (p <0.05, η_p^2 = 0.18) and cPP (p <0.05; η_p^2 = 0.22). For cDBP, greater differences were seen between prandial states (fasted vs. non-fasted) whilst seated than supine. For cPP, a post-prandial increase was observed when supine but a decrease was shown in the seated condition. Fasted state, but not posture, had a significantly large effect on cSBP whereas both fasting state and posture had a significant main effect on HR. For central blood pressure variables, ICC values generally exceeded the criterion value of 0.75 for the four conditions (Table 3), except for SBP in the supine-fasted condition between visits 1-2, SBP in the seated-fasted condition in visits 1-2 and 2-3 and PP in seated-fasted condition in visits 1-2 and 2-3 (Supplementary Table 1).

Hypertensive group

Significant interaction effects were observed for cPP (p <0.01; η_p^2 = 0.25; Table 2) with greater differences seen between prandial states whilst seated than supine. Posture was shown to have a significant main effect on DBP, cDBP and HR, whereas fasted state had a significant effect on DBP, PP, cSBP, cDBP and HR (all p<0.05). The between-day reliability of the XCEL was demonstrated by ICC

values > 0.75 for all central haemodynamic variables in all conditions between visits 1-2 and 2-3 (Supplementary Table 1).

Central systolic loading

Whole sample

Mean values for central systolic loading variables in the whole participant sample are shown in Table 2. Significant interaction effects were observed for AIx and AIx75 (p <0.05; η_p^2 = 0.10-0.18) with greater differences observed between prandial states whilst supine than seated. The between-day ICC of 0.75 was exceeded in all conditions for AIx and AIx75 (Table 3).

Normotensive group

The normotensive group presented significant interaction effects for AIx75 (p <0.01; η_p^2 = 0.74) with larger differences reported between prandial states whilst supine compared to seated. Posture caused a significant main effect on AIx (p <0.05; η_p^2 = 0.19) as did fasting state (AIx p <0.05; η_p^2 = 0.70 [Table 2]). ICC values exceeded 0.75 for all central systolic loading variables in all conditions (Table 3).

Hypertensive group

Significant interaction effects were observed for AIx (p <0.05; η_p^2 = 0.20) and AIx75 (p <0.05; η_p^2 = 0.29). In the hypertensive group, and following food consumption, greater changes in AIx were demonstrated when supine compared to seated. For AIx75, food consumption elicited a 5.2% decrease in the supine condition whereas a 5.2% increase was observed in the seated condition. ICC values of ≥0.75 were observed in both variables in all conditions other than supine-fasted (ICC = 0.73 and 0.74 [Table 3]), but after breaking data down, ICC values exceeded 0.75 in visits 1-2 and 2-3 (AIx = 0.76-0.92; AIx75 = 0.77-0.92; [Supplementary Table 1]).

DISCUSSION

This study demonstrated that the SphygmoCor XCEL is a reliable tool for measuring central haemodynamic variables in a non-clinical participant sample > 50 years old in a range of normotensive and hypertensive individuals. Importantly, fasting state was shown to have a greater influence on central measures in a seated than a supine posture. Less disparity after food consumption due to posture was observed in central systolic loading variables.

Limitations and strengths

Limitations and strengths should be noted to allow better contextualisation of the results. One limitation was that we recruited a mixed sex sample of healthy adults over the age of 50. Previous work has suggested that the effect which posture has on peripheral BP may be sex specific [22] and future work should recruit unisex cohorts to similar protocols to determine whether this is the case for central blood pressure (cBP) measures. It is worth noting that AIx75 may be physiologically and statistically inappropriate as a standalone measure, due to the assumption being made that the relationship between HR and AIx is linear [23]. Consequently, our statistical analysis reports both AIx and AIx75 The structure of the present study did, however, involve post-prandial measures up to 45 minutes after food intake which is in accordance with Ahuja and colleagues' [16] recommendations for assessing changes to haemodynamic variables after food intake. Furthermore, the overnight fast undertaken by participants and randomised order of conditions result in a robust protocol and data collection was consistently undertaken at the same time of day, reducing the likelihood of circadian blood pressure cycles influencing results. It should be noted that two of the thirty female participants were pre-menopausal at the time of assessment due to the age demographic of our population. An international study of ~19,000 women reported the median age of natural menopause to be 50 (median range of 49-52y [24]. Although this is a condition which causes increased prevalence of hypertension [25], further analysis demonstrated that study outcomes were not influenced by menopausal state.

Central blood pressure

The results of this study demonstrate that the SphygmoCor XCEL can reliably record central markers of blood pressure. The ICC values we observed for cSBP for the whole group (0.89-0.92) and after splitting of data (normotensive = 0.58-0.77; hypertensive = 0.85-0.88) are similar to previous research in a younger sample (ICC = 0.89; [7]) and suggest that the SphygmoCor XCEL is a reliable tool for assessing these central pressures in non-clinical participant sample over the age of 50. However, despite excellent reliability between visit 1 and 2 and visit 2 and 3 (Supplementary Table 1) for the whole study sample and the hypertensive group, moderate correlations were only reported for the normotensive sample. This may be due to the presence of white coat syndrome and should be considered in terms of recommendations for blood pressure assessment protocols. This point may be particularly relevant in GP practices where blood pressure measures tend to only be completed once per visit, potentially giving a false indication of a patient's blood pressure at that time.

Significant interaction effects were observed for cDBP and cPP in the whole group, with similar findings generally reported for both the normotensive and hypertensive groups. The present study has shown smaller differences in blood pressures (cDBP, cPP) between fasted and non-fasted conditions when a participant is supine (mean difference of 1.4 mmHg and 0.8 mmHg, respectively) than seated (mean difference of 2.7 mmHg and 1.5 mmHg, respectively). This may be due to increased speed of early-stage digestion taking place in a seated position because of gravity; leading to subsequent greater vasodilation and a drop in BP not seen in a supine position. This finding may be important in clinical environments such as GP practices where blood pressure is measured in a variety of fasting states but frequently in a seated rather than supine posture. These findings were mirrored in the normotensive and the hypertensive group.

Greater variability in the cDBP and cPP response to food was seen in a seated posture than a supine posture, and thus the seated posture traditionally adopted in a clinical setting may be sub-optimal,

particularly as cPP is potentially a more direct indicator of vascular aging than other blood pressure variables [26]. In accordance with Young and colleagues [7], the SphygmoCor XCEL has optimal reliability in a supine posture with an older population, due to the smaller changes caused by prandial state.

The posture of a patient is important to consider when measuring blood pressure [14] and the role posture plays in aortic haemodynamics is less well known [27]. Our results would suggest the greater differences observed for changes in some central variables in fasting state in a seated posture may also be insufficiently recognised in the literature. We observed a significant increase in cDBP in the seated compared to supine posture in the whole sample as well as the normotensive and hypertensive sub-groups. This is in agreement with previous studies investigating peripheral diastolic pressures [13, 28], although research incorporating only 1–5-minute postural conditions before assessments has shown a greater peripheral blood pressure in a supine than seated posture [14, 29); highlighting the differing acute and chronic responses to postural change.

A forty-eight hour fast has been demonstrated to significantly lower peripheral blood pressures [15], but the acute effects of food on vascular haemodynamics have received less attention. Our observations of a significant drop in cBP and non-significant responses of peripheral systolic blood pressure in a post-prandial state are in support of previous work [16]. These significant decreases in cSBP and cDBP in the post-prandial state were reported in the sample as a whole and in both sub-groups.

Central systolic loading

The strong between-day reliability when measuring AIx and AIx75 (ICC > 0.75) in our older participant sample supports previous research undertaken with a young, healthy sample (ICC = 0.71-0.82; [7]). Smaller differences were observed between visits 1-2 and 2-3 for AIx and AIx75 than central blood pressure measures (Supplementary Table 1), meaning that the physiological

mechanisms resulting in potential white coat syndrome in peripheral and central blood pressures may not extend to AIx and AIx75 measures.

The significant interaction effects observed for AIx and AIx75 for the whole sample suggested greater post-prandial variability in a supine posture (mean differences of 7.2% and 2.9% respectively) than seated (mean differences of 5.3% and 1.8% respectively). These results are converse to the findings in this study with regards to central blood pressure measures and suggest that, when assessing central systolic loading, a seated posture is optimal to reduce the variability caused by food consumption. These interaction effects were not observed in previous research using a younger sample [7] and suggest that central systolic loading becomes more variable as a person ages.

Significant differences were observed in AIx and AIx75 in the whole sample due to postural alterations. These differences were not seen in previous work [7], although after the calculation of AIx75, systolic augmentation index was reported to be lower in a supine posture than seated in young females [30]. Fasting state was reported to cause a significant drop in AIx. This may be due to alterations of the tone of small vessel beds, large artery function and large artery geometry [7]. Vasodilation after food consumption may lead to a lessening of wave reflection intensity, leading to this decrease in arterial stiffness.

Clinical inference

The present study suggests that the SphygmoCor XCEL is a reliable measure when assessing cBP and central systolic loading variables. Clinicians and researchers may find it useful to measure cBP in a supine posture due to the reduced effect of food intake, but that central systolic loading variables are recorded in a seated position.

Conclusions

Blood pressure assessments occur in a range of postures and fasting states depending on an array of variables both at home and in the clinical environment. This study highlights the significant effect that fasting state can have on central haemodynamic variables and measures of arterial stiffness. We also note that the influence food consumption has on central haemodynamics is minimised with the use of a supine posture – a position which has also previously been shown to cause the greatest between-day reliability of the SphygmoCor XCEL. Although previous work has highlighted the possibility of white coat syndrome and the necessity for second blood pressure measures to be recorded, this study suggests that more than one visit may be necessary, particularly for a normotensive population. The SphygmoCor XCEL is a reliable tool in assessing cBP and measures of arterial stiffness in a non-clinical sample over the age of 50 and trials should now begin to determine the reliability of this equipment in clinical populations.

Conflict of interest

The authors declared they do not have anything to disclose regarding conflict of interest with respect to this manuscript.

Author contributions

All authors aided with the writing and critically revised the manuscript for important intellectual content. All authors gave final approval for publication

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		Whole sample		Normotensive		Hypertensive	
		n	%	n	%	n	%
Participants		51		25		26	
Age (y)		57.1y ±6.4y		57.3y ±7.1y		56.9y ±5.8y	
Sex	Male	21	42	9	36	12	46
	Female	30	58	16	64	14	54
Descent	European	51	100	25	100	26	100
Family history of CVD	Myocardial infarction	14	28	8	32	6	23
	Heart surgery	5	10	3	12	2	8
	Stent	3	6	2	8	1	4
	Catheter	1	2	1	4	0	0
	Heart defect	8	16	1	4	7	27
	Stroke	19	37	9	36	10	38
Personal history of CVD	Hypertension	14	27	2	8	12	46
	High cholesterol	14	27	5	20	9	35
	Diabetes	1	2	0	0	1	4
	Heart problems	4	8	4	16	0	0
	Artery diseases	1	2	0	0	1	4
	Thyroid disease	3	6	1	4	2	8
	Lung disease	1	2	0	0	1	4
	Asthma	11	22	4	16	7	27
	Cancer	4	8	1	4	3	12
	Kidney disease	0	0	0	0	0	0
	Hepatitis	3	6	1	4	2	8
Signs and symptoms of CVD	Chest pain	8	16	4	16	4	15
	Dyspnoea	10	20	6	24	4	15
	Heart palpitations	8	16	5	20	3	12
	Skipped heartbeats	4	8	4	16	0	0
	Heart murmur	5	10	5	20	0	0
	Intermittent leg pain	9	18	3	12	6	23
	Syncope	12	24	7	28	5	19
	Fatigue	12	24	4	16	8	31
	Snoring	29	57	13	52	16	62
	Back pain	22	43	13	52	9	34
Lifestyle factors	Current smoker	4	8	2	8	2	8
	Previous smoker	18	35	7	28	11	42
	Current alcohol drinkers	40	78	19	76	21	81
	Current weight loss plan	4	8	1	4	3	12
Everyday activity	Sedentary	22	43	11	44	11	42
	Lightly active	15	29	9	36	6	23
	Moderately active	14	27	5	20	9	34
	Vigorously active	0	0	0	0	0	0
Medication	Statins	3	6	2	8	1	4
	Anti-thrombotic	0	0	0	0	0	0
	Diuretics	0	0	0	0	0	0
	Calcium blockers	2	4	0	0	2	8
	Alpha blockers	2	4	1	4	1	4
	Beta blockers	2	4	1	4	1	4
	Anticoagulants	0	0	0	0	0	0
	Other anti-hypertensive medication	7	14	2	8	5	19

Table 1: Participant demographic data

[a] CVD, cardiovascular disease.

[a] Aix, augmentation index; AIx75, augmentation index @ 75bpm; AP, augmented pressure; cDBP, central diastolic blood pressure; cPP, central pulse pressure; cSBP, central systolic blood pressure; DBP, diastolic blood pressure; Fast, fasted; Non, non-fasted; HR, heart rate; MAP, mean arterial pressure; SBP, systolic blood pressure.

Table 2: Mean (SD) central and peripheral blood pressures and arterial wave reflection values - supine and seated, fasted and non-fasted

		Total	Supine		Seated		Interaction		Posture		Fasted	
		X	Fast	Non	Fast	Non	P	η^2_p	P	η^2_p	P	η^2_p
Whole Population												
MAP (mmHg)	X	97	97	96	99	98	0.848	0.00	**0.001**	0.19	0.000	0.23
	SD	13	13	13	13	14						
SBP (mmHg)	X	133	133	133	133	135	0.193	0.03	0.081	0.06	0.202	0.03
	SD	18	18	18	18	18						
DBP (mmHg)	X	81	81	79	84	81	**0.022**	0.10	**0.000**	0.30	**0.000**	0.45
	SD	11	11	11	12	12						
cSBP (mmHg)	X	122	123	121	124	122	0.200	0.03	0.136	0.04	**0.001**	0.19
	SD	16	17	16	16	17						
cDBP (mmHg)	X	82	82	80	85	82	**0.025**	0.10	**0.000**	0.29	**0.000**	0.37
	SD	11	11	11	12	12						
cPP (mmHg)	X	40	41	41	39	40	**0.000**	0.23	**0.003**	0.16	0.400	0.01
	SD	9	9	10	9	10						
AP (mmHg)	X	11.8	14.2	10.8	12.1	10.3	**0.000**	0.23	**0.001**	0.19	**0.000**	0.53
	SD	5.4	6.0	4.9	6.2	5.7						
AIx (%)	X	27.8	32.5	25.3	29.3	24.2	**0.022**	0.10	**0.001**	0.20	**0.000**	0.66
	SD	9.7	10.1	9.2	11.6	10.2						
AIx@75 (%)	X	24.6	26.4	20.3	24.0	28.0	**0.002**	0.18	**0.000**	0.29	0.670	0.04
	SD	9.8	10.6	10.2	10.9	11.6						
HR (bpm)	X	64	62	65	64	67	0.248	0.03	**0.000**	0.33	**0.000**	0.57
	SD	8	8	8	8	9						
Normotensive Population												
MAP (mmHg)	X	88	88	87	90	88	0.499	0.02	0.126	0.10	**0.028**	0.19
	SD	7	7	8	7	8						
SBP (mmHg)	X	120	119	120	119	120	0.623	0.01	0.763	0.00	0.471	0.02
	SD	7	7	8	6	7						
DBP (mmHg	X	74	74	73	77	74	0.061	0.14	**0.014**	0.23	**0.001**	0.36
	SD	7	6	7	7	8						
cSBP (mmHg)	X	110	111	109	111	109	0.651	0.01	0.942	0.00	**0.035**	0.17
	SD	7	8	8	7	7						
cDBP (mmHg)	X	75	75	74	78	75	**0.032**	0.18	**0.024**	0.20	**0.005**	0.28
	SD	7	6	7	7	8						
cPP (mmHg)	X	35	37	35	34	36	**0.015**	0.22	**0.002**	0.33	0.806	0.00
	SD	7	9	6	7	7						
AP (mmHg)	X	10.3	12.7	9.1	10.6	8.5	**0.033**	0.18	**0.014**	0.23	**0.000**	0.54
	SD	5.5	6.5	4.4	6.9	5.3						
AIx (%)	X	27.0	32.0	24.1	28.9	23.0	0.283	0.05	**0.026**	0.19	**0.000**	0.70
	SD	10.9	11.6	9.8	13.9	10.6						
AIx@75 (%)	X	23.6	26.0	19.0	23.3	26.2	**0.000**	0.74	**0.000**	0.53	**0.000**	0.99
	SD	10.9	12.1	11.2	12.4	12.2						
HR (bpm)	X	65	62	65	64	68	0.331	0.04	**0.009**	0.25	**0.000**	0.66
	SD	9	10	9	8	10						
Hypertensive population												
MAP (mmHg)	X	106	106	104	108	107	0.737	0.01	**0.004**	0.29	**0.004**	0.28
	SD	11	11	11	12	12						
SBP (mmHg)	X	147	146	146	147	148	0.219	0.06	0.062	0.13	0.275	0.05
	SD	15	16	15	15	15						
DBP (mmHg	X	88	87	85	91	88	0.173	0.07	**0.001**	0.38	**0.000**	0.54
	SD	11	10	11	11	12						
cSBP (mmHg)	X	134	134	132	136	135	0.219	0.06	0.083	0.12	**0.019**	0.20
	SD	14	15	14	14	14						
cDBP (mmHg)	X	89	88	86	92	89	0.305	0.04	**0.001**	0.38	**0.000**	0.48
	SD	11	10	12	11	12						
cPP (mmHg)	X	45	46	46	44	46	**0.008**	0.25	0.166	0.08	0.356	0.03
	SD	8	8	10	9	9						
AP (mmHg)	X	13.3	15.5	12.3	13.4	11.9	**0.004**	0.28	**0.033**	0.17	**0.000**	0.52
	SD	4.9	5.2	4.9	5.3	5.7						
AIx (%)	X	28.6	32.9	26.5	29.6	25.4	**0.020**	0.20	**0.016**	0.21	**0.000**	0.64
	SD	8.5	8.7	8.7	9.2	9.8						
AIx@75 (%)	X	25.7	26.7	21.5	24.6	29.8	**0.047**	0.29	0.069	0.20	**0.008**	0.19
	SD	8.7	9.2	9.3	9.9	11.6						
HR (bpm)	X	64	62	64	64	66	0.530	0.02	**0.000**	0.43	**0.000**	0.49
	SD	8	7	8	8	8						

Table 3: Reliability of the SphygmoCor XCEL in each sample group

	Supine-F			Supine-NF			Seated-F			Seated-NF		
	ICC	SEM	SDC	ICC	SEM	SDC	ICC	SEM	SDC	ICC	SEM	SDC
Whole population												
MAP (mmHg)	0.90	4.0	11.0	0.93	3.4	9.3	0.91	4.1	11.2	0.94	3.3	9.1
SBP (mm Hg)	0.90	5.8	16.1	0.90	5.7	15.8	0.92	5.0	13.9	0.91	5.4	15.1
DBP (mm Hg	0.90	3.4	9.4	0.92	3.0	8.4	0.90	3.6	10.0	0.94	3.1	8.6
cSBP (mmHg)	0.89	5.4	15.0	0.92	4.5	12.5	0.90	5.2	14.3	0.92	4.7	13.1
cDBP (mmHg)	0.89	3.5	9.6	0.89	3.7	10.3	0.90	3.6	10.1	0.94	3.1	8.7
cPP (mmHg)	0.83	3.7	10.3	0.86	3.6	10.1	0.84	3.7	10.2	0.85	3.7	10.2
AP (mmHg)	0.75	3.0	8.3	0.84	1.9	5.3	0.82	2.6	7.3	0.86	2.2	6.0
AIx (%)	0.77	4.9	13.4	0.85	3.5	9.8	0.83	4.7	13.1	0.80	4.5	12.5
AIx75 (%)	0.75	5.3	14.6	0.87	3.7	10.3	0.82	4.7	13.0	0.84	4.6	12.8
HR (bpm)	0.86	3.1	8.6	0.84	3.3	9.2	0.86	3.0	8.4	0.80	4.0	11.0
Normotensive population												
MAP (mmHg)	0.71	3.5	9.8	0.85	2.9	8.1	0.68	4.0	11.0	0.86	2.9	8.0
SBP (mm Hg)	0.59	4.7	13.0	0.76	3.9	10.7	0.51	4.4	12.3	0.74	3.8	10.5
DBP (mm Hg	0.75	2.9	8.0	0.83	2.8	7.8	0.73	3.7	10.3	0.88	2.8	7.8
cSBP (mmHg)	0.68	4.7	13.1	0.77	3.7	10.2	0.58	4.4	12.1	0.75	3.4	9.5
cDBP (mmHg)	0.74	3.0	8.4	0.87	2.6	7.2	0.73	3.8	10.4	0.87	2.9	8.1
cPP (mmHg)	0.78	4.3	12.0	0.79	2.6	7.3	0.76	3.5	9.7	0.77	3.2	8.9
AP (mmHg)	0.80	2.9	8.1	0.81	1.9	5.3	0.84	2.8	7.7	0.86	2.0	5.5
AIx (%)	0.80	5.2	14.5	0.84	4.0	11.0	0.86	5.2	14.4	0.77	5.1	14.1
AIx75 (%)	0.76	5.9	16.3	0.86	4.1	11.5	0.83	5.1	14.0	0.83	5.0	13.9
HR (bpm)	0.88	3.3	9.3	0.80	3.8	10.6	0.85	3.1	8.7	0.84	3.9	10.7
Hypertensive population												
MAP (mmHg)	0.88	3.9	10.9	0.89	3.6	10.0	0.91	3.6	9.9	0.92	3.4	9.5
SBP (mm Hg)	0.87	5.7	15.8	0.86	5.6	15.4	0.87	5.4	14.9	0.82	6.3	17.4
DBP (mm Hg	0.88	3.6	9.9	0.91	3.1	8.6	0.92	3.2	8.8	0.93	3.3	9.1
cSBP (mmHg)	0.86	5.3	14.8	0.88	4.9	13.5	0.88	4.8	13.4	0.85	5.4	14.9
cDBP (mmHg)	0.87	3.6	9.9	0.84	4.6	12.9	0.92	3.1	8.7	0.93	3.2	8.8
cPP (mmHg)	0.79	3.7	10.2	0.79	4.5	12.4	0.80	3.8	10.7	0.84	3.8	10.4
AP (mmHg)	0.67	3.0	8.2	0.85	1.9	5.2	0.78	2.5	6.9	0.84	2.3	6.4
AIx (%)	0.73	4.5	12.4	0.87	3.1	8.6	0.79	4.3	11.8	0.83	4.0	11.0
AIx75 (%)	0.74	4.7	12.9	0.88	3.3	9.1	0.79	4.3	12.0	0.85	4.2	11.7
HR (bpm)	0.85	2.9	7.9	0.89	2.8	7.8	0.87	2.9	8.1	0.75	4.1	11.3

[a.] Aix, augmentation index; AIx75, augmentation index @ 75bpm; AP, augmented pressure; cDBP, central diastolic blood pressure; cPP, central pulse pressure; cSBP, central systolic blood pressure; DBP, diastolic blood pressure; ICC, intra-class correlation; F, fasted; HR, heart rate; MAP, mean arterial pressure; NF, non-fasted; SBP, systolic blood pressure; SDC, smallest detectable change; SEM, standard error of measurement.

Highlights

- Effect of posture and fasted state on central blood pressure estimation was observed
- Interaction effects for posture and fasted state reported for some central measures
- Fasting state had a greater influence on central pressures when seated than supine
- Oscillometric wave reflection has acceptable between-day reliability in over 50s
- SphygmoCor XCEL may be a suitable tool for clinical use in an older population

Reliability of oscillometric central blood pressure and central systolic loading in individuals over 50 years: effects of posture and fasting

As authors, we can confirm that there are no known conflicts of interest associated with the publication entitled “Reliability of oscillometric central blood pressure and central systolic loading in individuals over 50 years: effects of posture and fasting”.

The above titled manuscript has been read and approved by each author and no other individuals have contributed to the study without being credited. The order of authorship has also been agreed by the team.

All aspects of this work have been undertaken after appropriate ethical approval by the University of Winchester Ethics Committee. This approval is acknowledged in the manuscript. As corresponding author, I am responsible for communications relating to this study submission. We have provided a correct and current address for contact purposes.

Signed,

Andrew Mitchelmore (1st November 2017)

Dr Lee Stoner (1st November 2017)

Dr Danielle Lambrick (1st November 2017)

Dr Simon Jobson (1st November 2017)

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