Chapter

Inter Arm Blood Pressure and Cardiovascular Risk in Young Adults at Ellisras

Betty Sebati, Kotsedi Monyeki, Hlengani Siweya and Susan Monyeki

Abstract

Cardiovascular disease is a notable cause of death globally. When undetected, varying measurements of BP between arms can lead to inaccuracies in the interpretation and management of blood pressure consequently putting individuals in an avoidable risk through sub-optimal blood pressure control. The aim of the study was to determine the difference in blood pressure between the arms and its association to cardiovascular risk in young adults at Ellisras. A total of 624 young adults aged 18 to 29 years old participated in the study. Blood pressure measurements and blood analysis were done according to standard procedures. Multivariate logistic regression was used to determine the association between interarm blood pressure and cardiovascular risk factors. There was significant ($p \leq 0.05$) mean difference of diastolic blood pressure of the <10 mmHg and ≥ 10 mmHg groups. There was a positive significant association between systolic inter arm blood pressure difference and hypertension (B = 5.331; 95%CI = 12.260–23.183; P = 0.026) while no significant association was found between diastolic blood pressure and interarm diastolic differences in diastolic blood pressure (B = 1.081; 95%CI = 1.032–1.131; P = 0.920). The current study showed positive associations between inter arm differences and a few cardiovascular risk factors including BMI and gender. Detection of an inter-arm BP difference should motivate the need for a thorough cardiovascular/health assessment.

Keywords: inter arm blood pressure, young adults, cardiovascular risk, cross-sectional study, association

1. Introduction

Cardiovascular disease (CVD) is a notable cause of death globally [1]. One main contributing factor to cardiovascular disease development is arteriosclerosis and it is the key cause of morbidity and mortality [2]. Blood pressure (BP) measurement is the most commonly utilized method of assessing arteriosclerosis activity [3]. Systolic blood pressure (SBP) difference between arms (inter-arm difference/IAD) is one risk marker that is easy to measure since it does not require extra equipment and seems acceptable to patients. Circumstances in which differences in BP were found in clinical settings were infrequent [4, 5].

When undetected, varying measurements of BP between arms can lead to inaccuracies in the interpretation and management of blood pressure consequently putting individuals in an avoidable risk through sub-optimal blood pressure control [6]. Furthermore it has been reported that systolic BP difference of 10 mmHg or greater between both arms was related with cardiovascular risk/complications [7, 8]. Moreover an inter arm difference is mostly encountered with differences in systolic of 10 mmHg or greater prevalent in 11% of hypertensive patients, 7% diabetic patients as well as 4% of the general population [5].

Past studies have discovered a rise in the incidence of big inter arm difference in hypertensive [9] and diabetic patients [10]. The association between inter arm difference and atherosclerosis-related diseases, such as coronary artery disease [11], and other peripheral artery disease were also reported [12, 13]. Nevertheless, the majority of these studies took place in populations that were Westernized/urbanized with little sample sizes and comprising of certain disease groups. The prevalence of selected cardiovascular risk factors has been reported in young adults at Ellisras including BP/hypertension [14], but the inter arm BP difference was not investigated. Furthermore as far as we are aware, such a study was not reported among black South Africans in Limpopo Province. Therefore the study aimed to determine the blood pressure difference between arms and its association to cardiovascular risk in young adults at Ellisras.

2. Methods and materials

2.1 Sample

The study constituted of 624 young adults (306 males; 318 females) aged 18 to 29 years old from the Ellisras Longitudinal Study (ELS) in Lephalale, Limpopo province in South Africa. The details of ELS are explained elsewhere [15]. The study was approved by the Ethics Committee at the University of Limpopo prior to the study commencing. Consent forms were also signed by the participants.

Participants with factors that could influence the reliability of the study including pregnancy and chronic diseases or hospitalization were excluded.

2.2 Blood pressure measurements

Prior to being measured the participants rested for approximately 5 minutes. Afterwards, three blood pressure (BP) readings of systolic blood pressure (SBP) And diastolic blood pressure (DBP) were measured five minutes apart in both the left and right arms using an electronic Micronta monitoring kit, [16, 17]. Average BP was calculated for both arms. Then the difference between the average SBP and DBP in the left and right arms was calculated.

2.3 Cardiovascular risk factor measurements

All participants underwent height and weight measurements according to the standard procedures [18]. The weight and height were then used to determine the body mass index (BMI) [18].

There was fasting of between 8–10 hours before the collection of blood samples. All blood sample collections were carried out in schools by qualified nurses from the

Witpoort Hospital at Ellisras in the morning. The samples were collected, stored, transported, and analyzed according to standard procedures [14].

Blood glucose (fasting) was drained into fluoride tubes and measured using an Accu-chek [19]. The total cholesterol (TC) and high-density lipoprotein cholesterol (HDL-C) levels were both measured using standard procedure that utilizes spectrophotometry. The Friedewald equation was then used to determine low density lipoprotein cholesterol (LDL-C) (LDL-C = TC - HDL-C - TG/2.2) [20]. Triglycerides (TG) measurement was done through standard enzyme-based colorimetric technique. These measurements were all accomplished using an AU480 Chemistry System from Beckman Coulter (Brea, Calif).

All apparatuses underwent calibration based on standard procedures. These blood analysis was carried out by workers in the Department of Pathology and Medical Science Unit at University of Limpopo.

The cut-off points were as follows: hypertension was defined as systolic and diastolic blood pressure ≥ 140/90 mmHg. Diabetes was defined as elevated FBG ≥7.8 mmol/L while obesity was defined as BMI (kg/m2) ≥25 kg/m^2 [21].

2.4 Statistical analysis

Inter arm systolic blood pressure difference (IASBPD) and inter arm diastolic blood pressure difference (IADBPD) were described as the absolute value of the left arm SBP/DBP minus the right arm SBP/DBP respectively. Both the IASBPD and IADBPD were grouped into two categories based on a cut-off point: <10 mmHg which is normal and ≥ 10 mmHg which is the category increasing cardiovascular risk [22]. Continuous variables were articulated as mean ± standard deviation while categorical variables were articulated as frequencies and percentages. Moreover comparisons of the variables were performed between the two cut-off groups using independent *t* test for continuous variables, and chi-square test for categorical variables. A multivariate logistic regression model was used to analyze the association between IASBPD and IADBPD, height, weight, BMI, SBP, DBP, fasting glucose, TC, TG, HDL-C, LDL-C, diabetes and hypertension. All analyses were performed using SPSS software version 14.0 and P-value of ≤0.05 was considered statistically significant.

3. Results

Table 1 represents the Descriptive statistics of the general characteristics. There was significant (p ≤ 0.05) mean difference of diastolic blood pressure of the <10 mmHg and ≥ 10 mmHg groups. The prevalence of obesity, diabetes and hypertension was insignificantly (p > 0.05) higher in the <10 mmHg group (1.8–30.9%) than the ≥10 mmHg (0–16.7%).

Table 2 shows the association between risk factors and inter arm differences in systolic blood pressure among Ellisras young adults. There was a positive significant association between IASBPD and hypertension (B = 5.331; 95%CI = 12.260–23.183; P = 0.026). There was also a positive significant association found between gender and IASBPD (B = 1.998; 95%CI = 0.022–3.903; P = 0.043).

Table 3 shows the association between risk factors and interarm differences in diastolic blood pressure among Ellisras young adults. There was a positive significant association found between SBP and IADBPD (B = 1.003; 95%CI = 0.967–1.041; P = 0.001) while there was no significant association found between DBP and IADBPD (B = 1.081; 95%CI = 1.032–1.131; P = 0.920).

Variables	<10 mmHg	≥10 mmHg	P-value
Height (cm)	168.26 ± 13.15	169.52 ± 10.19	0.743
Weight (Kg)	66.99 ± 14.22	67.74 ± 22.54	0.859
BMI (Kg/m^2)	23.51 ± 5.47	23.58 ± 7.39	0.964
SBP (mmHg)	119.99 ± 12.88	117.92 ± 20.38	0.585
DBP (mmHg)	70.03 ± 9.62	81.50 ± 15.41	0.000
Fasting glucose (mmol/L)	5.54 ± 1.27	5.38 ± 0.87	0.677
TC (mmol/L)	4.14 ± 1.03	4.39 ± 1.05	0.406
TG (mmol/L)	1.01 ± 0.59	1.05 ± 0.48	0.827
HDL-C(mmol/L)	1.15 ± 0.34	1.18 ± 0.33	0.724
LDL- C (mmol/L)	2.80 ± 0.87	3.00 ± 0.84	0.429
Gender	m = 301(49.2%) f = 311(50.8%)	m = 5 (41.7%) f = 7(58.3%)	0.606
Obesity	189(30.9%)	2(16.7%)	0.716
Diabetes	10(1.66%)	0(0%)	0.655
Hypertension	11(1.8%)	1(8.3%)	0.103
$P \leq 0.05$.			

Table 1.
Descriptive statistics showing general characteristics.

Variables	B	95%CI		P-value
		Lower	upper	
Age (years)	0.929	0.825	1.046	0.222
Gender	1.998	0.022	3.903	0.043
Height (cm)	1.002	0.981	1.024	0.853
Weight (kg)	1.038	0.986	1.092	0.159
BMI (Kg/m^2)	0.882	0.764	1.018	0.087
SBP (mmHg)	1.000	0.974	1.026	0.983
DBP (mmHg)	1.012	0.980	1.045	0.464
Fasting glucose(mmol/L)	1.093	0.822	1.454	0.540
TC(mmol/L)	0.000	0.000	—	1.000
TG (mmol/L)	23.905	0.000	—	1.000
HDL-C (mmol/L)	1174525.430	0.000	—	1.000
LDL-C (mmol/L)	7854389.463	0.000	—	1.000
Diabetes	0.000	0.000	—	0.999
Hypertension	5.331	12.260	23.183	0.026
$P \leq 0.05$.				

Table 2.
The association between risk factors and inter arm differences in SBP.

Variables	B	95%CI		P-value
		Lower	upper	0.105
Age (years)	0.858	0.713	1.032	0.203
Gender	1.970	0.963	5.596	0.596
Height (cm)	1.023	0.940	1.113	0.851
Weight (kg)	1.013	0.889	1.153	0.654
BMI (Kg/m^2)	0.920	0.640	1.323	0.853
SBP (mmHg)	1.003	0.967	1.041	0.001
DBP (mmHg)	1.081	1.032	1.131	0.920
Fasting gucose(mmol/L)	1.024	0.624	1.632	1.000
TC(mmol/L)	187307.604	0.000	—	1.000
TG (mmol/L)	0.072	0.000	—	1.000
HDL-C (mmol/L)	0.000	0.000	—	1.000
LDL-C (mmol/L)	0.000	0.000	—	1.000
Diabetes	0.000	0.000	—	0.999
Hypertension	0.261	0.022	3.132	0.290

$P \leq 0.05$.

Table 3.
The association between risk factors and inter arm differences in diastolic blood pressure among Ellisras young adults.

4. Discussion

In the current study, 12 participants (5 males and 7 females; 1.92% of the sample size) showed an inter arm difference ≥ 10 mmHg. A previous study has suggested that interarm BP difference was more usual among young healthy study participants, with an interarm blood pressure difference > 10 mm Hg reported in 111 (12.6%) and 77 (8.8%) participants for SBP and DBP respectively [23]. The current study did not find similar results due to a low prevalence found. Another study conducted among hypertensive patients reported a prevalence of 7.7% (285 patients with a systolic interarm difference of ≥10 mm Hg), while 1.5% (57 patients) had a ≥ 10 mmHg diastolic interarm blood pressure difference. Furthermore, a study by Kim et al. [22] reported a 0.6% (21 patients) prevalence for both systolic and diastolic interarm difference ≥ 10 mmHg.

The different findings found between the current and other related studies could be because of the varying age groups, diseases profile of the participants (some being healthy and others suffering from hypertension and other chronic diseases) or even the different methods used to measure the interarm BP difference. The difference in systolic blood pressure between arms is considered a risk marker and advantageous due to that it is easy to measure clinically without additional equipment and is more acceptable to patients. Furthermore, studies have associated a systolic inter arm difference ≥ 15 mmHg [24], and ≥ 10 mmHg with cardiovascular risk and mortality [7]. The inability to detect the interarm BP difference may result in insufficient treatment of people suffering from hypertension and interrupt hypertension diagnosis. Hence, it is vital to measure blood pressure in both arms.

A previous study has reported that blood pressure measured in only one arm would lead to approximately 30% misdiagnosis of hypertensive patients being wrongfully classified as normotensive [25].

In multivariate logistic regression of the current study, a positive significant association was found between systolic interarm blood pressure and hypertension as well as gender. In addition there was also a positive significant association found between SBP and diastolic interarm blood pressure difference in the current study. A previous study by Kimura et al. [26], reported a positive association between systolic interarm systolic blood pressure > 10 mm Hg and SBP and BMI. This was different from the findings of the current study since we found a non-significant association between BMI and both IASBPD and IADBPD. Furthermore, another study by Grossman et al. [27], reported that interarm BP difference was not associated with age, BMI, and heart rate, but was in association with SBP in both young and healthy patients [27]. The latter findings are similar to the current study since we found an association between SBP and IADBPD. Moreover, A study by Grossman et al. [27] which is supported by another study by Ma et al. [28], reported that high inter arm systolic blood pressure difference seems to be more common in older than in younger people.

The study had several limitations. The study had limited variables to broadly represent the large spectrum of cardiovascular risk/health. The effect of controlling interarm blood pressure difference on cardiovascular risk could not be evaluated at this stage. The study did not have a large range in terms of the age hence the effect of age on the inter arm blood pressure difference could not be adequately determined. The cardiovascular health status of the participants was determined on a cross sectional basis hence some factors that can temporarily affect measurements may have affected the readings. The nature of the study cannot fully establish a cause and effect relationship, hence possible bias cannot be ruled out.

5. Conclusions

The current study found a low prevalence of interarm BP difference and showed positive associations between inter arm differences and a few cardiovascular risk factors including hypertension and gender. More similar studies should include a variety of risk factors and diseases as well as a broader age group. Carrying out such an investigation on a longitudinal basis is also necessary for exclusion of factors that can temporarily affect the findings. Detection of an interarm BP difference that is ≥10 mmHg should motivate the need for a thorough cardiovascular/health assessment to prevent late diagnosis and other related complications.

Acknowledgements

The Ellisras Longitudinal Study (ELS) administrators, Mr. Makata, Mrs. Makgae, as well as Mr. T Tselapedi are greatly acknowledged. The ELS participants and community coordinators are gratefully recognized for their assistance.

Abbreviation

ELS	Ellisras Longitudinal Study

DOI: http://dx.doi.org/10.5772/intechopen.96704

Author details

Betty Sebati[1], Kotsedi Monyeki[1*], Hlengani Siweya[2] and Susan Monyeki[1]

1 Department of Physiology and Environmental Health, University of Limpopo, Sovenga, South Africa

2 Executive Dean Faculty of Science and Agriculture, University of Limpopo, Sovenga, South Africa

*Address all correspondence to: kotsedi.monyeki@ul.ac.za

References

[1] Clark CE, Boddy K, Warren FC, Taylor RS, Aboyans V, Cloutier L, McManus RJ, Shore AC, Campbell JL. Associations between interarm differences in blood pressure and cardiovascular disease outcomes: protocol for an individual patient data meta analysis and development of a prognostic algorithm. BMJ Open. 2017; 7:e016844. doi:10.1136/bmjopen-2017-016844.

[2] Kusunose K, Sato M, Yamada H, Saijo Y, Bando M, Hirata Y, Nishio S, Hayashi S, Sata M. Prognostic implications of non-invasive vascular function tests in high-risk atherosclerosis patients. Circ J. 2016; 80:1034-40.

[3] Shimamoto K, Ando K, Fujita T, Hasebe N, Higaki J, Horiuchi M, Imai Y, Imaizumi T, Ishimitsu T, Ito M, Ito S, Itoh H, Iwao H, Kai H, Kario K, Kashihara N, Kawano Y, Kim-Mitsuyama S, Kimura G, Kohara K, Komuro I, Kumagai H, Matsuura H, Miura K, Morishita R , Naruse M, Node K, Ohya Y, Rakugi H, Saito I ,Saitoh S, Shimada K, Shimosawa K, Suzuki H,Tamura K ,Tanahashi N, Tsuchihashi T, Uchiyama M , Ueda S, Umemura S. The Japanese Society of Hypertension Guidelines for the Management of Hypertension (JSH 2014). Hypertens Res. 2014; 37:253-390.

[4] Tanaka Y, Fukui M, Tanaka M, Fukuda Y, Mitsuhashi K, Okada H, Yamazaki M, Hasegawa G, Yoshioka K, Nakamura N. The inter-arm difference in systolic blood pressure is a novel risk marker for subclinical atherosclerosis in patients with type 2 diabetes. Hypertens Res. 2014; 37:548-52.

[5] Clark CE, Taylor RS, Shore AC, Campbell JL. Prevalence of systolic inter-arm differences in blood pressure for different primary care populations: system- atic review and meta-analysis. Br J Gen Pract. 2016; 66:e838-47.

[6] McDonagh, S, Clark, CE. Inter-arm differences in blood pressure: a brief summary. Diabetes and Primary Care. 26 September 2019.

[7] Cao KW, Xu JS, Qing SG, Hu WT, Li P, Cheng XS, Su H. Association of an inter-arm systolic blood pressure difference with all-cause and cardiovascular mortality: an updated meta-analysis of cohort studies. Int J Cardiol. 2015; 189: 211-9.

[8] Zhou M, Gao Z, Chen F, Xu HJ, Dong X, Ma L. The inter-arm systolic blood pressure difference and risk of cardiovascular mortality: a meta-analysis of cohort studies. Clin Exp Hypertens. 2016; 38:317-24.

[9] Fonseca-Reyes S, Forsyth-MacQuarrie AM, Garcia de Alba-Garcia JE. Simultaneous blood pressure measurement in both arms in hypertensive and nonhypertensive adult patients. Blood Press Monit. 2012; 17:149-54.

[10] Clark CE, Steele AM, Taylor RS, Shore AC, Ukoumunne OC, Campbell J. Interarm blood pressure difference in people with diabetes: measurement and vascular and mortality implications: a cohort study. Diabetes Care. 2014; 37:1613-20.

[11] Igarashi Y, Chikamori T, Tomiyama H, Usui Y, Hida S, Tanaka H, Nagao T, Yamashina A. Clinical significance of interarm pressure difference and ankle-brachial pressure index in patients with suspected coronary artery disease. J Cardiol. 2007; 50:281-9.

[12] Clark CE. Difference in blood pressure between arms might reflect peripheral vascular disease. BMJ. 2001; 323:399-1399.

[13] Clark CE, Campbell JL, Powell RJ. The interarm blood pressure difference

as predictor of cardiovascular events in patients with hypertension in primary care: cohort study. J Hum Hypertens. 2007; 21:633-8.

[14] Sebati B, Monyeki K ,Kemper HCG, Sekgala MD, Mphekgwana P. 2019. Anthropometric indices for predicting cardiovascular risk factors: Ellisras longitudinal study. AM J HUM BIOL. 2019; e23293.

[15] Monyeki KD, Van Lenthe FJ, Steyn NP. Obesity: does it occur in African children in a rural community in South Africa?. Int j epidemiol. 1999; 28: 287-292.

[16] National High Blood Pressure Education Program (NHBPEP). Update on the 1987 task force report on high blood pressure in children and adolescents: a working group report from the National High Blood Pressure Education Program. Paediatrics. 1996; 98: 649-658.

[17] National High Blood Pressure Education Program NHBPEP. National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents. The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents. Pediatrics. 2004; 114: 555-576.

[18] Norton K, Olds, T. (Eds.). Anthropometrica: a textbook of body measurement for sports and health courses. UNSW press: 1996.

[19] Barrett SC, Huffman FG, Johnson, P. Validation of finger-prick testing of fasting blood glucose, total cholesterol, and HbA1c in adolescents. Point of Care. 2011; 10: 51-58.

[20] Friedewald WT, Levy RI, Fredrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clinical chemistry. 1972; 18: 499-502.

[21] Ho SY, Lam TH, Janus ED. Waist to stature ratio is more strongly associated with cardiovascular risk factors than other simple anthropometric indices. Ann epidemiol. 2003; 13(10): 683-691.

[22] Kim SA, Kim JY, Park JB. Significant interarm blood pressure difference predicts cardiovascular risk in hypertensive patients. Medicine. 2016: 95(24).

[23] Grossman A, Prokupetz A, Gordon B, Morag-Koren N, Grossman E. Inter-arm blood pressure differences in young, healthy patients. *J Clin Hypertens (Greenwich)*. 2013;15:575-578.

[24] Clark CE, Taylor RS, Shore AC, Ukoumunne OC, Campbell JL. Association of a difference in systolic blood pressure between arms with vascular disease and mortality: a systemic review and meta-analysis. The Lancet. 2012; 379 (9819):905-914.

[25] Poon LC, Kametas N, Strobl I, Pachoumi C, Nicolaides KH. Inter-arm blood pressure differences in pregnant women. *BJOG*. 2008; 115:1122-1130.

[26] Kimura A, Hashimoto J, Watabe D, Takahashi H, Ohkubo T, Kikuya M, Imai Y. Patient characteristics and factors associated with inter-arm difference of blood pressure measurements in a general population in Ohasama, Japan. *J Hypertens*. 2004; 22:2277-2283.

[27] Grossman A, Weiss A, Beloosesky Y, Morag-Koren N, Green H, Grossman E. Inter-arm blood pressure difference in hospitalized elderly patients-is it consistent? *J Clin Hypertens (Greenwich)*. 2014; 16:518-523.

[28] Ma W, Zhang B, Yang Y, Qi L , Meng L, Zhang Y, Huo Y. Correlating the relationship between interarm systolic blood pressure and cardiovascular disease risk factors. *J Clin Hypertens*. 2017;19:466-471. https://doi.org/10.1111/jch.12987