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Research Article

DIFFERENCES IN BLOOD PRESSURE MEASUREMENTS IN THE FOREARM AND UPPER ARM OF OBESE OTHERWISE HEALTHY FIRST YEAR MEDICAL STUDENTS

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ABSTRACT

Background: The prevalence of obesity is increasing in Indian youth and obesity is associated with complications like systemic hypertension. Often, due to the non-availability of appropriate sized cuffs, standard cuff bladders are used to measure blood pressure in the forearms of obese young adults. **Aim:** To compare the upper arm arterial blood pressure measured using an appropriate cuff with the forearm arterial blood pressure measured using a standard cuff and conventional sphygmomanometry in obese otherwise healthy first year medical students. **Materials and Methods**: Blood pressure was measured in 27 obese otherwise healthy first year medical students after five minutes of rest using a mercury sphygmomanometer with the subjects seated and the arm and forearm at heart level, using an appropriate sized cuff for the upper arm according to American Heart Association standards and a standard cuff for the fore arm. **Results:** A statistically significant difference in both systolic [t-test (paired) = -6.921; df = 26; sig = .000 (2- tailed)] and diastolic blood pressure [t-test (paired) = -8.508; df = 26; sig = .000 (2- tailed)] was found, with the blood pressure readings being higher in the forearm. The correlations between upper arm and forearm systolic and diastolic blood pressure were 0.785 (p = .000) and 0.870 (p = .000). **Conclusion:** Both systolic and diastolic blood pressure measurements were significantly higher in the forearm. Further studies with larger sample size should be conducted to confirm that forearm blood pressure measurements using standard cuff bladders cannot be considered equal to upper arm measurements made using an appropriate sized cuff in all young obese individuals

Keywords: Blood pressure measurements; cuff bladders; forearm; obese; upper arm.

INTRODUCTION

The prevalence of obesity is increasing globally. Chopra et al note that the prevalence of obesity is increasing in Indian youth, with studies from different regions of India revealing a high prevalence of childhood obesity; especially in urban school going girls.[1] Obesity is associated with complications like systemic hypertension which is the most common risk factor for cardiovascular disease. While attempts are being made to diagnose systemic hypertension in obese young adults early, failure to sufficiently follow guidelines on the correct methodology of blood pressure measurement can be

counterproductive and contribute to confusion and wrong diagnosis instead.

Parati et al recognize that despite growing awareness on the impact of hypertension on health and rapid progress in the field of blood pressure measurement, many methodological issues still needed to be addressed.[2] Arterial blood pressure can be measured non-invasively by manually operated and automated devices. Tholl et al point out that the quality of blood pressure monitoring depends not only on the technical limitations of the devices used, but more commonly on correct handling by the user.[3] This is especially applicable while measuring blood pressure in obese patients. Prineas states that choosing the correct cuff width-arm circumference (CW/AC) ratio is very important in the obese.[4] Obese individuals and individuals with muscular arms require a longer and wider cuff to adequately compress the brachial artery.[5] The use of small cuff bladders can lead to overestimation of blood pressure while over-cuffing can cause underestimation of blood pressure.[6,7]

Often, in routine clinical practice, due to the non-availability of appropriate sized cuffs, standard cuff bladders are used to measure blood pressure in the forearms of obese patients. Schell et al, in 2005, compared automatic noninvasive measurements of blood pressures in the upper arm and forearm in 204 stable patients attending the emergency department and concluded that forearm and upper arm values were not interchangeable despite strict attention to correct cuff size and placement of the upper arm or forearm at heart level.[8] Earlier, Tachovsky had in 1985 compared indirect auscultatory blood pressure values measured at the forearm with the upper arm in 98 female non-obese subjects aged 18 to 25 years, and found lower systolic values and higher diastolic values at the forearm site.[9] Latman et al who had in 1996 evaluated the performance of an automatic, noninvasive BP monitoring instrument concluded that the forearm was an acceptable site for clinically useful systemic blood pressure measurement.[10] Singer et al had in 1999 found that the correlations between forearm and upper arm systolic and diastolic BPs measured using an automated device were 0.75 and 0.72 respectively in a study involving 151 patients, 40% of whom were female and suggested that the forearm may be used when measurement of blood pressure in the upper arm was not feasible.[11] Emerick proved that non-invasive blood pressure measured at the wrist consistently overestimated mean arterial, systolic and diastolic pressure by approximately 10 mmHg when compared to the upper arm.[12]

Pierin et al used an automatic oscillometric device to compare upper arm blood pressure readings recorded using an appropriate cuff bladder and forearm values recorded using a standard cuff bladder in obese patients.[13] They found that the forearm measurements in obese patients could not replace upper arm measurements as the fore arm blood pressure values were higher.[13] Domiano et al too found that forearm blood pressure was higher than the upper arm-they however also found that this site difference was greatest for men, obese adults and middle aged adults.[14] Fonseca-Reyes et al not only confirmed that usage of a standard cuff in obese patients overestimates blood pressure, also found a high prevalence of patients with arms of large circumference among hypertensive patients and normo-tensive subjects and therefore stressed the need for using cuffs of different size.[15] Watson et al found that both forearm blood pressure and the use of an extra-long blood pressure cuff on the upper arm lead to a significant overestimation of the upper arm blood pressure measured using a recommended cuff in post anaesthesia patients with large upper arm circumferences.[16] Another study done by Schell et al to determine the effects of anatomical structures like limb subcutaneous tissue and vessels on the differences between forearm and upper arm oscillometric noninvasive blood pressure measurements revealed that forearm and upper arm vessel depth, forearm vessel diameter, and upper arm circumference explained a statistically significant portion of the difference between forearm and upper arm blood pressures.[17] While Palatini et al found that forearm blood pressure overestimated upper arm blood pressure, they also found a significant relationship between the systolic difference in blood pressure and both BMI and skin fold thickness in males for whom the systolic blood pressure difference was greater.[18]

While other researchers studied differences in blood pressure measurements in the general population, hospitalized patients, or in obese patients, in 2006, Schell and Waterhouse studied young healthy college students, recognizing the increasing prevalence of obesity and hypertension in young adults in the United States and the tendency of health care workers

to measure blood pressure in the forearm during routine screening when the standard size cuff did not fit the upper arm. They found statistically significant differences between upper arm and forearm diastolic blood pressures while differences between systolic blood pressure readings were not significant and concluded that upper arm and forearm automatic, noninvasive blood pressures were not interchangeable.[19] Recognizing that such readings were used interchangeably in nursing practice, Fortune et al studied 100 healthy undergraduate nursing students using an automatic blood pressure device and found that both systolic and diastolic blood pressure measurements were significantly higher in the forearm when compared to the upper arm.[20]

Researchers have thus compared upper arm and forearm blood pressure readings in subjects belonging to a varied age group, in obese subjects and in young healthy non-obese/non-overweight young adult students. Given the increasing prevalence of obesity in Indian youth and the tendency to use forearm blood pressure readings as an alternative to upper arm readings due to non-availability or lack of easy access to appropriate size cuff bladders, we were interested in studying whether there were any differences in blood pressure measurements in forearm and upper arm in our obese otherwise healthy first year medical students**.** We however chose to use conventional sphygmomanometry unlike the automatic noninvasive measurements of blood pressures done by many other researchers.

AIM: The aim of this study was to compare the upper arm arterial blood pressure measured using an appropriate cuff with the forearm arterial blood pressure measured using a standard cuff and conventional sphygmomanometry in obese otherwise healthy first year medical students.

MATERIALS AND METHODS

This study was done in the Department of Physiology of VMKVMCH in Salem, South India, after obtaining clearance from the institution's ethical committee.

Sample size: Out of the 100 first year medical students in the age group 18-19 years, 27 obese students with a BMI ≥ 30 (9 = male, 18 = female) were selected for the study on the basis of the following inclusion and exclusion criteria:

Inclusion criteria: First year medical students with a BMI ≥ 30, in the age group 18-19 years, with an arm circumference of ≥ 32 cm were studied.

Exclusion criteria: Individuals with history of any diseases like diabetes mellitus, systemic hypertension, heart disease, bronchial asthma and medical problems that could influence blood pressure or any surgical problems, were excluded from the study. Individuals with history of smoking, alcohol or nicotine intake and individuals with history of current intake of any medication were also excluded.

The purpose of doing the study was explained and written consent was obtained after a detailed history and physical examination. The subjects' blood pressure was measured using a conventional manual mercury sphygmomanometer after five minutes of rest with the subjects seated and the arm and forearm at heart level. For the arm blood pressure measurement, an appropriate sized cuff was used for each subject according to American Heart Association standards [5], while a standard cuff was used for the forearm blood pressure. The blood pressures measurements were done for each site with a two minute resting period in between, the order of sites being selected at random and alternated.

Statistical analysis: The systolic and diastolic blood pressure values obtained for the arm and forearm of the 27 subjects were compared using the paired Student's t test. A 'p' value of < 0.05 was considered to be significant. Pearson product-moment correlation coefficient was determined to find the relationship between the upper and forearm arterial blood pressure. SPSS 17 was used for statistical analysis.

RESULTS

This study done to compare the upper arm arterial blood pressure measured using an appropriate cuff with the forearm arterial blood pressure measured using a standard cuff in obese otherwise healthy first year medical students. The sample included 27 obese otherwise healthy first year medical students in the age group 18-19 years (9 = male and 18 = female) with an arm circumference of ≥ 32 cm and a BMI ≥ 30. It was found that there was a statistically significant difference in both systolic blood pressure [t-test (paired) = -6.921; df = 26; sig = .000 (2-tailed)] and diastolic blood pressure [t-test (paired) =

-8.508; df = 26; sig = .000 (2- tailed)] with the blood pressure readings being higher in the forearm than in the upper arm **(Table 1).**

The Pearson product-moment correlation coefficients between upper arm and forearm systolic and diastolic BPs were 0.785 (p = .000) and 0.870 (p = .000) respectively.

Table 1: Comparison of the upper arm and forearm blood pressure values of obese otherwise healthy young adults.

	Upper Arm	Forearm	Difference	't'	df	p value
	Mean± SD	Mean± SD	Mean ± SD			
Systolic Blood Pressure (mm Hg)	109.4±11.6	119.3±11.2	-9.9±7.5	-6.921	26	.000*
Diastolic Blood Pressure (mm Hg)	75.4± 8.7	83.2±9.6	-7.8±4.8	-8.508	26	.000*

Systolic and Diastolic blood pressure in mmHg expressed as mean and standard deviation, being measured in the upper arm of 27 obese otherwise healthy young adults using an appropriate cuff and in the forearm using a standard cuff, with corresponding t values and degrees of freedom; *p value of <0.05 being taken as significant.

DISCUSSION

Our study done to compare the upper arm arterial blood pressure measured using an appropriate cuff with the forearm arterial blood pressure measured using a standard cuff in 27 obese otherwise healthy first year Indian medical students revealed that both systolic and diastolic blood pressure measurements were significantly higher in the forearm. Although Schell et al too concluded that forearm and upper arm values were not interchangeable, the mean age of their subjects 52% of whom were male was 36.5 years.[8] Our findings do not agree with those of Tachovsky who found lower systolic values and higher diastolic values at the forearm in 98 female non-obese subjects aged 18 to 25 years,[9] as both systolic and diastolic blood pressure measurements were found to be significantly higher in the forearm in our study which however included both male and female obese subjects. While the correlations between upper arm and forearm systolic and diastolic BPs were 0.785 (p = .000) and 0.870 (p = .000) in our study, Singer et al found that the correlations between forearm and upper arm systolic and diastolic BPs were 0.75 and 0.72 respectively. [11] Only 40% of their subjects were female, whereas in our study, 67% were female. Latman et al however found that systolic blood pressure and heart rate correlated more closely than diastolic blood pressure with the standard. [10] While Emerick proved that blood pressure measured at the wrist consistently overestimated mean arterial, systolic and diastolic pressure by approximately 10 mmHg,[12] the difference in systolic and diastolic blood pressure in our study was 9.9 and 7.8 mmHg respectively. Obese individuals require a longer and wider cuff to adequately compress the brachial artery and hence the upper arm blood pressure measurements that we obtained using an appropriate cuff were measured as per recommendations. [5] Schell et al determined the effects of anatomical structures like limb subcutaneous tissue and vessels on the differences between forearm and upper arm forearm and suggested that upper arm vessel depth, forearm vessel diameter, and upper arm circumference explained a statistically significant portion of the difference between forearm and upper arm blood pressures. [17] This could be the reason for the differences obtained.

Our findings are in agreement with those of other researchers who specifically studied obese individuals and found that the forearm blood pressure was significantly higher, [13-16, 18] and other researchers who found the same while studying young healthy college students. [19,20] In the study by Pierin et al, [13] 116 out of 129 patients were women, in the study by Domiano et al 64% of their participants were female,[14] and 90 out of 100 subjects were female in the study by Fortune et al,[20] while in our study 67% of the participants were female. The findings of our study assume relevance in view of the observation of Chopra et al of a high prevalence of childhood obesity in India, especially in urban school going girls. [1] Forearm blood pressure measurements made using standard cuff bladders in such young obese individuals cannot be considered equal to upper arm measurements made using an appropriate sized cuff. Awareness on the need to use cuffs of appropriate sizes as per guidelines, [5] should be created in health care providers.

Limitations: Limitations of the study include the sampling of only first year medical students in one medical college, less sample size, study population consisting more of females, ethnic similarity and non-representativeness of the participants and failure to use Bland Altman plots. All the subjects of this study were first year medical students of a medical college in South India and hence may not be representative of young adults in general. Further studies can be done to overcome these limitations using random diverse samples of larger sizes, the effect of different variables can be analyzed and the data can be used to create awareness on the need to use cuffs of appropriate sizes as per guidelines while measuring upper arm blood pressure, instead of considering forearm measurements made using a standard cuff. This is especially relevant in view of the increasing prevalence of obesity in the young. The possibility of obtaining an equation to correct forearm blood pressure measurements could also be explored after further studies.

CONCLUSION

Our study done to compare the upper arm arterial blood pressure measured using an appropriate cuff with the forearm arterial blood pressure measured using a standard cuff in 27 obese otherwise healthy first year medical students revealed that both systolic and diastolic blood pressure measurements were significantly higher in the forearm. Further studies with larger sample size should be conducted to confirm that forearm blood pressure measurements using standard cuff bladders cannot be considered equal to upper arm measurements made using an appropriate sized cuff in all young obese individuals.

Conflict of interest: Nil

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