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The influence of posture and environmental temperature on the diagnostic ability of finger systolic blood pressure

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The influence of posture and environmental temperature on the diagnostic ability of finger systolic blood pressure

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Individuals with the vascular component of hand-arm vibration syndrome (HAVS) experience whiteness or blanching of the fingers in cold conditions, which is accompanied by numbness and then tingling or pain when the fingers warm-up. In the absence of a gold-standard diagnosis based upon pathology it is currently necessary to rely on self-reporting of key symptoms for the vascular component, which include the frequency and extent of blanching attacks. The accuracy and reproducibility of the diagnosis and staging depends upon an individual's recall of their current symptoms and when they first commenced. Consequently there is a need for a suitable diagnostic test to help confirm the diagnosis.

Measurement of Finger Systolic Blood Pressure (FSBP) with cold-provocation has been reported to be of diagnostic value in individuals with the vascular component of HAVS and those with Primary Raynauds phenomenon. The overall aim of this work was to investigate if factors such as posture and environmental temperature were important in influencing the ability of FSBP to discriminate between controls and those with Primary Raynauds.

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EXECUTIVE SUMMARY

Individuals with the vascular component of hand-arm vibration syndrome (HAVS) experience whiteness or blanching of the fingers in cold conditions, which is accompanied by numbness and then tingling or pain when the fingers warm-up. In the absence of a gold-standard diagnosis based upon pathology it is currently necessary to rely on self-reporting of key symptoms for the vascular component, which include the frequency and extent of blanching attacks. The accuracy and reproducibility of the diagnosis and staging depends upon an individual's recall of their current symptoms and when they first commenced. Consequently there is a need for a suitable diagnostic test to help confirm the diagnosis.

Measurement of Finger Systolic Blood Pressure (FSBP) with cold-provocation has been reported to be of diagnostic value in individuals with the vascular component of HAVS and those with Primary Raynauds phenomenon. However, historically we have not been able to confirm the value of this test. There were some methodological differences between the studies cited in the literature and our research, with the main one being that the studies that had found FSBP to be useful had studied volunteers in the supine position, whereas we had studied individuals in the seated position. The effect of posture on measurements of FSBP, and its ability to discriminate between controls and those with abnormal vascular responses to cold, has not been investigated.

Changes in room temperature have been shown to affect the measurement of FSBP in normal healthy controls, but the effect upon discrimination between normal and abnormal populations has not been investigated. It appears that with standard cold-provocation testing, where the speed of rewarming of the skin following local cold-provocation to the hands is assessed, that cooling of the body in addition to the hands can increase the diagnostic power of the technique.

The overall aim of this work was to investigate if factors such as posture and environmental temperature were important in influencing the ability of FSBP to discriminate between controls and those with Primary Raynauds. If these factors were shown to be important then conditions for optimum testing of FSBP could be recommended.

Objectives

1. Investigate the influence of posture and subsequent change in sympathetic nervous system activation on FSBP measurements in normal subjects and individuals with Primary Raynauds phenomenon.

2. Investigate the effect of environmental temperature on the discrimination between controls and those with Primary Raynauds in measurements of FSBP.

3. Report on the efficacy of FSBP measurements as a useful vascular test within health surveillance.

Main Findings

- There was no significant effect of posture on the mean FSBP levels, but there was a reduced variability in FSBP measurements of the control group in the seated position.

- On a group basis there were some significant differences between the mean FSBP levels in the control and Primary Raynauds (PR) groups in the seated position, but not in the supine position.

- On an individual basis the ability of the FSBP measurements to diagnose vascular abnormality was poor with the sensitivity ranging from 30-56% in the seated position, depending upon the cut-off for abnormality used.

- FSBP measurements had a tendency to be higher when measured in an environmental temperature of 27°C, as compared to those at 17 and 22°C, although there were few statistically significant differences. The higher temperature also had the effect of reducing the variability of measurements in the control group.

- Differences between the two groups were greatest in a room temperature of 27°C, but there were few significant differences. There was considerable overlap in the measurements of the two groups, which potentially limits the usefulness of this as a diagnostic technique.

- Some of the overlap between the groups was a consequence of abnormal responses in two controls, who did not report any signs or symptoms of PR. It is possible that these controls had pre-symptomatic PR. If they were excluded from the analysis the diagnostic ability of FSPB was still poor at a room temperature of 22°C, but was better when the tests were performed at a room temperature of 17°C.

Recommendations

FSBP measurements performed at the recommended room temperature of around 22°C do not appear to have great diagnostic power in discriminating normal subjects from Primary Raynauds sufferers. Measurements performed with additional body cooling in an environmental temperature of 17°C have greater diagnostic power, particularly if individuals who give a 'false positive' result are excluded.

The reason why we have not been able to replicate the diagnostic usefulness of this technique that others have reported remains unclear. Two possible reasons include whether the use of specific equipment for this test has a significant influence on the diagnostic outcome and the definition of 'normality' and a normal range for the test. The finding of 2 out of 15 individuals in this study who were ascribed after medical interview to the control population, but either visually blanched or gave a zero finger blood pressure during the testing is interesting. None of the published FSBP papers, which defined a control population and a 'normal' range for FSBP, have indicated whether they noted this phenomena and how they handled such information. There has been a very limited discussion in the literature of vascular testing identifying pre-symptomatic Raynauds phenomena. It is unclear whether these two individuals in our study should be regarded as showing 'false positive responses' or pre-symptomatic Primary Raynauds, which would preclude the definition as normal controls. Case definition of secondary (HAVS) Raynauds is driven by self-reporting of the blanching phenomena. So the issue of either a 'false positive' response or detection of 'pre-symptomatic' Primary Raynauds phenomena in an applied vascular test is a serious confounding issue.

Based on this and our previous studies, we still cannot recommend that FSBP measurement has a role in health surveillance for HAVS.

1 INTRODUCTION

Diagnosis of the vascular component of HAVS greatly depends upon the accurate reporting of the extent and frequency of symptoms by the individual. However, there are concerns that this may cause significant under or over-diagnosis depending on the circumstances. For example, it is possible that individuals under health surveillance may under report symptoms because they are afraid of being redeployed, whereas those seeking compensation may over report symptoms. Even when individuals have no vested interest in the staging resulting from questioning we have found that the reported symptoms can vary considerably on two different occasions (unpublished). Therefore, some occupational health physicians may feel more comfortable making decisions regarding somebody's fitness to work with vibration if there were a suitable vascular diagnostic test available.

Two objective tests, rewarming of finger skin temperature following cold-provocation (CPT) and Finger Systolic Blood Pressure (FSBP) have been proposed as potential tests that could aid in the diagnosis of the vascular component of hand-arm vibration syndrome (HAVS). However, the diagnostic value of the CPT as used and standardized in the United Kingdom [1], which involves immersion of the hands in 15°C for five minutes, has been questioned from data from health surveillance [2, 3], medico-legal work [4] and a recent review of the literature [5] .

Alternatively, there have been several publications suggesting that Finger Systolic Blood Pressure (FSBP) may be a useful diagnostic test in HAVS, and that this technique seems to have good sensitivity and diagnostic power [6-11]. One group of investigators (Bovenzi *et al*) have published favourable reports on the usefulness of FSBP over a number of years, often involving quite large study populations [8-10]. However, when we investigated the diagnostic usefulness of this technique in a small population of individuals who were under health surveillance and diagnosed with stage 2/3V HAVS, we found that the diagnostic accuracy of this technique was poor and not any better than standardized CPT testing [2]. There were, however, some methodological differences between the way in which we performed the tests and Bovenzi's group performed their tests. One of the key differences was that Bovenzi's group performed the tests in the supine position, whereas we conducted our testing in the seated position. Whilst there is no evidence that this may affect the measurement it is conceivable that changes in posture may lead to changes in baseline blood pressure/heart rate, which may be a consequence of changes in the balance of the sympathetic/parasympathetic nervous systems. This may then lead to changes in the responsiveness of the vascular system to cold-provocation, such as has been suggested in HAVS [12].

The temperature of the room within which the FSBP tests are to be conducted is a further consideration. The average room temperature used in our study was 22.7°C (SD 0.9) [2] and this was similar to that reported by Bovenzi [10], so this cannot account for differences in diagnostic power in the two studies. However, cooling of both the body and hands has been used to increase the diagnostic ability of FSBP testing [13, 14]. It may be that the additional stress to the thermoregulatory system caused by body cooling is more likely to lead to vasospastic events and blanching, and thus increased diagnostic power.

The current study wished to investigate the influence of both posture and environmental temperature on measurements of FSBP, and their discrimination between controls and individuals with vasospastic events. We aimed to evaluate what the optimum testing procedure may be, and under these conditions, assess the diagnostic power of FSBP measurements.

The main objectives of this study were:

1. Investigate the influence of posture and subsequent change in sympathetic nervous system activation on FSBP measurements in normal subjects and individuals with Primary Raynauds phenomenon.

2. Investigate the effect of environmental temperature on the discrimination between controls and those with Primary Raynauds in measurements of FSBP.

3. Report on the efficacy of FSBP measurements as a useful vascular test within health surveillance for HAVS.

2 EFFECT OF POSTURE ON MEASURMENT OF FINGER SYSTOLIC BLOOD PRESSURE

2.1 METHODS

2.1.1 Study design

Finger systolic blood pressure measurements were performed in normal healthy controls and individuals with Primary Raynauds (PR) defined through medical interview. Subjects were tested in both the seated and supine positions. These measurements were performed in a random order, on separate days, but at a similar time of day.

2.1.2 Subjects

We aimed to recruit ten normal healthy volunteers and ten individuals who had PR. All individuals were recruited from HSL staff using a calling notice. Those individuals who volunteered were then screened by interview with one of our physicians to establish if (i) they were fit to take part in the study and (ii) whether they would be in the control or PR group. Individuals with a history of heart problems, hypertension, were taking medication which could interfere with the test, or had been exposed to hand-arm vibration occupationally were excluded from the study.

When individuals first attended the laboratory the study was explained to them and informed consent obtained. This study was approved by the HSE research ethics committee (ETHCOM/REG/05/05).

2.1.3 Procedure

Following arrival in the temperature controlled laboratory the individual was asked to rest for 30 minutes in the position allocated, and the right hand at heart level, before beginning the measurements. For the latter 15 minutes of this equilibration period the individual's heart rate was recorded using a Polar heart monitor, such that heart rate variability could be calculated. Skin temperature (index finger of the right hand) and room temperature were recorded at the end of this equilibration period.

Finger systolic blood pressure measurements were then performed at three finger-cuff perfusion temperatures (30^{o}C, 15^{o}C and 10^{o}C). The right hand was tested for each of these measurements and the reference measurement (air) was always taken on the thumb. The test finger in the control group was the index finger and for the PR group it was the finger that they reported was their worst affected finger.

2.1.3.1 Measurement of Finger Systolic Blood Pressure

Cuffs that can be perfused with water were placed around the mid-phalanx of the reference and test finger of the right hand. Strain gauges were positioned on the tips of the reference and test fingers, at the base of the finger-nail, and secured in position using micropore tape. Once the cuffs and gauges were in position the FSBP measurements were performed. The tips of the fingers were squeezed to allow venous outflow. The perfusion cuffs were then inflated to a

pressure of 250mmHg to prevent arterial inflow, and at the same time the cuffs were perfused with water thermostatically controlled at a temperature of 30°C. After 5 minutes the pressure in the cuffs was reduced gradually and the pressure at which blood flow returned to the finger (as detected by the strain gauge) was measured. This procedure was then repeated using 15°C water in the perfusion cuffs, followed by 10°C. However, if an individual clearly had blanching following provocation at 15°C we did not then perform the measurement at 10°C. Measurements of systemic blood pressure were taken from the upper arm following each measurement to act as an additional reference measurement and adjust for any changes during the course of the measurement.

2.1.4 Analysis of Finger Systolic Blood Pressure measurements

Finger systolic blood pressure was calculated as the cuff inflation pressure at which the strain gauge signal starts to increase i.e. the point at which arterial inflow returns to the finger. This was measured from each trace for measurements performed with perfusion temperatures of 30°C ($FSBP_{30}$), 15°C ($FSBP_{15}$) and 10°C ($FSBP_{10}$). The percentage change of finger systolic blood pressure (FSBP%) from 30°C to 15°C, and for 30°C to 10°C were calculated according to the following formulae which make adjustments for changes in systolic blood pressure over the measurement period by taking either a reference measurement from the thumb, or arm:

A% $(FSBP_{t,15oC} * 100)/(FSBP_{t,30oC} - (ASP_{30oC} - ASP_{,15oC}))$

B% $(FSBP_{t,10oC} * 100)/(FSBP_{t,30oC} - (ASP_{30oC} - ASP_{,10oC}))$

C% $(FSBP_{t,15oC} * 100)/(FSBP_{t,30oC} - (FSBP_{ref,30oC} - FSBP_{ref,15oC}))$

D% $(FSBP_{t,10oC} * 100)/(FSBP_{t,30oC} - (FSBP_{ref,30oC} - FSBP_{ref,10oC}))$

Where: FSBP finger systolic blood pressure
t test finger

ref reference finger (thumb)

ASP systolic blood pressure measured in the arm

2.1.5 Griffin score

In order to quantify the degree of abnormality and blanching in the PR group the Griffin score was calculated [15]. This calculation gives a score to each phalange of the finger that is reported to blanch, with the distal phalange scoring 1, the medial phalange scoring 2 and the proximal phalange scoring 3. If the whole of one finger is affected then the maximum score that can be obtained is 6.

2.1.6 Calculation of Heart Rate Variability (HRV)

Calculation of the heart rate data obtained with the Polar monitor was performed using specific commercially available software (Nerve express, Heart Rhythm Instruments. USA). The interbeat interval for the heart rate was subjected to spectral analysis and the low frequency (LF) component (0.04-0.15Hz) is related to sympathetic nervous system activity, the high frequency (HF) component (0.15-0.5Hz) is related to parasympathetic activity. The ratio of the two components (HF/LF) was calculated for each recording, to reflect the relative balance of the nervous system, the lower the ratio the more sympathetic activity there is.

2.1.7 Statistical analysis

All statistical analysis was performed using SPSS software (Statistical Package for Social Sciences v14.0). Comparison of mean values of FSBP in the control and PR groups was done using unpaired t-tests (unadjusted for multiple comparisons). Evaluation of the effect of posture on paired measurements within individuals was done by comparing the mean differences (seated-supine) to zero using t-tests (unadjusted for multiple comparisons). The differences in skin or room temperature related to posture or group were investigated using two-way analysis of variance. The relationships between the Griffin score, heart rate variability and the measurements of FSBP were investigated using correlation analysis and the Pearson correlation coefficient and p-value reported.

To establish the diagnostic value of the FSBP measurements the sensitivity, specificity, positive predictive value, negative predictive value, positive and negative likelihood ratios were calculated in either posture using two different cut-offs. The first cut-off was derived from our previous work investigating the diagnostic usefulness of FSBP in HAVS. This study included 22 male control subjects and 24 individuals with hand-arm vibration syndrome (stage 2/3V). [2]. The second cut-off has been published by other investigators using FSBP in HAVS [10].

2.2 RESULTS

A total of 25 subjects were studied, 10 individuals diagnosed with Primary Raynauds (PR) and 15 control volunteers. There were 9 females in both groups. All individuals with PR were asked which fingers were affected and to what extent. One volunteer who had been diagnosed with PR could not report which fingers were affected as they said that it was mainly their toes that were affected. For the rest of the group 7 reported that two fingers were affected and 2 reported that 3 fingers were affected on the right hand (the test hand). The extent of blanching for the tested finger was noted, with 4 just having the tip of the finger affected, 3 having the tip and middle phalanx affected and 2 having the whole finger affected (Griffin scores of 1,3 and 6 respectively).

The mean (SD) age of the control group was 33.1 (8.4) years and 41.0 (12.5) years in the PR group, but these differences were not statistically significant (p=0.07).

During testing we experienced some technical problems (see section 4) that meant that some of the tests were not acceptable (n=9). Consequently, we were unable to do paired comparisons of the measurements in the supine and seated positions in all the subjects. Paired data for measurements at 15^{o}C were available in 15 controls and 8 individuals with PR, whereas at 10^{o}C these were available for 13 controls and 10 individuals with PR.

The mean (SD) recorded room temperatures at the end of the equilibration period were significantly elevated in the PR group compared to the control group (p=0.014), but there were no differences related to posture (Table 2.1). It is unlikely that these small differences (around 0.5°C) in room temperature will affect the comparison of the two groups. Primary Raynauds cases had lower skin temperature compared to controls in both postures, but there were no significant differences in skin temperature following equilibration related to the group or posture (Table 2.1).

Table 2.1 Mean (SD) room and skin temperatures following equilibration period related to group and posture at testing

		Room temperature (°C)	Skin temperature (°C)
Controls	Seated	23.9 (0.4)	31.4 (3.0)
	Supine	23.9 (0.7)	31.3 (3.5)
PR	Seated	24.4 (0.6)	29.7 (4.9)
	Supine	24.4 (0.7)	30.1 (4.0)

Two-way ANOVA used to test for significant differences between mean room/skin temperatures and effect of group (control or PR) and posture. Only significant effect was for group on room temperature (p=0.014).

2.2.1 Effect of posture on measurements of FSBP

The mean (SD) for the paired FSBP measurements in both postures and groups are shown in Table 2.2. In general, for the control group the measurement of FSBP recorded in the seated position was slightly higher than that measured in the supine position, but not statistically significantly so. Interestingly, the variability of the measurements, as reflected by the standard deviation, was greater in the supine position for the control group (Table 2.2). There was very little change in the FSBP measurements with change in posture in the PR group (Table 2.2).

Table 2.2 Mean (SD) FSBP measurements in the two postures for both groups

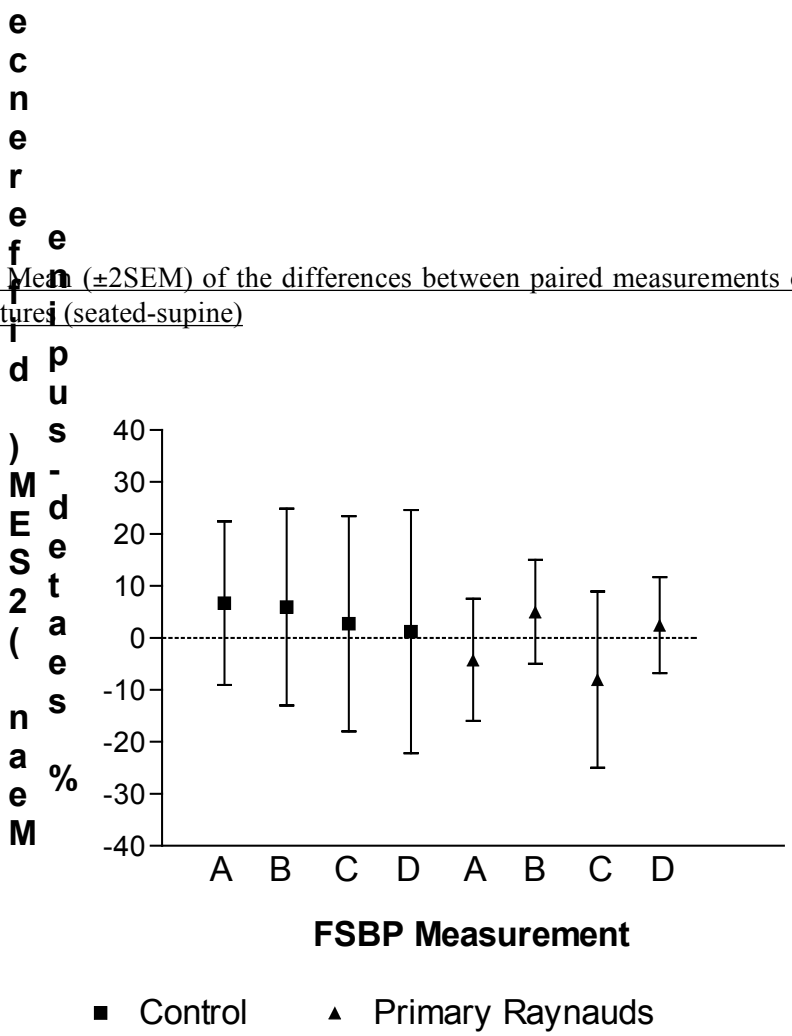
	Seated				**Supine**			
	A	B	C	D	A	B	C	D
Control	85.8 (19.2)	90.0 (19.9)	82.0 (17.0)	84.5 (19.3)	79.1 (39.9)	84.0 (28.5)	79.3 (38.7)	83.3 (31.5)
p-value					0.411	0.540	0.795	0.918
PR	47.8 (45.2)	62.9 (45.2)	48.8 (44.4)	66.8 (47.9)	52.0 (40.9)	57.9 (42.4)	56.8 (48.5)	64.3 (46.9)
p-value					0.503	0.343	0.379	0.603

Measurement A is FSBP measured at 15^{o}C using the arm as a reference, B relates to measurements at 10^{o}C using the arm as a reference, C relates to measurements at 15^{o}C using the thumb as a reference and D relates to measurements at 10^{o}C using the thumb as a reference.

Table shows mean (SD) measurements for FSBP parameters in the seated and supine positions, for both groups. The p-values are for paired comparison of the means in the two positions.

The mean (±2SEM) differences (seated-supine) for each paired observation is shown in Figure 2.1. Whilst many of the mean differences were positive (i.e. seated position gave slightly higher values than the supine position), these differences were not statistically significant from zero and thus there did not appear to be a significant effect of posture on the measurement.

Figure 2.1 Mean (±2SEM) of the differences between paired measurements of FSBP made in the two postures (seated-supine)



Measurement A is FSBP measured at 15°C using the arm as a reference, B relates to measurements at 10°C using the arm as a reference, C relates to measurements at 15°C using the thumb as a reference and D relates to measurements at 10°C using the thumb as a reference.

The large variability in measurements in the control group was partly a consequence of the fact that two controls exhibited total closure of the digital arteries with blanching during localised cold-provocation in the supine position. However, even if these two individuals were excluded from the analysis, whilst it did have an effect upon the mean and SD values this did not have an effect on the overall finding that posture did not have a significant effect upon measurements of FSBP.

2.2.2 Comparison of FSBP measurements in control and PR groups

The mean FSBP measurements were lower in the PR group when compared to the controls (Table 2.3 and Figure 2.2). However, there was considerable overlap in the results from the two groups, such that there were few statistically significant differences between groups. The differences between groups were slightly greater in the seated position, as the variability of the control group increased in the supine position (Figure 2.2). As mentioned above this was mainly a consequence of individuals within the control group having complete responses with an FSBP of zero. When these two individuals were excluded from the analysis the mean values in the supine position were higher in the control group and the SD was lower, leading to statistically significant differences between the groups (Table 2.4).

Table 2.3 Mean (SD) FSBP measurements in the two groups for both postures

	Seated				**Supine**			
	A	B	C	D	A	B	C	D
Control	85.8 (19.2)	90.0 (19.9)	82.0 (17.0)	83.6 (18.8)	79.1 (39.9)	78.0 (35.4)	79.3 (38.7)	77.3 (37.6)
PR	53.6 (45.7)	62.9 (45.2)	53.6 (43.9)	66.8 (47.9)	54.1 (38.8)	57.9 (42.4)	59.4 (46.0)	64.3 (46.9)
p-value	0.024	0.066	0.033	0.243	0.147	0.219	0.268	0.459

Measurement A is FSBP measured at 15^{o}C using the arm as a reference, B relates to measurements at 10^{o}C using the arm as a reference, C relates to measurements at 15^{o}C using the thumb as a reference and D relates to measurements at 10^{o}C using the thumb as a reference.

P-values relate to those for independent samples t-test (unadjusted for multiple comparisons) comparing the control and PR groups.

Table 2.4 Mean (SD) FSBP measurements in the two groups for both postures (excluding two controls)

	Seated				**Supine**			
	A	B	C	D	A	B	C	D
Control	88.1 (18.0)	88.6 (20.1)	82.3 (16.7)	81.7 (18.1)	91.3 (26.6)	91.0 (13.8)	91.5 (23.3)	90.2 (20.0)
PR	53.6 (45.7)	62.9 (45.2)	53.6 (43.9)	66.8 (47.9)	54.1 (38.8)	57.9 (42.4)	59.4 (46.0)	64.3 (46.9)
p-value	0.022	0.092	0.043	0.312	0.013	0.019	0.043	0.098

Measurement A is FSBP measured at 15^{o}C using the arm as a reference, B relates to measurements at 10^{o}C using the arm as a reference, C relates to measurements at 15^{o}C using the thumb as a reference and D relates to measurements at 10^{o}C using the thumb as a reference.

P-values relate to those for independent samples t-test (unadjusted for multiple comparisons) comparing the control and PR groups.

Figure 2.2 Comparison of the Mean (±2SEM) for each FSBP measurement in the two groups for each position

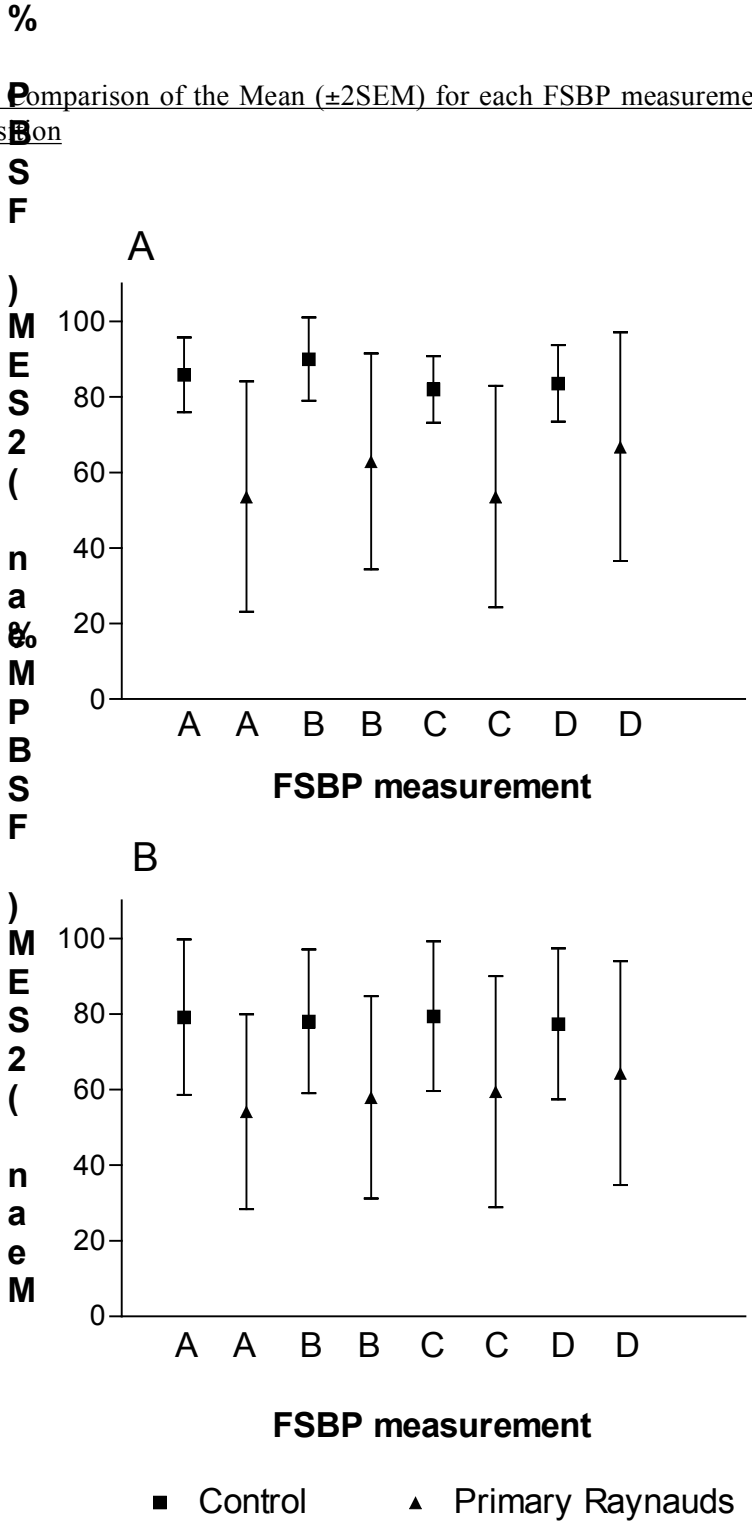


Figure A relates to measurements in the seated position and figure B to measurements in the supine position.

FSBP measurement A is FSBP measured at 15°C using the arm as a reference, B relates to measurements at 10°C using the arm as a reference, C relates to measurements at 15°C using the thumb as a reference and D relates to measurements at 10°C using the thumb as a reference.

Cut-offs for abnormality (controls versus hand-arm vibration syndrome) were applied to all of the data to establish how useful the FSBP measurements in this study were in discriminating between controls and PR (Table 2.5). The cut-offs used were obtained from our own data [2] and from Bovenzi [10] (for 10°C provocation only). Overall, the diagnostic usefulness of these measurements was poor in either position. Exclusion of the two controls who had complete responses did not improve the diagnostic accuracy of the technique, for example the sensitivity and specificity in the seated and supine positions for FSBPD% (HSL cut-off) were 40%, 69%, 50% and 75% respectively (compared to 40%, 71%, 50% and 64% with all controls included). The data expressed as likelihood ratios suggest that the FSBP test would have little use in helping a physician in either ruling-in or ruling-out a diagnosis of RP.

Table 2.5 Sensitivity, specificity, positive and negative predictive values and likelihood ratios for FSBP measurements in the two postures

	Seated						**Supine**					
	Sens	Spec	PPV	NPV	+LR	-LR	Sens	Spec	PPV	NPV	+LR	-LR
FSBPA (HSL cutoff ≤ 79.5)	56	73	56	73	2.1	0.6	67	67	55	77	2.0	0.5
FSBPB (HSL cutoff ≤ 74.0)	50	77	63	67	2.2	0.6	60	86	75	75	4.3	0.5
FSBPB (Bovenzi cutoff < 50)	30	92	75	63	3.8	0.8	30	86	60	63	2.1	0.8
FSBPC (HSL cutoff ≤ 62.4)	44	80	57	71	2.2	0.7	44	73	50	69	1.6	0.8
FSBPD (HSL cutoff ≤ 79.5)	40	71	50	63	1.4	0.8	50	64	50	64	1.4	0.8
FSBPD (Bovenzi cutoff < 60)	30	86	60	63	2.1	0.8	30	86	60	63	2.1	0.8

Table presents data for sensitivity (Sens), specificity (Spec), positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio (+LR) and negative likelihood ratio (-LR) for each of the FSBP parameters in the two positions. HSL cut-offs obtained from [2] and Bovenzi cut-offs obtained from [10] (only available for 10°C provocation).

2.2.3 Relationship between extent of blanching and FSBP

To investigate the relationship between the extent of blanching and measurement of FSBP all the data collected in both positions was used. There was a statistically significant correlation

between all measurements of FSBP and the extent of blanching (Griffin score) on the finger that was tested (Table 2.6). However, the correlation coefficients suggest that FSBP explains relatively little of the variation in Griffin score.

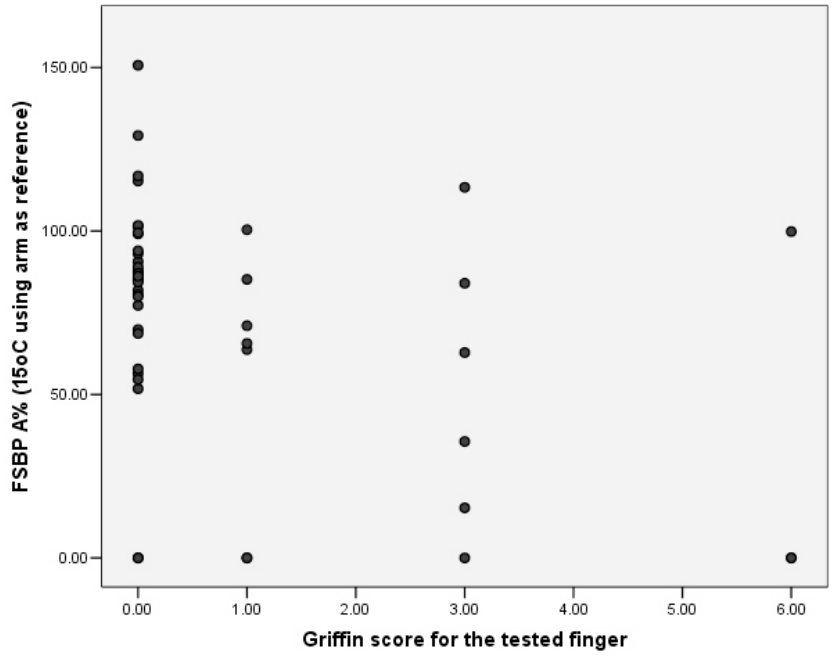
The range of FSBP results obtained for a given Griffin score was large. A typical example is shown in Figure 2.3, where the range of values obtained with a Griffin score of 3, was between 0 and around 120%. The data suggests that FSBP measurements cannot be used as an indicator of the extent of blanching.

Table 2.6 Correlation between measurements of FSBP and the griffin score for the tested finger for all data

	Pearson Correlation coefficient	P value	N
FSBP A%	-0.398	0.005	48
FSBP B%	-0.350	0.016	47
FSBP C%	-0.408	0.004	48
FSBP D%	-0.339	0.019	48

Table gives results of correlation analysis of FSBP and Griffin score, using the seated and supine data together. P-value is for the correlation and N is the number of observations.

Figure 2.3 Relationship between FSBPA% and the griffin score in all data collected



2.2.4 Effect of heart rate variability on measurements of FSBP

2.2.4.1 Effect of posture and group

The mean (SD) HF/LF (high frequency/low frequency) ratio for the paired data for the controls in the seated position was 0.56 (0.40) and in the supine position was 0.71 (0.37). This difference was not statistically significant (p=0.176). For the PR group the mean (SD) in the seated position was 0.92 (0.85) and 0.99 (1.32) in the supine position (p=0.80). Overall, there did not appear to be any statistically significant effect of posture on the HRV measurements.

When the mean HRV was compared in the control and PR groups for the seated and supine positions there was no statistically significant difference between the groups (p=0.71 and 0.48 respectively).

2.2.4.2 Relationship between HRV and FSBP

When all the data from both positions was used there was some relationship between the results of the measurements of FSBP and the ratio of high to low frequency heart rate variability (Table 2.7). The higher the HRV ratio (i.e. the more high frequency activity), the lower the FSBP measurement.

Table 2.7 Correlation between results of the FSBP test and HF/LF ratio measure of heart rate variability

	Pearson correlation	p-value
FSBP A%	-0.428	0.005
FSBP B%	-0.375	0.019
FSBP C%	-0.433	0.005
FSBP D%	-0.354	0.025

Table presents the results of correlation analysis of FSBP and HF/LF ratio, using all data in seated and supine positions together.

Main findings – Effect of posture on measurements of FSBP

- Measurements of FSBP are variable, particularly in the supine position (control group). This was mainly as a result of two controls having positive responses to the test (i.e. complete digital arterial closure during cold provocation to the finger) while in the supine position.
- There was no statistically significant effect of posture on measurements of FSBP.
- When the mean values for the control and Primary Raynauds groups were compared there were some significant differences, with the PR group having lower values. However, there was considerable overlap in the measurements in the two groups.
- Differences between groups appeared to be greater in the seated position. However, both postures gave similar results if the two controls with positive responses in the supine position were excluded.
- Diagnostic value of FSBP measurements in either posture was poor.

3 EFFECT OF ENVIRONMENTAL TEMPERATURE ON MEASUREMENTS OF FINGER SYSTOLIC BLOOD PRESSURE

3.1 METHODS

3.1.1 Study design

Finger systolic blood pressure measurements were performed in normal healthy controls and individuals with Primary Raynauds (PR) in a temperature controlled room. Individuals were asked to attend the laboratory on three separate days where FSBP measurements would be performed at three different temperatures (around 16°C, 22°C and 27°C). These measurements were performed in a random order at a similar time of day.

As phase one of this work showed that posture did not significantly affect the results of this test, all tests were performed in the seated position for the investigation of the effect of environmental temperature.

3.1.2 Subjects

We aimed to recruit ten normal healthy volunteers and ten individuals who had PR. All individuals were recruited from HSL staff using a calling notice. Those individuals who volunteered were then screened by one of the physicians to establish if (i) they were fit to take part in the study and (ii) whether they would be in the control or PR group. Individuals with a history of heart problems, hypertension, were taking medication which could interfere with the test, or had been exposed to hand-arm vibration occupationally were excluded from the study.

When individuals first attended the laboratory the study was explained to them and informed consent obtained. This study was approved by the HSE research ethics committee (ETHCOM/REG/05/05).

3.1.3 Procedure

Following arrival in the temperature controlled laboratory the individual was asked to rest for 30 minutes in the seated position. Skin temperature (index finger of the right hand) and room temperature were recorded at the end of this equilibration period.

Finger systolic blood pressure measurements were then performed at three cuff perfusion temperatures (30^{o}C, 15^{o}C and 10^{o}C). The right hand was tested for each of these measurements and the reference measurement (air) was always taken on the thumb. Finger systolic blood pressure measurements were obtained on two test fingers, which were the right index and middle fingers in the control group, and the two worst affected fingers in the PR group.

3.1.3.1 Measurement of Finger Systolic Blood Pressure

The procedure as described in section 2.1.3.1 was followed.

3.1.4 Analysis of Finger Systolic Blood Pressure measurements

Analysis of FSBP measurements was carried out as described in section 2.1.4.

3.1.5 Statistical analysis

All statistical analysis was performed using SPSS software (Statistical Package for Social Sciences v14.0). All comparisons of mean FBSP measurements from independent samples were analysed using either one-way analysis of variance, or unpaired t-tests (unadjusted for multiple comparisons). The effect of environmental temperature on measurements of FSBP within individuals was assessed using paired t-tests (unadjusted for multiple comparisons).

Relationship between measurements of FSBP on the two tested fingers was examined using correlation analysis and reporting the Pearson correlation coefficient and p-value.

3.2 RESULTS

Ten normal healthy control volunteers and 10 individuals diagnosed with Primary Raynauds phenomenon (PR) were included in this study. Thirteen of these volunteers had previously taken part in stage one (the effect of posture). The mean (SD) age for the control and PR groups was 39.4 (11.3) and 42.0 (8.4) respectively, and was not statistically different (p=0.609). There were 5 males in the control group and 2 males in the PR group.

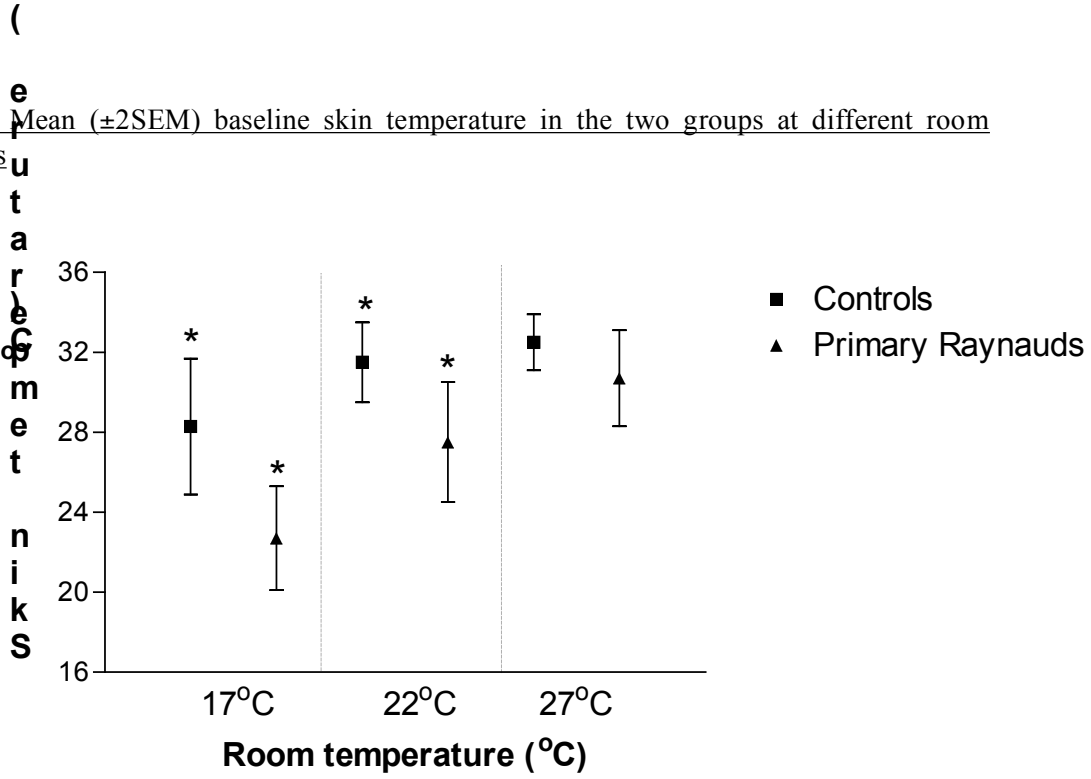
Complete data for measurements of FSBP was not available for all subjects due to a number of reasons including volunteer availability, or technical failure and loss of data. Two tests (controls) were missing at 17°C, 4 tests were missing at 22°C (3 controls) and 2 tests were missing at 27°C (1 control).

In the control group the fingers tested for FSBP were the right index and middle fingers in all cases. In the PR group the two worst affected fingers were tested; these were right middle finger (n=9), the right ring finger (n=6) and the right index finger (n=3).

3.2.1 Room and baseline skin temperature measurements

Following the 30-minute equilibration period the room and skin temperature was recorded. The mean (SD) room temperature for the 16, 22 and 26°C were 16.9 (1.3), 21.5 (1.3) and 26.8 (1.7) respectively in the control group. In the PR group they were 17.1 (0.5), 21.7 (1.8) and 26.5 (2.1) respectively. There were no statistically significant differences between the groups and the mean room temperatures. For the two groups combined the mean (SD) temperatures were 17.0 (0.9)°C, 21.6 (1.5)°C and 26.7 (1.8)°C. These exposure conditions are subsequently referred to as 17, 22 and 27°C. The mean skin temperature at the end of the equilibration period (Figure 3.1) was lower in the PR group when compared to the controls. This difference was particularly noticeable at the coolest room temperature (17°C). The mean skin temperature in the PR group was significantly lower than controls at 17°C (p=0.016), at 22°C (p=0.042), but not at 27°C (p=0.210).

Figure 3.1 Mean (±2SEM) baseline skin temperature in the two groups at different room temperatures



Each data point represents the mean (±2SEM). * denotes that the means in the control and PR group are significantly different from each other ($p<0.05$).

3.2.2 Relationship between measurements of FSBP on two fingers tested

The measurements on the two fingers tested were highly correlated with each other in both the control and PR groups (Table 3.1).

Table 3.1 Pearson correlation coefficients for correlation between the FSBP results obtained on the two fingers tested

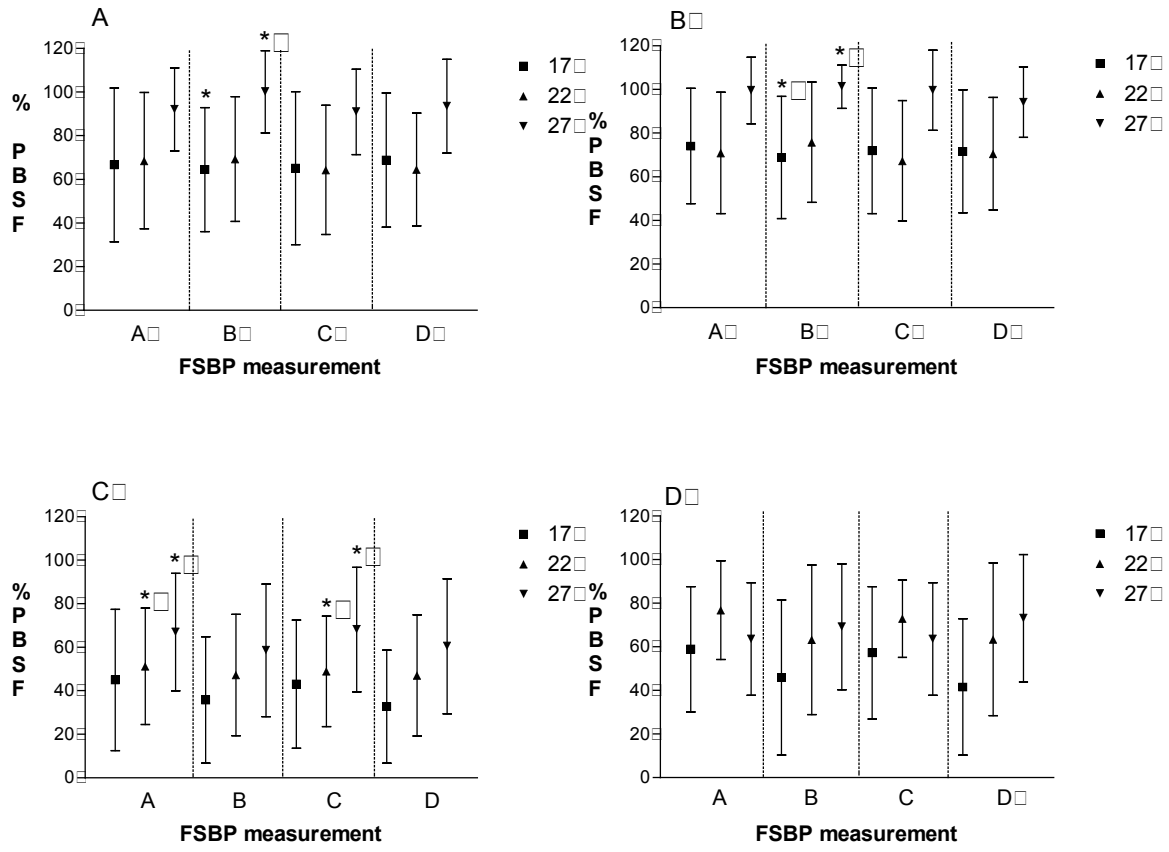
	Control	Primary Raynauds
FSBPA%	0.884	0.823
FSBPB%	0.844	0.884
FSBPC%	0.911	0.837
FSBPD%	0.843	0.841

All correlation coefficients above were statistically significant at $p<0.001$ level.

3.2.3 Effect of environmental temperature on FSBP measurements in controls and those with Primary Raynauds

The mean FSBP measurements were compared across the three different exposure temperatures (17, 22 and 27°C) within the control and PR groups. In the control group the FSBP measurements taken at 27°C were generally higher than those taken in the lower room temperatures (Figure 3.2). There was also a suggestion in the PR group that FSBP% increased with increasing room temperature. When the means were compared using paired t-tests few statistically significant differences were found (Appendix one). In the control group the mean FSBPB% (measured at 10°C using arm blood pressure as reference) measured at a room temperature of 27°C was significantly greater than that measured at a room temperature of 17°C for both fingers tested (p=0.012 and p=0.046 for fingers 1 and 2 respectively). In the PR group the only significant differences were between measurements of FSBPA% and FSBPC% measured at room temperatures of 22 and 27°C, for finger 1 (p=0.017 and 0.006 respectively).

Figure 3.2 Effect of room temperature on measurements of Finger Systolic Blood Pressure



Each data point is the mean (±2SEM). Panels A and B relate to measurements on the control group, tested fingers 1 and 2 respectively. Panels C and D relate to measurements on the Primary Raynauds group, tested fingers 1 and 2 respectively. The x-axis relates to the type of FSBP measurement. * relates to statistically significant ($p<0.05$) paired comparisons, unadjusted for multiple comparisons.

Increasing the room temperature to 27°C had the effect of reducing the between subject variability of the FSBP measurements in the control group. This was partly because, even in the control group, we found that some individuals had total closure of the digital arteries following local cold-provocation (i.e. FSBP of zero).

Two control individuals (one of which also had a total response in stage one) had FSBP measurements of zero in a room temperature of 17°C and 1 had this at 22°C. However, none of the controls experienced this with a room temperature of 27°C. In comparison 4 individuals in the RP group experienced a total response at 17°C, compared to 3 at room temperatures of 22 and 27°C.

Reanalysis of the above data following exclusion of the two controls with complete digital arterial closure did not significantly change the results.

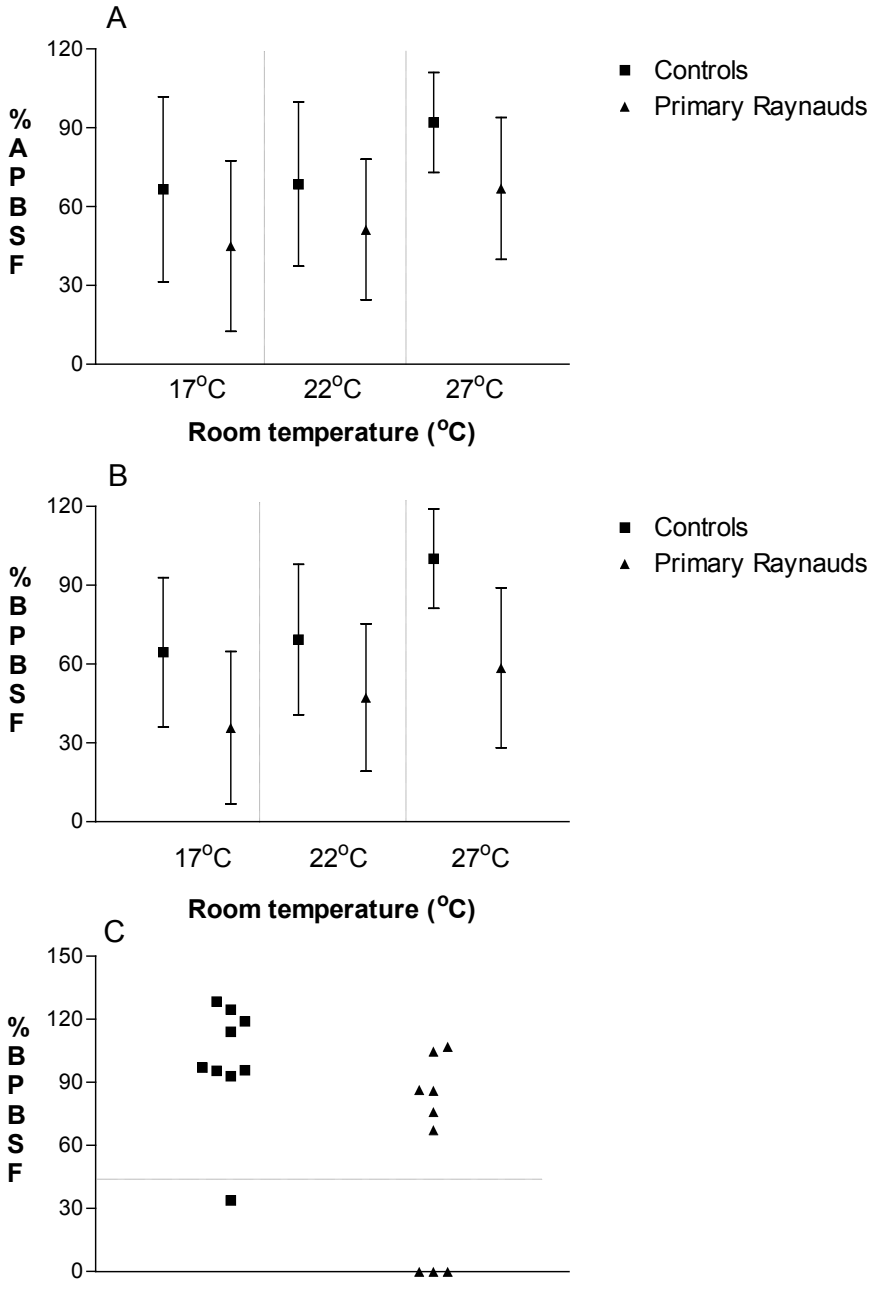
3.2.4 Comparison of control and PR groups

The mean FSBP% was compared between the control and PR groups at each room temperature using unpaired t-tests. The mean (SEM) values and statistical analysis for each FSBP parameter are given in Appendix two. In general, there appeared to be larger differences between the groups at the highest room temperature (27°C) (Figure 3.3). The only statistically significant differences between groups were found at a room temperature of 27°C. Those measurements where the controls had a significantly higher measurement than the PR group were FSBPA% on finger 2 ($p=0.028$), FSBPB% on finger 1 ($p=0.034$) and FSBPC% on finger 2 ($p=0.037$). However, even though there were some significant differences there was significant overlap between the measurements in the two groups. An example of this is shown in figure 3.3 Panel C for measurement of FSBPB% on finger 1 at a room temperature of 27°C. Only 3 out of 9 measurements in the PR group would be identified as abnormal when compared to the lower limit of normal (mean – 2SD for the control group).

The above analysis was repeated following exclusion of the two individuals in the control group who had total closure of the digital arteries following cold-provocation. This time there were more differences in mean levels between the groups (see Appendix 3), in particular at the lower room temperature (Figure 3.4). There were no statistically significant differences between the groups at a room temperature of 22°C. The most significant difference between the groups was found at a room temperature of 17°C and a cold-provocation of 10°C on the first tested finger, using the thumb as a reference (FSBPD%) ($p=0.003$).

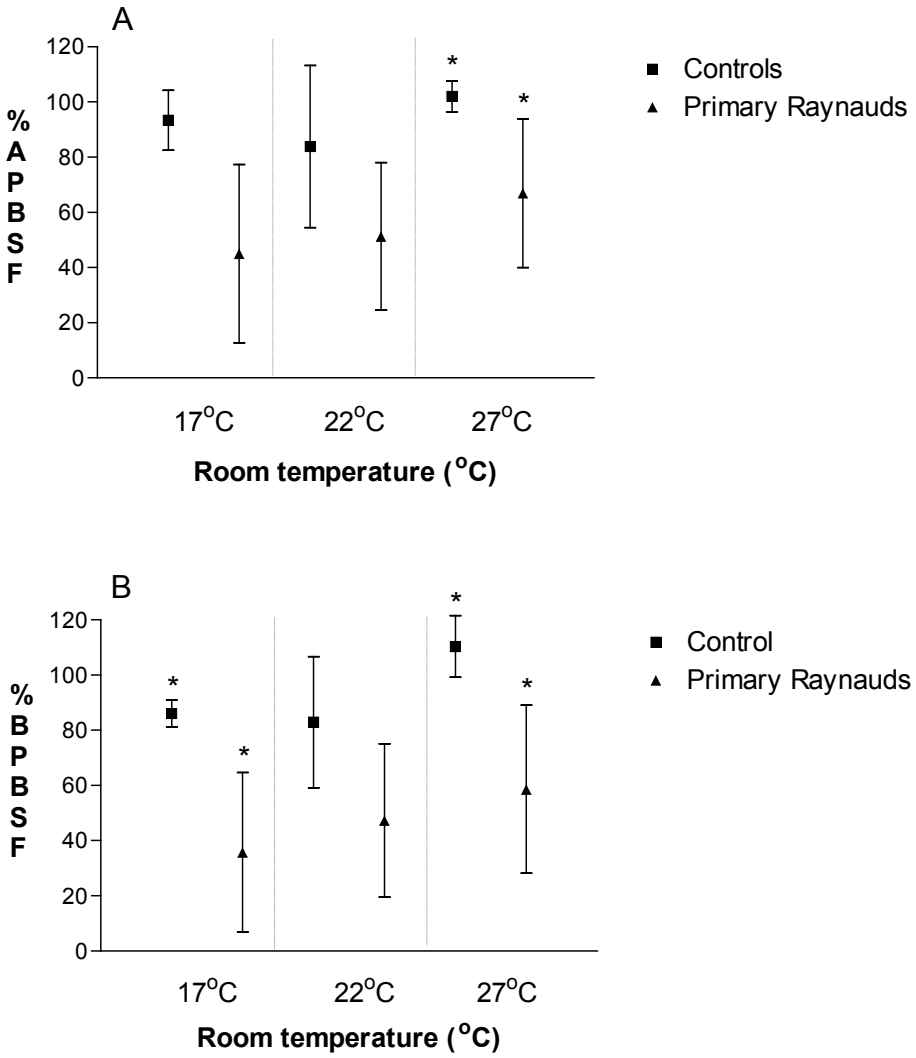
Following exclusion of the two controls with total responses the diagnostic ability of this technique was assessed using the measurement of FSBPD% (10°C provocation using thumb as a reference), which showed the greatest difference between groups. The cut-offs for abnormality at each different room temperature were calculated as the mean –2SD of the control group (68.7% at 17°C, 34.9% at 22°C and 53.3% at 27°C). The resulting sensitivities at the three room temperatures were 75%, 33% and 33% respectively. The specificity was 100% at each room temperature.

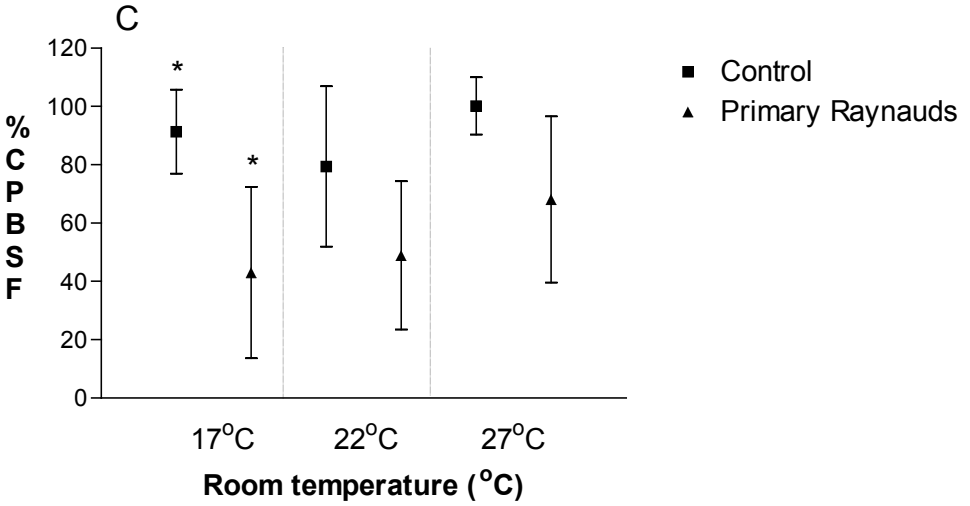
Figure 3.3 Comparison of mean (±2SEM) of FSBP measures for the control and Primary Raynauds groups

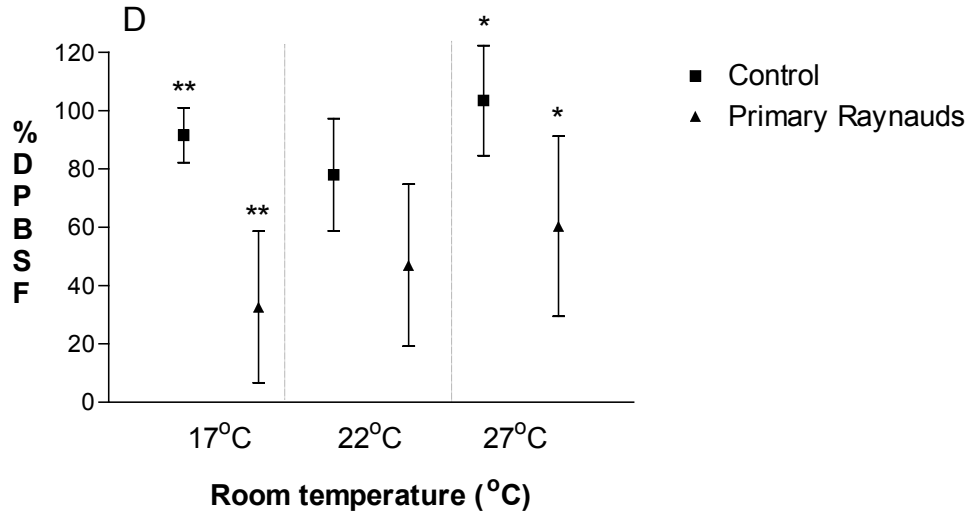


Panel A is for measurements of FSBPA% (15°C using arm as reference), panel B is measurements of FSBPB% (10°C using arm as reference). These panels show the mean (±2SEM) of the groups. Panel C shows each data point for FSBPB% (10°C using arm as reference) at a room temperature of 27°C, for both groups. The dashed line represents the lower limit of normal (mean – 2SD for control group). All measurements are for tested finger 1.

Figure 3.4 Mean (±2SEM) for the two groups in the three room temperatures







Panel A is for measurements of FSBPA% (15°C using arm as reference), panel B is measurements of FSBPB% (10°C using arm as reference), panel C is measurements of FSBPC% (15°C using thumb as reference) and panel D is measurements for FSBPD% (10°C using thumb as reference). All measurements are for the first tested finger.

* denotes significant difference between groups at 5% level. ** denotes significant difference between groups at the 1% level.

Main findings – effect of environmental temperature on measurements of FSBP

- Measurements of FSBP taken in a room temperature of 27°C were generally higher than those undertaken at the lower environmental temperatures (22 and 17°C), but there were few statistically significant differences.

- When all the measurements in the defined control and PR groups were compared the only significant differences between the means occurred in the room temperature of 27°C.

- There were two individuals in the control group who did not report symptoms of PR, but responded in an abnormal way to the FSBP test, and experienced blanching. If these individuals were excluded from the analysis then discrimination between the two groups was highly dependent upon the room temperature. The best discrimination was with a local provocation of 10°C in a room temperature of 17°C, which gave good diagnostic power in the limited size study.

4 TECHNICAL ISSUES WITH FSBP TESTING

When stage one of this work was performed it was noted that we had various technical problems performing the measurements of FSBP, which may limit the usefulness of this technique. When we conducted stage two of this work we systematically logged all of the problems that we had in obtaining good quality FSBP measurements. The technical problems that we experienced with the FSBP equipment are tabulated below (Table 4.1).

Table 4.1 Technical issues experienced with the FSBP equipment

Technical issue	Number of occasions this was a problem	Outcome
Software Issues		
Tests completed but software did not save the results	16	16 test results lost
Computer crashed during testing	1	Tests repeated on another occasion
Hardware Issues		
Leaking cuffs	>20 occasions	Repeated testing
Water flow blockage	2	Repeated testing
Equipment failure at higher room temperature	1	Repeated testing
Data unacceptable on analysis	2	Repeated testing

Overall, the problems that occurred most frequently were the cuffs leaking and data being lost following completion of the testing.

5 DISCUSSION AND CONCLUSION

This study has aimed to investigate the influence of posture and environmental temperature on the diagnostic power of the measurement of Finger Systolic Blood Pressure (FSBP). The rationale for this study was to explore whether posture or environmental temperature may underlie divergent opinions about the value of FSBP between ourselves and a small body of published data. This was a small study, but significant overlap between measurements in our control and abnormal groups (Primary Raynauds) has suggested that FSBP may be limited in its diagnostic ability.

We have previously published work investigating the usefulness of FSBP testing in discriminating between control individuals and those with significant vascular abnormality as a consequence of vibration exposure (stage 2/3 vascular HAVS) [2]. The findings of this work were that FSBP measurements were poor in discriminating between these groups, was not any better than the standard cold-provocation test, and that it was not a very useful diagnostic tool in vascular HAVS. However, this was contrary to other reports published in the literature [6-11] that reported that FSBP had good diagnostic power. For example, Bovenzi published that FSBP measured at 10°C (using the thumb as a reference) had a sensitivity of 87%, specificity of 94%, positive predictive value of 75% and negative predictive value of 97% [10]. The corresponding values from our previous work were sensitivity of 47.6%, specificity of 95.2% and positive and negative predictive values of 87.0% and 73.2% respectively [2]. The results from our previous work would suggest that the sensitivity and negative predictive values are lower when we test individuals using our methodology. This led us to question whether there were any fundamental ways in which we were conducting the tests differently.

One fundamental difference was that we did all of our measurements in the seated position, whereas Bovenzi's group, and others [11, 16], have conducted theirs in the supine position. Whilst there does not appear to be any reported influence of posture on FSBP measurements it is possible that changes in posture may lead to changes in the balance between the sympathetic and parasympathetic nervous systems, which may have an influence on the control of the vasculature to cold conditions. It has been shown that increased responses to cold-provocation in individuals with HAVS are related to sympathetic nervous activity [12]. Therefore, the first part of this study was designed to investigate the influence of posture on these measurements, to see if this may explain the differences in reported diagnostic power.

The results of the first part of this study demonstrate that the posture the measurements are performed in does not have a significant effect either within individuals, or in discriminating between the groups. The main influence of posture appeared to be on the variability of measurements in the control group, with the seated position yielding the lower variability. There was no significant effect of posture on the measurements of heart rate variability (HRV) either, although there was some correlation between HRV and FSBP. These results suggest that changes in the balance of the sympathetic/parasympathetic (and changes in HRV), are related to changes in FSBP, but that the posture itself does not significantly change the HRV.

This was an appropriate small study to address it aims. It was not designed, or possible, to obtain accurately defined cut-offs for abnormality from these data. Therefore, to look at the diagnostic ability of the test we applied cut-offs that we had previously derived from a study comparing controls and those with stage 2/3V HAVS [2], and also those published by Bovenzi [10]. Regardless of which cut-off was used, or which FSBP parameter was used, the diagnostic ability of FSBP was poor with the greatest sensitivity being 67%, with a specificity of 67%, PPV of 55% and NPV of 77% (FSBPA%, supine). Under the conditions that Bovenzi's group conducted their measurements, we found a sensitivity of 30%, a specificity of 86%, positive

predictive value of 60% and a negative predictive value of 63% (compared to 87%, 94%, 75% and 97% from Bovenzi). Therefore, regardless of which FSBP parameter we use, or the posture the measurements are performed in, we could not obtain measurements that appeared as diagnostically useful as those previously reported [10]. This corresponds to the work of Virokannas (1991) who found that, in general, the FSBP test gave a low sensitivity but a higher specificity (38% and 97% respectively with a cut-off of 60%) [16]. They suggested that the FSBP test was useful for the HAVS, but the sensitivity was too low for screening.

The second part of this study investigated whether room temperature had an effect upon the ability of FSBP to discriminate between controls and those with Primary Raynauds. It has previously been shown by other investigators that body cooling may increase the sensitivity of this technique for detecting abnormality [13, 17], but the need for this has been questioned recently [5]. These measurements were conducted in the seated position because the previous work had demonstrated that the variability of measurements in the control group was lower in the seated position, and that there was no significant effect of posture. When measurements at the three room temperatures were compared within individuals there was a tendency for the mean value to be higher than the others at a temperature of 27°C, however there were few statistically significant differences. When the mean levels were compared for the two groups the largest differences between the groups were found at a room temperature of 27°C. This appeared to be mainly a consequence of an increase in the mean level and reduction in variability in the control group at the highest room temperature. Interestingly, this was in part a consequence of the fact that in our control group we had 2 individuals who exhibited complete closure of the digital arteries (FSBP of 0) in a room temperature of 17°C, whereas this didn't occur at the highest room temperature. Even at a room temperature of 22°C one of our controls exhibited complete closure. Two studies that have been published on FSBP measurements in normal healthy controls [18, 19] have not reported complete closure in response to cold-provocation, but often the characteristics of the control group are not clearly defined. One publication did show that around two controls out of 341 experienced a total response [20].

In the whole study (phases one and two) a total of 3 control subjects had a total response under one or more of the experimental conditions. One of these control subjects experienced a total response with blanching in several experimental conditions (lying down, room temperatures of 17 and 22°C). These findings either represent false-positive responses and a weakness of the test, or it may suggest that these individuals (particularly the one control who responded on several occasions) may have pre-symptomatic PR. These individuals did not report any problems with their hands, and had not been exposed to hand-arm vibration, consequently they were allocated to our control group. This raises issues about case definition for PR and, in particular, whether individuals who do not report symptoms but have an abnormal positive result, should be excluded from control groups and seen as a separate pre-symptomatic group. If we excluded such individuals from our study this affected the diagnostic power of FSBP testing, particularly at the lower room temperature (17°C). The diagnostic ability of FSBP was good in the cooler environment.

In this study we used a group of individuals with Primary Raynauds as our abnormal group rather than a group with vascular HAVS. It has previously been shown that the sensitivity of FSBP testing is greater in PR (95%) when compared to individuals with vascular HAVS (84%) [8]. It would not have been feasible for us to use a HAVS population for this study. In the majority of the PR group in this study the FSBP measurements obtained did not reach the criteria for abnormality as reported in the literature [10], or as reported by ourselves in HAVS [2]. However, all of these individuals were diagnosed by a physician as having Primary Raynauds and all except 1 reported blanching on the tested finger (4 tip only, 3 tip and middle phalanx and 2 whole finger affected). Therefore, we do not feel that the results of the present study would have been any different had we used a HAVS population as our abnormal group.

Indeed, the sensitivity of the 10°C provocation (using arm as reference) for discriminating between controls and PR in the current study was 50% and 52.4% in the previous study, which included HAVS cases [2].

During this study we also experienced a great many technical problems with the FSBP equipment that made it difficult to obtain good quality data reliably. These ranged from issues with software and retrieval of data, to problems with cuffs leaking. If this test were to be used in the future for diagnostic testing these issues would need to be resolved, so that tests could be obtained reliably.

In conclusion, measurement of FSBP under cold-provocation at a room temperature of 22°C does not appear to be a reliable diagnostic indicator of vascular abnormality. This diagnostic ability appears to be improved in cooler environmental temperatures. The blanching or arterial closure during FSBP manoeuvres in two subjects who had been identified by medical interview as controls rather than Primary Raynauds sufferers opens a number of issues about case definition and whether Primary Raynauds is a dichotomous state or represents a spectrum of arterio-vascular sensitivity.

6 APPENDICES

6.1 APPENDIX ONE

Results of statistical analysis of effect of room temperature on measurements of FSBP

	17°C to 22°C		17°C to 27°C		22°C to 27°C	
	Control	PR	Control	PR	Control	PR
FSBPA% - finger 1	0.112	0.361	0.199	0.448	0.320	0.017
FSBPA% - finger 2	0.204	0.221	0.113	0.951	0.243	0.465
FSBPB% - finger 1	0.281	0.244	0.012	0.287	0.139	0.770
FSBPB% - finger 2	0.298	0.252	0.046	0.346	0.220	0.842
FSBPC% - finger 1	0.253	0.288	0.141	0.340	0.233	0.006
FSBPC% - finger 2	0.890	0.154	0.148	0.833	0.198	0.771
FSBPD% - finger 1	0.655	0.215	0.082	0.180	0.232	0.926
FSBPD% - finger 2	0.650	0.234	0.194	0.213	0.444	0.859

Table presents p-values for all paired comparisons (unadjusted for multiple comparisons) of FSBP measurements at different room temperatures.

6.2 APPENDIX TWO

Mean (SEM) FSBP measurements in the two groups at different room temperatures

Room temperature 17°C

	Control	PR	p-value
FSBPA% - finger 1	66.7 (17.6)	45.0 (16.2)	0.382
FSBPA% - finger 2	74.1 (13.2)	58.9 (14.4)	0.454
FSBPB% - finger 1	64.5 (14.2)	35.8 (14.5)	0.178
FSBPB% - finger 2	68.8 (14.0)	45.9 (17.8)	0.325
FSBPC% - finger 1	65.2 (17.6)	43.0 (14.7)	0.345
FSBPC% - finger 2	71.9 (14.4)	57.3 (15.2)	0.496
FSBPD% - finger 1	68.8 (15.4)	32.8 (13.0)	0.096
FSBPD% - finger 2	71.7 (14.1)	41.6 (15.6)	0.174

Room temperature 22°C

	Control	PR	p-value
FSBPA% - finger 1	68.6 (15.6)	51.4 (13.4)	0.414
FSBPA% - finger 2	71.0 (13.9)	76.8 (11.3)	0.746
FSBPB% - finger 1	69.3 (14.3)	47.3 (14.0)	0.292
FSBPB% - finger 2	75.8 (13.8)	63.2 (17.2)	0.580
FSBPC% - finger 1	64.3 (14.8)	48.9 (12.7)	0.441
FSBPC% - finger 2	67.3 (13.8)	72.9 (8.9)	0.737
FSBPD% - finger 1	64.6 (12.9)	47.0 (13.9)	0.376
FSBPD% - finger 2	70.6 (13.0)	63.4 (17.5)	0.746

Room temperature 27°C

	Control	PR	p-value
FSBPA% - finger 1	92.1 (9.5)	66.9 (13.5)	0.147
FSBPA% - finger 2	99.5 (7.6)	63.5 (12.9)	0.028
FSBPB% - finger 1	100.2 (9.5)	58.6 (15.2)	0.034
FSBPB% - finger 2	101.3 (5.0)	69.3 (14.4)	0.052
FSBPC% - finger 1	90.9 (9.8)	68.2 (14.3)	0.210
FSBPC% - finger 2	99.7 (9.2)	63.6 (12.9)	0.037
FSBPD% - finger 1	93.5 (10.8)	60.4 (15.5)	0.098
FSBPD% - finger 2	94.2 (8.1)	73.1 (14.6)	0.223

Tables present data for mean (SEM) for each FSBP parameter in the two groups. P-values are from independent t-tests comparison of means, unadjusted for multiple comparisons.

6.3 APPENDIX THREE

Mean (SEM) FSBP measurements in the two groups at different room temperatures (excluding two controls who had FSBP of 0)

Room temperature 17°C

	Control	PR	p-value
FSBPA% - finger 1	93.4 (12.0)	45.0 (48.5)	0.052
FSBPA% - finger 2	91.9 (16.2)	58.9 (43.2)	0.100
FSBPB% - finger 1	86.0 (5.8)	35.8 (40.9)	0.012
FSBPB% - finger 2	86.9 (23.3)	45.9 (47.0)	0.079
FSBPC% - finger 1	91.3 (16.1)	43.0 (44.1)	0.038
FSBPC% - finger 2	93.1 (11.8)	57.3 (42.9)	0.073
FSBPD% - finger 1	91.7 (11.5)	32.8 (36.8)	0.003
FSBPD% - finger 2	90.7 (19.9)	41.6 (41.2)	0.022

Room temperature 22°C

	Control	PR	p-value
FSBPA% - finger 1	83.8 (32.8)	51.4 (37.8)	0.143
FSBPA% - finger 2	87.7 (19.5)	76.8 (31.8)	0.509
FSBPB% - finger 1	83.0 (26.7)	47.3 (39.6)	0.105
FSBPB% - finger 2	88.7 (18.0)	63.2 (45.4)	0.266
FSBPC% - finger 1	79.4 (30.8)	48.9 (35.9)	0.145
FSBPC% - finger 2	84.4 (20.6)	72.9 (25.2)	0.412
FSBPD% - finger 1	78.1 (21.6)	47.0 (39.3)	0.136
FSBPD% - finger 2	83.9 (17.1)	63.4 (46.3)	0.372

Room temperature 27°C

	Control	PR	p-value
FSBPA% - finger 1	102.0 (7.5)	66.9 (40.5)	0.042
FSBPA% - finger 2	102.7 (22.1)	63.5 (38.6)	0.031
FSBPB% - finger 1	110.3 (14.8)	58.6 (45.6)	0.013
FSBPB% - finger 2	102.9 (16.4)	69.3 (43.2)	0.073
FSBPC% - finger 1	100.2 (13.1)	68.2 (42.8)	0.078
FSBPC% - finger 2	102.7 (28.4)	63.6 (38.8)	0.042
FSBPD% - finger 1	103.5 (25.1)	60.4 (46.5)	0.045
FSBPD% - finger 2	97.2 (27.1)	73.1 (43.7)	0.225

Tables present data for mean (SEM) for each FSBP parameter in the two groups. P-values are from independent t-tests comparison of means, unadjusted for multiple comparisons. These data exclude two controls who had FSBP of 0.

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HSE

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The influence of posture and environmental temperature on the diagnostic ability of finger systolic blood pressure

Individuals with the vascular component of hand-arm vibration syndrome (HAVS) experience whiteness or blanching of the fingers in cold conditions, which is accompanied by numbness and then tingling or pain when the fingers warm-up. In the absence of a gold-standard diagnosis based upon pathology it is currently necessary to rely on self-reporting of key symptoms for the vascular component, which include the frequency and extent of blanching attacks. The accuracy and reproducibility of the diagnosis and staging depends upon an individual's recall of their current symptoms and when they first commenced. Consequently there is a need for a suitable diagnostic test to help confirm the diagnosis.

Measurement of Finger Systolic Blood Pressure (FSBP) with cold-provocation has been reported to be of diagnostic value in individuals with the vascular component of HAVS and those with Primary Raynauds phenomenon. The overall aim of this work was to investigate if factors such as posture and environmental temperature were important in influencing the ability of FSBP to discriminate between controls and those with Primary Raynauds.

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