Article 11

The Effects of Crossed Leg on Blood Pressure Measurement

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ABSTRACT.

Background: It is clear that numerous factors influence an individual's blood pressure measurement. However, guidelines for accurately measuring blood pressure inconsistently specify that the patient should keep feet flat on the floor.

Objective: To determine if the crossing of a leg at the knee during blood pressure measurement has an effect on the patient's blood pressure reading.

Methods: A convenience sample of 100 hypertensive male subjects was selected from various outpatient clinics in an inner-city acute-care veterans' hospital. The first 50 subjects positioned their feet flat on the floor while their blood pressure was measured. After 3 minutes, the blood pressure was measured again with the subject's leg crossed at the knee. The procedure was reversed for the second 50 subjects.

Results: The results indicated that both systolic and diastolic blood pressure increased significantly ($p < .0001$) with the crossed leg position.

Conclusion: When blood pressure is measured, patients should be instructed to have feet flat on the floor to eliminate a potential source of error.

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Blood pressure monitoring is one of the most commonly used techniques in the diagnosis and treatment of various health care problems. Accurate measurement of blood pressure is especially crucial in the assessment of hypertension. Consequently, all efforts should be made to eliminate errors in measuring blood pressure.

Numerous factors influence an individual's blood pressure measurement including medications, arm and body position, noise, extreme temperatures, constrictive clothing, faulty equipment, white-coat effect, attitude of the person taking the measurement, anxiety, improper cuff length or width, and talking. Furthermore, an individual's blood pressure varies from minute to minute, is affected by respiration and heart rate, and is under the influence of the autonomic nervous system. During the course of the day, blood pressure changes according to the degree of mental and physical activity.

Additionally, an overall diurnal variability in blood pressure has been observed. Blood pressure typically falls by approximately 15% during the night in people who are active during the day, although a lesser nocturnal decrease in blood pressure has been noted in some hypertensive subjects. During the early morning hours, some individuals exhibit an abrupt rise in blood pressure, which has been associated with cardiovascular complications (Kaplan, 1998).

Although not an acceptable practice, a single blood pressure measurement often is the basis for clinical decisions such as adjustment of a person's antihypertensive drug dosage. Thus, it is crucial to eliminate all possible sources of error in measuring a person's blood pressure (Hill & Grim, 1991).

Some guidelines for accurately measuring blood pressure specify that the patient should keep feet flat on the floor. However, research is lacking on the effect of crossing the leg at the knee during blood pressure measurement. The current study was initiated to determine if blood pressure measurement is affected by the leg crossed at the knee as compared with feet flat on the floor.

Relevant Literature

Cooper (1992), Rudy (1986), and Hill and Grim (1991) recommended that the patient keep both feet resting on the floor during blood pressure measurement. However, others do not address leg position (Anderson & Maloney, 1994; Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure [JNC], 1997). Blood pressure research typically does not control for leg po-

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sition as a measurement variable (Hellmann & Grimm, 1984; Jamieson et al., 1990).

The physiologic mechanism for the rise in blood pressure with leg crossing is a translocation of blood volume from the dependent vascular beds to the thoracic compartment. Case reports have documented the usefulness of leg crossing as a physical maneuver to maintain blood pressure in symptomatic orthostatic hypotension (Takishita, Touma, Kawazoe, Maratani, & Fukiyama, 1991; van Lieshout, ten Harkel, & Wieling, 1992; Wieling, van Lieshout, & van Leeuwen, 1993).

In the Takishita et al. (1991) and van Lieshout et al. (1992) studies, orthostatic hypotensive subjects displayed increased blood pressure when blood pressure was measured with the leg crossed at the knee. These patients experienced an alleviation of many of their symptoms, such as dizziness and lightheadedness, as a result of this increased blood pressure. However, the research findings were inconsistent in the normal comparison study group. Specifically, Takishita et al. (1991) showed no increase in blood pressure taken with the leg crossed at the knee in normal subjects. The study by van Lieshout et al. (1992) demonstrated a significant increase in blood pressure in normal subjects with the leg crossed at the knee.

Methods

Subjects were recruited from the outpatient medical clinics of a midwestern Veterans' Administration medical center. A convenience sample of 100 male patients, ages 31 to 81 years, participated in this study. All subjects had a medical diagnosis of hypertension and were taking antihypertensive medications. Hypertension was defined as a blood pressure reading of 140/90 or higher sustained for more than 1 year and diagnosed by a physician. Patients were excluded from this study if they had a history of peripheral vascular disease, lower extremity surgery, amputation of any lower extremities, or any condition that would interfere with lower extremity positioning.

Blood Pressure Measurement

Blood pressure measurements were monitored and recorded by two clinic nurses, who followed a written protocol to ensure identical technique. To exclude observer bias, the blood pressures were measured with the IVAC Vital.Check® Vital Signs Measurement System, Model 4200 (IVAC Corporation, 1989). This model is a microprocessor-based electronic instrument specifically designed to measure and display systolic and diastolic blood pressure. The blood pressure monitor is equipped with a normal adult size (24 × 42 cm) cuff and large adult size cuff (33 × 56 cm). The cuff inflation pressure range is 20–275 mmHg. The monitor was calibrated according to the *IVAC Corporation Service Manual* procedure for verification of accuracy by a biomedical technician before the study began. This blood pressure monitor was used by the nurse researchers throughout the data collection period.

Procedure

Potential subjects were identified and verbal consent was obtained. The subjects were placed in a room with a temperature of 73°F away from the noise of the clinic to control environmental stress. Each subject was instructed to remove constricting clothing (e.g., coats, sweaters, shirts). The subject was seated and encouraged to relax for a minimum of 5 minutes. After the relaxation period, the subject was instructed to place his feet flat on the floor. The subject's right arm was positioned comfortably on a table at the heart level, with the palm of the hand upward. The brachial artery was palpated, and the appropriately sized cuff was placed on the subject's right arm with the arrow directly over the brachial artery. The subject was instructed to refrain from talking or moving during the procedure. The blood pressure was measured and recorded. After a minimum of 3 minutes, the subject was instructed to cross one leg (the leg of comfort) over the knee. Then the blood pressure was measured again and recorded.

In the first 50 subjects, the initial blood pressure was measured with the subject's feet positioned flat on the floor. In the second 50 subjects, the initial blood pressure was measured with the leg crossed over the knee. For the second blood pressure measurement, the leg position was the reverse of the initial leg position.

Statistical Analysis

The model for this design was repeated measures analysis of variance (ANOVA). The two within-subjects' factors were blood pressure type (systolic and diastolic) and leg position (crossed and uncrossed leg). Statistical significance was defined as $p < .05$ for all three effects in the model (two within-subjects' factors and their interaction).

Results

Because all subjects were assumed to be taking medication for the treatment of hypertension, 16 subjects were excluded because they failed to take their medication on the day of blood pressure measurement. The blood pressure values of these subjects showed greater variability than for the remainder of the sample (Table 1). After excluding these cases, 84 subjects remained.

Examination of the appropriate diagnostic statistics (for distributions and equality of covariance matrices) revealed no violations of model assumptions. The main effect for leg crossing indicated that systolic and diastolic blood pressure, considered together, increased significantly when the leg was crossed (Table 2). The interaction owes much of its strength to the change in systolic over diastolic blood pressure across leg-cross conditions. Diastolic pressure changed by about 3.7 mmHg, from 80.24 to 83.95 mmHg, whereas systolic pressure changed at more than double that rate, 145.80 to 155.25 mmHg (Table 3).

Table 1
Systolic and Diastolic Blood Pressure Measurement by Medication Status

Medication Taken on Day of Measurement		Systolic Leg Uncrossed	Systolic Leg Crossed	Diastolic Leg Uncrossed	Diastolic Leg Crossed
No (n = 16)	*M*	150.62	157.06	84.38	89.62
	SD	25.67	25.17	13.71	12.98
Yes (n = 84)	*M*	145.80	155.25	80.24	83.95
	SD	17.02	18.20	10.61	11.13
Total	*M*	146.47	155.54	80.90	84.86
	SD	18.60	19.34	11.19	11.57

M = mean; *SD* = Standard deviation

Table 2
Repeated Measures Analysis of Variance (ANOVA)

Source	*SS*	*df*	*MS*	*F*	*p*
Blood pressure type	393,327.43	1	393,327.43	1,759.85	< .0001
Error	18,550.57	83	223.50		
Leg crossed versus uncrossed	3,640.58	1	3,640.58	66.78	< .0001
Error	4,525.42	83	54.52		
Interaction (BP type × leg crossed)	691.44	1	691.44	21.19	< .0001
Error	2,708.56	83	32.63		

Table 3
Cell Statistics

	M	*SE*	*t*	*p*	95% Confidence Interval Lower	95% Confidence Interval Upper
Systolic, leg uncrossed	145.80	1.86	78.51	< .0001	142.10	149.49
Systolic, leg crossed	155.25	1.99	78.17	< .0001	151.30	159.20
Diastolic, leg uncrossed	80.24	1.16	69.32	< .0001	77.94	82.54
Diastolic, leg crossed	83.95	1.22	69.12	< .0001	81.54	86.37

Discussion

Many patient variables affect accurate measurement of blood pressure. Procedure guidelines for blood pressure measurement inconsistently address feet position (Anderson & Maloney, 1994; Cooper, 1992; Hill & Grim, 1991; JNC, 1997; Rudy, 1986). According to the results of this study, crossing the leg during blood pressure measurement in 84 male hypertensive subjects significantly increased both the systolic and diastolic blood pressure readings ($p < .0001$).

Clinical guidelines state that blood pressure should be measured while patients are seated in a chair with back supported and arms bared and supported at the heart level (JNC, 1997). According to the findings of this study, blood pressure readings may be artificially high if measured while an individual has a leg crossed at the knee. Therefore, patients also should be instructed to keep their legs uncrossed during office and home measurements. Finally, the current authors recommend that this study be replicated on a larger sample that includes female hypertensives because the sample of all-male hypertensive veterans limits the generalizability of this study.

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Quality Ratings

Directions: Indicate your level of agreement with each of the following statements by circling a number from 5 for strongly agree (SA) to 1 for strongly disagree (SD). If you believe an item is not applicable to this research article, leave it blank. Be prepared to explain your ratings.

A. The introduction establishes the importance of the study.

SA 5 4 3 2 1 SD

B. The literature review establishes the context for the study.

SA 5 4 3 2 1 SD

C. The research purpose, question, or hypothesis is clearly stated.

SA 5 4 3 2 1 SD

D. The method of sampling is sound.

SA 5 4 3 2 1 SD

E. Relevant demographics (for example, age, gender, and ethnicity) are described.

SA 5 4 3 2 1 SD

F. Measurement procedures are adequate.

SA 5 4 3 2 1 SD

G. All procedures have been described in sufficient detail to permit a replication of the study.

SA 5 4 3 2 1 SD

H. The participants have been adequately protected from potential harm.

SA 5 4 3 2 1 SD

I. The results are clearly described.

SA 5 4 3 2 1 SD

J. The discussion/conclusion is appropriate.

SA 5 4 3 2 1 SD

K. Despite any flaws, the report is worthy of publication.

SA 5 4 3 2 1 SD

Research Critique Worksheet:

Title of Article: ____

Author(s):_______________________________________Journal:_______________________Mo/Yr:____________________________Pages:______________________________ ____________________________

Reviewer:_______________________________________Mentor:_______________________Date:____

Level I Research Design	**Level II Research Design**	**Level III Research Design**	**MAJOR FINDINGS/STRENGTHS/LIMITATIONS**
Purpose of study: Research Questions: Research Variable: Research Design (Qualitative Non-experimental): Ethnography Phenomenology Grounded Theory	Purpose of study: Research Questions/Associative Hypothesis: Independent Variable: Dependent Variable(s): Research Design (Quantitative Non-experimental): Correlational (ex post facto) Comparative Case-control Cohort	Purpose of study: Research Questions/Causal Hypothesis: Independent Variable(s): Dependent Variable(s): Research Design (Quantitative Experimental): True Experimental (Random Controlled Trial) Quasi-Experimental	Findings: Strengths: Limitations:
SAMPLE	**MAJOR TOOLS (Quantitative)** **Level II-III Research Design**	**Systematic Reviews/Meta-analysis/Guidelines**	**QUALITY OF EVIDENCE**
Number (N): Type of sampling plan: Age: Gender: Health status: Diagnosis: Other: **SETTING** Type: Acute care hospital Community Nursing Home Other Location: Urban Rural	Name(s): #1 ________________________ #2 ________________________ #3 ________________________ Reliability: #1 ________________________ #2 ________________________ #3 ________________________ Validity: #1 ________________________ #2 ________________________ #3 ________________________	**Systematic Review:** Research Question: Independent Variable(s): Dependent Variable(s): **Meta-Analysis:** Research Question: Independent Variable(s): Dependent Variable(s): **Guidelines:** Purpose: Clinical Question:	Evidence Rating: Level I: Evidence from a systematic review or meta-analysis of mostly randomized controlled trials (RCT, experimental studies) or evidence-based clinical practice guidelines based on systematic reviews of experimental studies that are RCTs Level II: One well-designed RCT (true experimental study) Level III: Well-designed controlled trial without random assignment to group (quasi-experimental study) Level IV: Well-designed case-control or cohort study Level V: A systematic review of descriptive and qualitative studies (nonh-experimental quantitative or qualitative studies) Level VI: One descriptive or qualitative study (non-experimental quantitative or qualitative) Feasibility: Could this practice change be implemented easily in your organization and with minimal resources?______________Yes ___________________No Benefit/Risk: Would the benefits of this practice change outweigh The risks to patients? ________________Yes ___________________No Comments:

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RESEARCH DESIGNS

Research Level and Design	Conceptual Base	Purpose	Research Question	Research Strategies	Sample	Data Analysis
Level 1 – Qualitative, non-experimental Ethnography – investigation of cultures Phenomenology – describe experiences as the experiences are lived Grounded Theory – discovering what problems exist in a social scene	Little or no knowledge about the topic. Some knowledge of the variable, but variable has not been studied in a particular population.	Describe the dimensions of the one variable. Generate new theory.	What are the livid experiences of those who have survived a man-made disaster?	Observations Participant observation Open-ended interviews	Non-probability – no random selection of the sample. Small size. Subjects have experience with the topic.	Content analysis of words Descriptive analysis of the sample (frequency, percentage, mean, median, mode, standard deviation,, and other data analysis of the sample)
Level II – Quantitative, non-experimental Correlational (ex post facto) – investigation of relationships between two or more variables Comparative – describe differences in variables in two or more groups in a natural setting Case Control – comparison of a "case" such as persons with lung cancer with matched controls (similar but no lung cancer) Cohort – defined groups of people (cohorts) followed over time to study outcomes	Literature on variables but action of the variables cannot be predicted.	Test the relationship (differences, correlation, associations) between two or more variables. Test theory Test associative hypothesis(es)	What is the relationship between social support and dying patients' degree of hopelessness? What is the difference between men and women's feelings of hopelessness?	Multiple measurements with reliable and valid instruments. Self-report questionnaires Observation data collection Biophysiological data collection	Non-probability – no random selection of the sample. Probability – random selection of the sample As large as possible	Univariate descriptive statistics (frequency distributions, histograms, central tendency) Bivariate descriptive statistics (contingency table, Pearson's *r*) Multivariate statistics to analyze the relationships among three or more variables (multiple regression, ANCOVA) *t*-test – two groups ANOVA – three or more groups Chi square - proportions
Level III – Quantitative, experimental True experimental – There is manipulation of the independent variable (treatment; intervention), a control group, and random assignment to group. Quasi-experimental – There is manipulation of the independent variable (treatment; intervention) and either a control group or random assignment to group.	Previous research on relationships of variables. Action of variables can be predicted from the theoretical framework.	Explain and predict cause and effect relationships between the variables. Test theory Test causal hypothesis(es)	What is the effect of palliative care program on hopelessness in a dying patient?	Same as above.	Non-probability – no random selection of the sample. Probability – random selection of the sample As large as possible Statistical calculation of size (power analysis)	Same as above.

Opinion of Authorities and/or Expert Committee Articles
(Level VII: Hierarchy of Evidence)

Title of Article:____

Author(s):______________________________Journal:__________________Mo/Yr:______________________Pages:____________________________

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Purpose of Article:
Summary of Major Points:
Comments:

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