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Cardiovascular responses to postural stress among young Black African students at University of Ibadan, Nigeria: Sex differences.

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Abstract

Introduction: Squatting, an active posture manoeuvre imposes potent postural stress. Blood pressure and heart rate changes, during change in posture, provide information on performance of the baroreflexes and haemodynamic homoeostasis. This study was aimed at determining the cardiovascular responses to squatting in young Black African men and women.
Method: Sixty five (M/F: 32/33) aged 16-30 years were recruited. Systolic and diastolic blood pressure (SBP, DBP) and heart rate (HR) were recorded in sitting, standing and squatting positions. Mean arterial blood pressure (MABP) and pulse pressure (PP) were calculated. Differences in SBP, DBP, MABP, PP and HR between squatting position and standing were calculated at onset (0s), 60s and 120s of squatting. Effect of squatting was determined using Student's T test and repeated measures ANOVA with Bonferroni post hoc tests. Statistical significance was determined at level of $p < 0.05$.
Result: Prompt squat increased SBP by 8.57 ± 1.71 mmHg, MAP by 3.57 ±1.03 mmHg, DBP by 1±1.09 mmHg, leading to augmentation of PP by 7.57 ± 1.07 mmHg, with a decrease in HR by 9.15 ±1.48 beats/min. Women showed greater increase in DBP and MAP compared with men during prompt squatting (3.84 ±1.72 vs 1.76 ±1.18 mmHg; 6.00±1.71 vs 1.12±1.46 mmHg, $p < 0.05$). Sustained squatting evoked greater increase in SBP, DBP and MABP in women than men.
Conclusion: Squatting evoked increase in blood pressure with augmentation of pulse pressure, however, women showed greater increase in blood pressure relative to men during squatting. The sex differences require further investigation.

Keywords: *Sex, squatting, Black African, blood pressure, heart rate.*

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Résumé

Contexe: S'accroupir, une manœuvre de posture active impose un stress postural puissant. Les variations de la pression artérielle et de la fréquence cardiaque, lors d'un changement de posture, renseignent sur les performances des baroréflexes et l'homéostasie hémodynamique. Cette étude visait à déterminer les réponses cardiovasculaires au squat chez de jeunes hommes et femmes noirs africains.
Méthode : Soixante cinq (H/F : 32/33) âgés de 16 à 30 ans ont été recrutés. La pression artérielle systolique et diastolique (PAS, PAD) et la fréquence cardiaque (FC) ont été enregistrées en position assise, debout et accroupie. La pression artérielle moyenne (MABP) et la pression pulsée (PP) ont été calculées. Les différences de SBP, DBP, MABP, PP et HR entre la position accroupie et debout ont été calculées au début (0s), 60s et 120s de squat. L'effet de l'accroupissement a été déterminé à l'aide du test T de Student et de l'ANOVA à mesures répétées avec les tests post hoc de Bonferroni. La signification statistique a été déterminée au niveau de $p < 0,05$.
Résultat : le squat rapide a augmenté la PAS de 8,57 ± 1,71 mmHg, la PAM de 3,57 ± 1,03 mmHg, la PAD de 1 ± 1,09 mmHg, entraînant une augmentation de la PP de 7,57 ± 1,07 mmHg, avec une diminution de la FC de 9,15 ± 1,48 battements/min. Les femmes ont montré une augmentation plus importante de la PAD et de la PAM par rapport aux hommes pendant l'accroupissement rapide (3,84 ± 1,72 vs 1,76 ± 1,18 mmHg ; 6,00 ± 1,71 vs 1,12 ± 1,46 mmHg, $p < 0,05$). L'accroupissement soutenu a provoqué une augmentation plus importante de la PAS, de la PAD et de la MABP chez les femmes que chez les hommes.
Conclusion : L'accroupissement a évoqué une augmentation de la pression artérielle avec augmentation de la pression pulsée, cependant, les femmes ont montré une augmentation plus importante de la pression artérielle par rapport aux hommes pendant l'accroupissement. Les différences entre les sexes nécessitent une enquête plus approfondie.

Mots-clés : *Sexe, accroupissement, Noir africain, tension artérielle, fréquence cardiaque.*

Introduction

Squatting, an active postural manoeuvre imposes potent postural stress. In many African cultures, squatting position is adopted during exchange of pleasantries, defaecation and micturition. Squatting is also used commonly as a punitive measure as sustained squat or repeatedly as used in the frog jump. Although, squatting is an effective physical manoeuvre in preventing vasovagal syncope [1,2] and micturition syncope [3], there is evidence of adverse consequence of squatting as incidents of stroke have been associated with squatting during defaecation in the morning [4].

Squatting increases preload by augmentation of venous return via skeletal muscle pump action and increase in cardiac output (CO) without changes in systemic vascular resistance [5-7]. This results in greater increase of systolic blood pressure (SBP) than diastolic blood pressure (DBP), and pulse pressure (PP) is augmented [8]. Blood pressure (BP) is controlled by hormonal, neural and local factors which interact to provide long term control, however, short term regulation of BP during postural changes is achieved by baroreceptor reflexes which act quickly to achieve homeostasis [9]. Squatting is accompanied by a rise in mean arterial blood pressure (MABP), PP and CO with bradycardia due to baroreflex mediated cardiac parasympathetic nerve activity. Conversely, assumption of standing posture following squatting is associated with an immediate drop in BP, due to venous pooling followed by reflex tachycardia associated with baroreflex activation of cardiac sympathetic nervous activity and vagal inhibition [5]. Prompt active postural manoeuvre such as squatting therefore induces an immediate arterial BP variation followed by a period of regulation. The squat test can be used to assess haemodynamic responses to orthostatic stress, as well as adaptation to orthostatic stress and autonomic function [10-12]. O'Donnell and Mc Ilroy [13] reported that healthy subjects showed an immediate increase in SBP, DBP and PP following squatting from the standing position. Further, Kim and others reported increased SBP and DBP in adults during squatting [2].

Individual variability in response to squatting has been reported. There is evidence that some subjects show no changes in heart rate whereas others show large reductions while some show increase in heart rate [14]. Further, Mengesha [15] showed that squatting increased mean MABP by 9 mmHg and decreased HR by 5 beats/min in normal White Europeans (WEs). Likewise, Hanson and others [16] reported an increase in MABP of 8.5 mmHg at onset of squatting, with a further rise as the period of squatting increased. However, individuals vary in responses as changes in BP over a wide range of 1-37% have been reported [17].

Mean arterial blood pressure varies over the period of squatting, with the greatest increase occurring during the first few seconds of squatting, and thereafter falling about 20s after squatting due to peripheral vasodilation, and eventually normalizing to a level which is higher than baseline level due to baroreceptor reflex responses [5]. Therefore, analyses of BP and HR changes during transition from standing to squatting position and from squatting to standing position provide information on performance of the baroreflexes and haemodynamic homeostasis which can be used as predictors of cardiovascular function. Previous studies on these cardiovascular responses to squatting were done on WEs not Black Africans (BAs), given that there is evidence of greater arterial blood pressure reactivity to laboratory stressors among normotensive BAs compared with WEs [18,19] there is a high likelihood that BAs would be at higher risk of adverse effect of squatting than WEs. Therefore, it is of interest to determine whether or not normotensive young BAs would show exaggerated responses to squatting.

Further, there is evidence of sex difference in cardiovascular responses to mental stress among WEs, men show greater vasoconstrictive responses with greater increase in peripheral resistance revealed by higher diastolic pressure while women show greater heart rate responses [20]. Further, WE women show greater orthostatic hypotension relative to WE men [21]. However, whether there are sex differences in response to orthostatic stress among young BAs is not known. This raises the question of whether BA men could be at a higher risk of adverse effect of squatting relative to BA women.

Aim: This study aimed at determining the effect of prompt and sustained squatting on arterial blood pressure and heart rate in young Black African men and women.

Methods

The study was human laboratory based observational study**.** Using means and standard deviations of cardiovascular responses during orthostatic stress from other studies, error probability (á) of 0.05 and power (1 " â) of 0.80, a sample size of 65 men and women was used for the study [22]. 33 men and 32 women aged 16 – 30 years, non- smoking, who were undergraduate students of University of Ibadan, Nigeria, were recruited for the study using convenience sampling method. The subjects were recruited by word of mouth and advertisement in classes. Exclusion criteria included consumption of alcohol or coffee and pregnancy as well as known cardiovascular disorder. Ethical approval was obtained from University of Ibadan / University College Hospital (UI/UCH) Ethical Committee. Informed content was obtained from participants after information about the study had been given. Self-administered questionnaire was used to collect information about the subjects' socio-demographic characteristics. Anthropometric measurements were taken, height (in centimeters, cm) was measured with a stadiometer and weight (in kilograms, kg) was measured using a weighing scale. Body mass index (BMI, kg/m^2) was calculated by dividing weight by $height^2$. Automated blood pressure device (Omron MX2, Omron Healthcare Ltd, UK) was used to measure SBP, DBP and heart rate (HR). Subjects rested in sitting position for 10 minutes, at the end of which baseline measurements were taken, this was followed by standing for 3 minutes, at the end of 3 minutes a measurement was taken (Stand). Subjects then squatted with buttocks resting on the heels for 2 minutes; measurements were taken immediately on assumption of the squatting position (0 second), at 60 seconds and at 120 seconds of squatting. The squat test has used to test baroreceptor sensitivity in previous studies (10, 23). Mean arterial blood pressure (MABP) was calculated using the formula (1/3 PP + DBP) and PP was calculated using the formula; SBP - DBP.

Protocol:

Sitting position (10 min)	**Standing position (3 min)**	**Squat (2 min)**

Data Analysis

Mean with standard error of mean (SEM) of absolute values as well as change in values of blood pressure and heart were presented. Baseline blood pressure (SBP/DBP) measured in the sitting position was categorized as normal (SBP/DBP < 120/80 mmHg), pre-hypertensive (SBP/DBP 120-139/80-89 mmHg) and hypertensive (SBP > 140/90 mmHg) (24-26). Proportion of responders was presented as numbers (n) and percentage (%). Changes (") in SBP, DBP, MABP, PP and HR between standing and squatting positions were determined at onset (0s), 60s and 120s of squatting. Changes at 0s were labelled as effect of prompt squat while the changes at 0s, 60s, 120s were labelled as effect of sustained squat. Changes in SBP, DBP, MABP, PP and HR were categorized into responder groups as increased (> 0 mmHg), decreased (< 0 mmHg) or no change (0 mmHg). Further, " SBP and " DBP were categorized into responder groups as hypo-reactors (d" 0 mmHg), normo-rectors (1-14 mmHg), hyper-reactors (1 - 30 mmHg), extreme hyper-reactors >30mmHg. Proportion of responders was presented as numbers (n) and percentage (%). Sex difference between responder groups was determined using Chi square test.

Effect of prompt squat was determined by comparing values during standing and prompt squat using unpaired Student's T test. The effect of sustained squatting at 0s, 60s and 120s was determined using one-way repeated measures ANOVA. Sex differences in responses to sustained squat at 0s, 60s and 120s (3 time points) was determined using two way mixed factors ANOVA with time as within subjects factor and sex as the between subjects factor. Bonferroni post hoc tests were done as appropriate. Statistical significance was determined at level of $p < 0.05$.

Results

Baseline in the whole group of men and women

The mean age of the 65 subjects was 27.85±1.21 years. Height, weight, body mass index (BMI), mean baseline BP and HR were within normal limits (Table 1). There was variability in BP, majority of the subjects showed normal SBP and DBP respectively, however, 9.2% and 4.6% of the subjects showed systolic prehypertension and hypertension respectively, while 3.1% showed diastolic prehypertension and hypertension respectively.

Effect of prompt squat in the whole group of men and women

Absolute SBP, MABP, PP but not DBP were significantly higher in squatting position relative to standing (Table 2).

Effect of sustained squat in the whole group of men and women

" SBP progressively increased from +8.57 ± 1.24 mmHg at 0s to +10.57 ± 1.34 mmHg at 120s ($p = 0.049$). Likewise, " DBP increased from +1.00 ± 1.09 mmHg at 0s to +2.59 ± 1.17 mmHg at 120s ($p = 0.038$). Further, " MABP increased from +3.52 ± 1.02 mmHg at 0s to +5.24 ± 1.09 mmHg at 120s ($p = 0.014$). However, there was no significant change in PP (Table 3).

Sex differences

Baseline

There was no significant difference in age of the men and women. Men were taller and had smaller BMI relative to women. Relative to women, men showed higher SBP (p = 0.001) and PP (p < 0.0001). However, there was no significant difference in DBP (p = 0.433) and MABP tended to be higher in men relative to women (Table 1).

“ MABP (p = 0.016). However there were no differences in “ SBP, “ PP or “ HR (Table 5).There were significantly higher proportions of DBP hyper-reactors among women relative to men (+15 - 30 mmHg, 0 (0%) vs 2 (6.3%), p=0.001).

Effect of sustained squat

Women showed greater “ SBP at 60s and 120s (p=0.049), greater “ DBP and “ MABP over the whole period of sustained squat (p=0.001, p=0.002 respectively). There were no sex differences in “ PP and “ HR (Table 6).

Table 1. Anthropometric characteristics of the whole group of men and women.

	All participants (n=65)	Men (33)	Women (32)	p value
Age (years)	27.85±1.21	28.00±1.52	27.69±1.67	0.89
Male / Female (n, %)	33 (50.77%) / 32(49.23%)			
Height (cm)	171.52±0.01	177.27±0.01	165.69±0.01	0.000
Weight (kg)	63.75±1.31	66.03±1.36	61.41±2.19	0.079
Body mass index (kg/m2)	21.49±0.41	20.67±0.36	22.32±0.70	0.04
Systolic blood pressure (mmHg)	106.55±1.77	111.94±2.14	101.00±2.51	0.001
Diastolic blood pressure (mmHg)	64.18±1.34	65.24±1.82	63.24±1.82	0.433
Mean Arterial blood pressure (mmHg)	78.31±1.41	80.81±1.78	75.73±2.12	0.070
Pulse pressure (mmHg)	42.37±1.15	46.70±1.57	37.91±1.30	0.000
Heart rate (beats/min,bpm)	72.31±1.31	68.58±1.86	76.16±1.61	0.003

Values are mean ± SEM. Sex (Male / female) presented as number (n) and percentage (%).

Table 2. Absolute blood pressure and heart rate in standing and squatting positions in the whole group men and women.

	Standing position	Prompt squat	Mean difference	p value
Systolic blood pressure (mmHg)	104.72±1.71	113.29±2.05	8.57±1.24	0.000
Diastolic blood pressure (mmHg)	66.98±1.21	67.98±1.48	1.00±1.09	0.361
Mean arterial blood pressure (mmHg)	79.56±1.32	83.09±1.60	3.52±1.02	0.001
Pulse pressure(mmHg)	37.74 ± 0.97	45.31 ±1.16	7.57±1.07	0.000
Heart rate (bpm)	81.63 ± 1.48	72.48 ± 1.48	-9.15±1.09	0.000

Values are mean ± SEM. Standing position vs prompt squat position analysed by paired Student's T test.

Effect of prompt squat

In the men, prompt squat evoked significant increases in SBP and PP, while HR decreased. However, MABP and DBP did not change significantly. On the other hand, in the women prompt squat evoked increases in SBP, DBP, MABP and PP, while HR reduced (Table 4).

“SBP ranged from -10 to +22 mmHg vs -16 to +42 mmHg and “ DBP ranged from -14 to +12 mmHg vs -21 to +34 mmHg in men and women respectively. Relative to men, women showed significantly higher mean “ DBP (p = 0.009) and mean

Discussion

In this present study, the prevalence of hypertension among the young adults was 4.6% while the prevalence of systolic pre-hypertension was 9.2%. Higher prevalence of hypertension of 15% and prehypertension of 40% have been reported by others among African young adults [27]. The prevalence of hypertension and pre-hypertension was higher among men compared with women consistent with a previous report among young Nigerians aged 18-22 years [28].

than women [29]. Further, women had higher heart rate compared with the men consistent with previous report [29]. Heart rate at rest is controlled by vagal tone; thus higher basal heart rate could be due to

Table 3: Change in blood pressure and heart rate during sustained squat in the whole group of men and women.

	0s	60s	120s	F statistic	p value	Bonferroni Post hoc
Systolic blood pressure (mmHg)	8.57±1.24	9.22±1.26	10.57±1.34	F(2,128)=3.11, $\acute{\eta}^2$=0.046	0.049	
Diastolic blood pressure (mmHg)	1.00±1.09	0.68±0.991	2.59±1.17	F(2,128)=3.37, $\acute{\eta}^2$=0.050	0.038	60s vs 120s p=0.012
Mean arterial blood pressure (mmHg)	3.52±1.02	3.52±0.95	5.24±1.09	F(2,128)=4.41 $\acute{\eta}^2$=0.064	0.014	60s vs 120s p=0.004
Pulse pressure (mmHg)	7.57±1.07	8.54±1.12	7.98±1.16	F(2,128)=0.56, $\acute{\eta}^2$=0.009	0.571	
Heart rate (bpm)	-9.15±1.09	-10.76±0.96	-9.37±0.96	F(2,128)=3.02, $\acute{\eta}^2$=0.045	0.052	60s vs 120s p=0.049

Values are mean and SEM. Changes (“) in blood pressure and heart rate between standing and squatting at 0s, 60s and 120s of sustained squat, analysed with one way repeated measures ANOVA with Bonferroni post hoc tests.

Table 4: Blood pressure and heart rate in standing and squatting positions in men and women.

	Men (n=33)			Women (n=32)		
	Standing	Squatting	p-value	Standing	Squatting	p-value
Systolic blood pressure (mmHg)	108.30±2.15	115.18±2.19	0.000	101.03±2.53	111.34±3.51	0.000
Diastolic blood pressure (mmHg)	67.52±1.35	65.76±1.77	0.145	66.44±2.04	70.28±2.34	0.033
Mean Arterial blood pressure (mmHg)	81.11±1.56	82.23±1.31	0.272	77.97±2.13	83.97±2.68	0.001
Pulse pressure (mmHg)	40.79±1.17	49.42±1.31	0.000	34.59±1.30	41.06±1.63	0.000
Heart rate (bpm)	78.55±2.24	68.42±1.97	0.000	84.81±1.77	76.66±1.54	0.000

Values are mean ± SEM. Standing vs squatting positions in men or women analysed with paired Student's T test within each sex group.

Table 5. Change in blood pressure and heart rate in response to prompt squat in men vs women

	Men (n=33)	Women (n=32)	P value
Systolic blood pressure (mmHg)	6.88 ±1.30	10.31 ± 2.12	0.169
Diastolic blood pressure (mmHg)	1.76 ±1.18	3.84 ±1.72	0.009
Mean arterial blood pressure (mmHg)	1.12 ±1.46	6.00 ±1.71	0.016
Pulse pressure (mmHg)	10.12 ±1.82	8.16 ±1.16	0.372
Heart rate (bpm)	8.64 ±1.46	6.47 ±1.57	0.315

Values are mean ± SEM. Change in blood pressure and heart rate during squatting from standing position. Men vs women analysed with independent Student's T test.

At baseline, SBP and MABP were higher in men compared with women, consistent with previous report that men have a higher systolic blood pressure

higher resting sympathetic nervous activity with reduction in cardiac vagal outflow.

In the whole group of men and women, prompt squat evoked increase in mean SBP of 8.57

Table 6: Change in blood pressure and heart rate in response to sustained squat in men vs women.

		0s	60s	120s	Effect of Time F statistic, p value	Effect of sex F statistic, p value	Time*Sex F statistic, p value	Effect of sex, p value
Systolic blood pressure (mmHg)	Men	6.68±1.30	6.73±1.26	7.85±1.22	F(2,126)=3.151 ή²=0.046 p=0.048	F(1,63)=4.034 ή²=0.060 p=0.049	F(2, 126)=0.898 ή²=0.014 p=0.410	0s:0.169 60s :0.044 120s :0.038
	Women	10.31±2.11	11.78±2.13	13.38±2.32				
Diastolic blood pressure (mmHg)	Men	1.76±1.18	2.06±1.24	1.33±1.37	F(2,126)=3.455 ή²=0.052 p=0.034	F(1,63)=12.32 ή²=0.164 p=0.001	F(2,126)=1.530 ή²=0.22 p=0.024	0s:0.009 60s :0.004 120s :0.000
	Women	3.84±1.72	3.50±1.40	6.63±1.62				
Mean arterial blood pressure (mmHg)	Men	1.12±1.01	0.87±1.05	1.73±1.10	F(2,126)=4.527 ή²=0.057 , p=0.013	F(1,63)=10.748, ή²=0.146 p=0.002	F(2,126)=1.580 ή²=0.025 p=0.208	0s:0.016 60s :0.004 120s :0.001
	Women	6.00±1.72	6.25±1.47	8.88±1.71				
Pulse pressure (mmHg)	Men	8.64±1.46	8.79±1.43	9.18±1.59	F(2,126)=0.575 ή²=0.009 p=0.560	F(1,63)=0.744, ή²=0.012 p=0.362	F(2,126)=0.644 ή2=0.010 p=0.523	
	Women	6.47±1.57	8.28±1.74	6.75±1.70				
Heart rate (beats/min)	Men	-10.12±1.82	-11.46±1.45	-10.76±1.32	F(2,126)=2.998 ή²=0.045 p=0.053	F(1,63)=1.418 ή²=0.022 p=0.238	F(2,126)=0.357 ή²=0.006 p=0.701	
	Women	-8.16±1.18	-9.50±1.24	-7.94±1.38				

Values are mean ±SEM. Changes in Systolic blood pressure (SBP), Diastolic blood pressure (DBP), mean arterial blood pressure (MABP), Pulse pressure (PP) and heart rate (HR) during sustained squatting in men and women analysed by two way mixed factor ANOVA with Bonferroni post- tests.

±1.24 mmHg, with further increase in mean SBP to 10.57 ± 1.34 mmHg at end of 2 minutes of squatting. Squatting is known to increase venous return by increasing muscle pump action with subsequent increase in end diastolic volume, stroke volume and cardiac output leading to increased arterial blood pressure. Subsequently, this stretches the baroreceptors and activates the baroreceptor reflex leading to inhibition of sympathetic nervous activity with consequent vasodilation and activation of cardiac vagal activity leading to reduction in heart rate which normalises BP. The findings of this study show that sustained squatting evoked progressive increase in BP which was not normalised within the 2 minute period that we used.

In this present study, variability in pressor responses during squatting was observed. Majority of those studied showed increased SBP while some showed decreased SBP. The decline in SBP during squatting in these subjects was unexpected. The reasons for the decrease in blood pressure at onset of squatting could be due to failure to mobilize blood from periphery into the heart by skeletal muscle pump or could reflect a decrease in peripheral resistance by vasodilation in response to an initial increase in blood pressure leading to failure to augment preload. This warrants further investigation.

In response to squatting, normotensive South Asians showed an increase in mean SBP ± standard deviation of 8.09 ± 7.04 mmHg whereas hypertensive subjects showed higher increase of 14.49 ± 11.63 mmHg [4], providing evidence for association between hypertension and exaggerated BP response to squatting. Further, there is evidence that exaggerated increase in SBP of 15 - 30 mmHg in response to stressors predisposes to developing hypertension later in life [30,31]. In the present study, about 25% of those studied showed exaggerated systolic blood pressure responses and more women were hyper-reactors compared with men. This suggests that these hyper-reactors may develop elevated BP as they grow older, however, there are no studies on the association between response to postural stress and future development of hypertension among black Africans.

Consistent with previous report, when considered as a whole group of men and women, there was no significant increase in mean DBP during squatting [4]. However, when considered in sex specific groups, women showed greater increase in DBP at the onset and during sustained squatting in contrast to men. Increased DBP reflects an increase in peripheral vascular resistance which is influenced by sympathetic vasoconstrictor tone. Could it be that the healthy young BA women who show exaggerated increase in diastolic blood pressure already have altered sympathetic nervous activity? Although lower resting sympathetic nerve activity and arterial pressure have been reported in WE women compared with WE men (32), the BA women in the present study showed higher resting heart rate relative to the men suggesting a higher resting sympathetic nervous activity.

At rest, the young BA women showed lower BP relative to men, whereas during postural stress, the women displayed greater BP changes compared to men, suggesting that the alteration in BP pattern between men and women was induced by stress. There is evidence that during vascular sympathetic stimulation, young WE women exhibit greater beta-adrenergic vasodilatation which offsets alpha-adrenergic vasoconstriction and minimizes the pressor effects of a given level of sympathetic nervous activity relative to WE men [33,34]. Thus, WE women do not show exaggerated pressor responses during stress as observed in BA women. Although the reason for the exaggerated pressor responses in BA women is not clear, it could be due to attenuated beta adrenergic vasodilation, a situation that is similar to that seen in post-menopausal white women [34], implying an early vascular aging. These highlight ethnic and gender-specific responses to cardiovascular stress among young BA adults which require further investigation.

In conclusion, squatting elicited increase in BP and decrease in HR. BA women showed greater increase in BP relative to men and this could predispose to hypertension in later life. BA women rather than BA men may be at greater risk of adverse effects such as stroke if exposed to sustained squatting.

References

1. van Lieshout JJ, ten Harkel AD and Wieling W. Physical manoeuvres for combating orthostatic dizziness in autonomic failure. Lancet. 1992;339(8798):897-898.
2. Kim KH, Cho JG, Lee KO, *et al*. Usefulness of physical maneuvers for prevention of vasovagal syncope. Circ J. 2005;69(9):1084-1088.
3. Chakravarty A. Why women do not get micturition syncope?—a hypothesis. Med Hypotheses. 2003;61(4):463-464.
4. Chakrabarti SD, Ganguly R, Chatterjee SK and Chakravarty A. Squatting, blood pressure and stroke. The Journal of the Association of Physicians of India. 2002;50:382-386.

5. Sharpey-Schafer EP. Effects of squatting on the normal and failing circulation. British medical journal. 1956;1(4975):1072-1074.
6. Sanderson JE, Billingham JD and Floras J. Baroreceptor Function in the Hypertensive Black African. Clinical and Experimental Hypertension Part A: Theory and Practice. 1983;5(3):339-351.
7. Philips JC, Marchand M, Scheen AJ. Haemodynamic changes during a squat test, pulsatile stress and indices of cardiovascular autonomic neuropathy in patients with long-duration type 1 diabetes. Diabetes Metab. 2012;38(1):54-62.
8. Philips JC, Marchand M and Scheen AJ. Pulsatile stress in middle-aged patients with type 1 or type 2 diabetes compared with nondiabetic control subjects. Diabetes Care. 2010;33(11):2424-9.
9. Stewart J and Schwartz C. The Arterial Baroreflex Resets with Orthostasis. Frontiers in physiology. 2012;3(461).
10. Nakagawa M, Shinohara T, Anan F, *et al*. New squatting test indices are useful for assessing baroreflex sensitivity in diabetes mellitus. Diabet Med. 2008;25(11):1309-1315.
11. Philips JC, Marchand M and Scheen AJ. Squatting, a posture test for studying cardiovascular autonomic neuropathy in diabetes. Diabetes Metab. 2011;37(6):489-496.
12. Marfella R, Giugliano D, di Maro G, *et al*. The squatting test. A useful tool to assess both parasympathetic and sympathetic involvement of the cardiovascular autonomic neuropathy in diabetes. Diabetes. 1994;43(4):607-612.
13. O'Donnell TV, Mc Ilroy MB. The circulatory effects of squatting. Am Heart J. 1962;64:347-356.
14. Lance VQ and Spodick DH. Physiological responses to prompt and sustained squatting. Measurement by systolic time intervals. British heart journal. 1977;39(5):559-562.
15. Mengesha YA. Comparative study of haemodynamic responses to active and passive posture inducing head-ward pooling of blood in man. East African medical journal. 2001;78(4):212-215.
16. Hanson P, Slane PR, Rueckert PA and Clark SV. Squatting revisited: comparison of haemodynamic responses in normal individuals and heart transplantation recipients. British heart journal. 1995;74(2):154-158.
17. Lewis BS, Lewis N and Gotsman MS. Effect of postural changes on Pulsus Alternans: an echocardiographic study. Chest. 1979;75:634-636.
18. Anderson NB, Myers HF, Pickering T and Jackson JS. Hypertension in blacks: psychosocial and biological perspectives. J Hypertens. 1989;7:161-172.
19. Murphy JK, Alpert BS and Walker SS. Ethnicity, pressor reactivity, and children's blood pressure. Five years of observations. Hypertension. 1992;20(3):327-332.
20. Allen MT, Stoney CM, Owens JF and Matthews KA. Hemodynamic adjustments to laboratory stress: the influence of gender and personality. Psychosom Med. 1993;55(6):505-517.
21. Cheng YC, Vyas A, Hymen E and Perlmuter LC. Gender differences in orthostatic hypotension. Am J Med Sci. 2011;342(3):221-225.
22. Patel K, Rossler A, Lackner HK, *et al*. Effect of postural changes on cardiovascular parameters across gender. Medicine (Baltimore). 2016;95(28):e4149.
23. Philips J-C and Scheen A. Squatting test: A posture to study and counteract cardiovascular abnormalities associated with autonomic dysfunction. Autonomic neuroscience : basic & clinical. 2011;162:3-9.
24. Odunaiya NA, Louw QA and Grimmer KA. Are lifestyle cardiovascular disease risk factors associated with pre-hypertension in 15-18 years rural Nigerian youth? A cross sectional study. BMC Cardiovasc Disord. 2015;15:144.
25. Collier SR and Landram MJ. Treatment of prehypertension: lifestyle and/or medication. Vasc Health Risk Manag. 2012;8:613-619.
26. Gupta R, Deedwania PC, Achari V, *et al*. Normotension, prehypertension, and hypertension in urban middle-class subjects in India: prevalence, awareness, treatment, and control. Am J Hypertens. 2013;26(1):83-94.
27. Kayima J, Nankabirwa J, Sinabulya I, *et al*. Determinants of hypertension in a young adult Ugandan population in epidemiological transition-the MEPI-CVD survey. BMC Public Health. 2015;28(15):830.
28. Ibhazehiebo K, Dimkpa UI and Iyawe VI. Hypertension, and blood pressure response to graded exercise in young obese and non-athletic Nigerian university students. Nigerian journal of physiological sciences : official publication of the Physiological Society of Nigeria. 2007;22(1-2):37-42.
29. McCubbin JA, Wilson JF, Bruehl S, *et al*. Gender effects on blood pressures obtained during an on-campus screening. Psychosom Med. 1991;53(1):90-100.

30. Hines EAJ. Range of normal blood pressure and subsequent development of hypertension: A follow-up study of 1,522 patients. Journal of the American Medical Association. 1940;115(4):271-274.
31. Menkes MS, Matthews KA, Krantz DS, *et al*. Cardiovascular reactivity to the cold pressor test as a predictor of hypertension. Hypertension. 1989;14(5):524-530.
32. Hart EC, Charkoudian N, Wallin BG, *et al.* Sex differences in sympathetic neural-hemodynamic balance: implications for human blood pressure regulation. Hypertension. 2009;53(3):571-576.
33. Briant LJ, Charkoudian N and Hart EC. Sympathetic regulation of blood pressure in normotension and hypertension: when sex matters. Exp Physiol. 2016;101(2):219-229.
34. Hart EC, Charkoudian N, Wallin BG, *et al*. Sex and ageing differences in resting arterial pressure regulation: the role of the beta-adrenergic receptors. J Physiol. 2011;589(Pt 21):5285-5397.

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