

A Comparison of Forearm and Upper Arm Blood Pressure Measurements in a Sample of
Healthy Young Adults

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Abstract

Blood pressure measurements are internationally recognized as essential parameters for monitoring change in health and illness. Health care providers are increasingly obtaining blood pressures (BP) measurements in the forearm in place of the upper arm, but clear parameters are not known for pressures taken in this location.. Based on previous studies and physics, the researchers hypothesized that BP readings will be significantly higher in the forearm than in the upper arm. Blood pressure measurements on forearms and upper arms in 100 healthy young adult volunteers and both the diastolic and systolic readings were significantly higher (6mmHg) in the forearm. Findings suggest that upper arm and forearm measurements may not be similar enough to be treated as interchangeable readings in documentation or in making clinical judgments.

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Blood pressure (BP) measurements determining states of hypertension and are part of the universal standards for monitoring people's health status in most any clinical setting. Measuring BPs in the forearm rather than the traditional upper arm locations is becoming increasingly common. Larger patients, convenience of access, and use of automatic cuffs have led to use of alternative sites, especially the lower arm or leg (Prineas, Osthega, Carroll, Dillon, & McDowell, 2007; Short, 2000) but these alternative sites may not be similar enough when compared to traditional standard measurement of the upper arm to use interchangeably. Can BP readings in the upper and lower arm be treated interchangeably as is frequently done in current nursing practice?

Purpose and Hypothesis

The purpose of this non-experimental research was to determine if significant differences existed in diastolic and systolic measurements of blood pressure in the upper arm when compared to the forearm in a sample of healthy young adults. The researchers hypothesized that both diastolic and systolic readings will be significantly higher in the forearm than in the upper arm.

Review of Literature

Seven published studies of forearm measurement accuracy were found through a literature search. The earliest published study by Tachovsky (1985) compared BP readings in of a sample of 100 nursing students by manual BP cuffs and found a significant difference in the readings of blood pressure when using the upper arm and forearm. In 1996 and 1997 two studies (Latman, Coker, & Teague; Latman & Latman) compared the automatic wrist cuff (CardioAnalysis Systems) with standard auscultatory upper arm readings and concluded that the automatic wrist measurement was reliable and accurate but to use with caution for interpreting hypertension and hypertension readings. Emerick (2002) compared BP readings of wrist and upper arm in 85 hospitalized patients and reported that the degree of difference between the two readings was so significant that the location of the readings should be indicated.

Later comparative studies measured BP readings in a sample of 84 participants who ranged in age from 18 to 76 years old found that the “wrist consistently overestimated BP taken at the arm” (Palatini et al, 2004, p.78). The researchers concluded that wrist measurements are not reliable and accurate blood pressure readings. Two more recent studies by Schell, Bradley, Bucher, Seckel, Lyons, and Wakai (2005) and Schell, Richards and Farquhar (2007) also found significant differences in readings in a sample of 225 patients and suggested that the anatomical structures could partially account for the differences in readings of the two locations.

Conceptual Framework

For this study, BP is defined as the pressure one's blood exerts against vessel walls that can be measured indirectly by either auscultation or oscillometric methods measured in millimeters of mercury (mmHg) or water. The systolic pressure represents the force against vessel walls at the peak of cardiac contraction or systole, while the diastolic represents the pressure when the heart is at rest (Porth, 2007). Inaccuracies of BP readings can potentially result from many different causes. Incorrect cuff size, position of BP (Adiyaman, Verhoeff, Lenders, Deinum, & Thien, 2006), auscultator differences (Campbell, Conradson, Brant, & Anderson, 2005), position of body (Eser, Khorshid, Yapucu, & Demir, 2007), state of health, anatomical structures (Schell, Richards, & Farqyhar, 2007) or incorrect placement of the cuff on the extremity. The best method of obtaining accurate BP readings is specific to each manufacturer's recommendations and recommendations from the American Heart Association (Pickering et al., 2005).

Two physics principles may explain the forearm and upper arm differences. The left ventricle pumps systemic blood in waves that start in the aorta and larger vessels and flow to larger numbers of smaller diameter lower pressure arterioles and capillaries (Porth, 2007). Bernoulli's principle addresses how fluid passes over the surface of a vessel. Larger vessels have faster flow and lower internal vessel pressure while smaller vessels have slower flow and greater internal vessel pressure (Van Heuvelen, 1989).

Poiseuille's law addresses the resistance and in simple terms, the smaller blood vessel branching will in turn increase the total pressure (all are summed and the total pressure of many small vessels have a greater pressure or resistance the fewer larger ones) pressure (Van Heuvelen, 1989). This law and Bernoulli's principle may partially explain why differences in BP readings are found in other areas like the upper arm as greater than the leg (Short, 2000).

Methods

Design

This research is a non-experimental group comparison study of blood pressure readings.

Sample

The convenience sample consisted of male and female students who were students at a small private liberal arts college in a metropolitan area. Many of the students are from locations that fall within a four state area of the Midwest.

Instrumentation

A Welch Allyn Spot Vital Signs 420 series automatic BP machine was used to obtain data on all subjects during the experiment. The instrument was initially calibrated by a Welch Allyn Representative to ensure accuracy. A pilot study was done to determine the accuracy and reliability of readings. Inter-rater reliability was established among the researchers who did not vary in readings by more than 2-4 mm/Hg.

Data Collection

Data were obtained over a six month period. The 100 volunteers responded to a campus-wide email. The research was approved by an IRB and informed consent was obtained from the volunteers, several brief questions were asked to obtain demographics and determine if volunteers had a pre-existing conditions and were eliminated if they had chronic disease that might have an impact on BP measurements.

The best fitting cuff was used for each participant through American Heart Association standards of the bladder length in 80% of the arm circumference and was placed directly on the skin (Pickering, et al., 2005). All BP measurements were taken with volunteers sitting and with the arm resting on a table at heart level after 5 minutes of rest. There were two-minute minimum resting periods between each BP measurement to assure reliable readings. Three blood pressures measurements were taken in the upper arm and three from the forearm. The order of taking the measurements was randomly assigned and alternated so that half of the participants had first measurements from the upper arm followed by the forearm readings and half had forearm measurements first followed by upper arm measurements.

Results

The sample was homogeneous and representative of undergraduate nursing students. Ninety percent (n=90) were women, 88% (n=88) were 30 years old or younger with the range in age from 18 to 40years. Ninety percent (n=90) identified themselves as Caucasian; ethnicity in the remaining 10% were reported 50% (n=5) Black, 10% (n=1) Asian and 30% (n=3)Hispanic with one non-Caucasian not reporting specific ethnicity. To address the hypothesis, blood pressure readings were analyzed using the Paired Student t -Test. The average readings for the systolic and diastolic readings were higher in the forearm than the upper arm by approximately 6 mmHg. Our hypothesis was supported; a statistically significant difference existed in both systolic [t-Test (paired) = 8.969; df=99; sig=<.0001 (2- tailed)] and diastolic [t-Test (paired) =9.167; df=99; sig=<.0001(2=tailed)].

Discussion

The study findings support previous research. Both the diastolic and systolic measurements were significantly higher in the forearm when compared to the upper arm in the sampled health young adults and these readings cannot be treated interchangeably. This information has implications for further research, practice, and education.

Specific criteria for acceptance of variation in methods, according to Emerick (2002) indicate that if the mean of a method exceeds 5 mmHg then the BP method cannot be used interchangeably (White et al., 1993). Therefore this study, along with previous research, casts doubt on the continued use of forearm readings.

This study should be replicated with random samples and larger groups of healthy young adults where a variety of the effects of variables could be isolated or controlled and

studied. Heterogeneous groups in larger samples can be partitioned into sub-groups to determine if there are variables, as of yet unidentified, that may be associated with or impact the readings. For example, significant reading variations may occur in obese populations, pregnant women, ethnic populations, those diagnosed with hypertension or diabetes, and different age groups.

If the results of this research, along with other studies, validate the difference in BP measurement locations, the evidence can be used as a basis for a change in current practice to include recording the BP measurement along with the site, as is current practice with temperature measurement.

For the purpose of education, this knowledge could be incorporated into the classrooms of college nursing programs and healthcare facilities, as well as part of continuing education courses. Although further comparative research and establishment of normative parameters are needed. The best practice of recording both BP reading and site is an example of the practical value of research and its potential role in changing practice.

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