INSTRUCTIONAL DESIGN AND ASSESSMENT

Evaluation of Pharmacy Students' Blood Pressure and Heart Rate Measurement Skills After Completion of a Patient Assessment Course

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Objectives. To evaluate pharmacy students' skills at measuring brachial artery blood pressure and radial heart rate at the completion of a patient assessment course in the second-professional year of a doctor of pharmacy (PharmD) program.
Methods. Students enrolled in a required patient assessment laboratory course (n = 83) participated in this study. Each student was randomly matched with a classmate and manually measured the classmate's blood pressure by auscultation of the brachial artery and heart rate by palpation of the radial pulse.
Results. The student-device absolute disagreement was 6.5 ± 4.8 mmHg for systolic blood pressure (SBP), 6.2 ± 4.5 mmHg for diastolic blood pressure (DBP), and 5.3 ± 4.0 beats per minute (BPM) for heart rate. Student and machine measurements of SBP, DBP, and HR significantly correlated.
Conclusions. Pharmacy students in the second-professional year of a PharmD program demonstrated competence in but not mastery of manual blood pressure and heart rate measurement. These skills need further refinement during third- and fourth-professional year APPEs.

Keywords: vital signs, blood pressure, heart rate, physical assessment, pharmacy students

INTRODUCTION

New accreditation standards and guidelines for doctor of pharmacy degree programs in the United States were adopted on January 15, 2006, by the Accreditation Council for Pharmacy Education.[1] Standard number 15 of the new guidelines addresses "Assessment and Evaluation of Student Learning and Curricular Effectiveness." Guideline 15.2 under this standard states: "A system of evaluation of curricular effectiveness must be developed that, in general, should... foster data-driven continuous improvement of curricular structure, content, process, and outcomes." To this end, members of the *Patient Assessment* course teaching team at the Texas Tech School of Pharmacy proposed a data-driven assessment of the accuracy of 2 skills attained by second-professional year pharmacy students near the completion of this course. These skills were manual blood pressure measurement and heart rate measurement taken by palpation of a radial pulse.

A 1995 survey of physical assessment course offerings in US schools and colleges of pharmacy revealed that 75% of responding entry-level doctor of pharmacy (PharmD) degree curricula had offered a separate course devoted to this topic.[2] Sixty percent of the programs responding to this survey indicated that students are required "...to demonstrate competency in the use of a stethoscope, sphygmomanometer, ophthalmo-/otoscope, tuning fork, and reflex hammer."[2] However, only 37.5% of these programs had a formal mechanism for evaluating these skills. Unfortunately, the survey instrument did not solicit information about how such competencies were assessed.

A survey of community and hospital pharmacists who also served as preceptors for the St Louis College of Pharmacy revealed several perceived areas in which student competencies needed improvement.[3] According to this survey, the preceptor assessment of student competencies on a 5-point Likert scale (1 = low competency to 5 = high competency) included a mean score of less than 3 for only 2 skills: use of home diagnostic devices (mean 2.9) and physical patient assessment (mean 2.8). With this feedback in mind, the authors revised the pharmacy practice laboratory in order to enhance, among other things, patient assessment skills. This study provided an excellent example of a subjective instrument to improve instructional design. The goal of our study was to improve

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objective instructional assessment of student skills and then similarly use this information as a tool to improve instructional design. To our knowledge, accuracy of manual blood pressure and heart rate measurements by pharmacy students has not been evaluated.

METHODS

The Texas Tech University Health Sciences Center (TTUHSC) School of Pharmacy has offered a 4-year doctor of pharmacy (PharmD) degree as its single professional degree since the first class was admitted in 1996. The *Patient Assessment* course is a 2 semester-credit hour course in the spring semester of the second-professional year. Upon completion of this course, a successful student is able to obtain a medical and medication history, evaluate that history in the context of physical examination and laboratory findings, identify drug-related problems, and develop a pharmaceutical care plan with the goal of improving health outcomes of the patient. Among the physical examination skills taught in this course, vital signs are especially emphasized. The process of teaching these vital sign skills in *Patient Assessment* course involves a didactic lecture on technique, a laboratory session solely focused on practicing vital sign techniques with their peers, 7 laboratory sessions where vital sign skills are rehearsed in addition to other skills with their peers, 2 midterm examinations whereby student skills are demonstrated and assessed by faculty members' direct observation and using a procedure checklist, and 2 laboratory sessions in which students practice these skills on standardized patients who follow a script. All laboratory sessions and midterms are facilitated and evaluated by faculty members.

This study was approved by the TTUHSC Institutional Review Board for the Protection of Human Subjects (IRB number: A06-3310). Students enrolled in a patient assessment laboratory course (n = 83) participated in this study. The study was conducted during laboratory sessions in the 15th week of the course. Students were randomly matched with a classmate by drawing numbers. After a brief orientation, each student manually measured the classmate's blood pressure by auscultation of the brachial artery and heart rate by palpation of a radial pulse over 1 minute. These values were recorded. Next, the blood pressure and heart rate were measured by an Omron 711-AC automatic monitor and these results were recorded. Students were instructed to take the measurements manually prior to using the machine in order to avoid introducing any bias that could have resulted from students seeing the machine's readings before taking the measurements manually. The Omron 711-AC monitor has been tested for accuracy with 2 protocols: the Association for the Advancement of Medical Instruments and the International Protocol of the European Society of Hypertension.[4-6] In March 2001, the European Society of Hypertension recommended the Omron HEM-737 monitor (the European equivalent to the Omron 711-AC).[6] The accuracy of the Omron 711-AC is ±3 mmHg or 2% for blood pressure and ±5% for heart rate.[7] The manual blood pressure equipment consisted of an Omron Cardiology III stethoscope and an Omron blood pressure cuff with aneroid manometer. The blood pressure cuff manometers were inspected the week of the study and quality checked by connecting them via a Y tube with a mercury gravity sphygmomanometer.[8] Both the manual and automatic measurements were taken with the same cuff size, in the left arm, while the student was in a seated position, and in accordance with manufacturer's instructions. All activities were supervised by faculty members.

Statistical Analysis

Student and machine measurements were transcribed into *SPSS* 11.5. All student data were de-identified. Basic descriptive statistics including means, standard deviations, and percentages were produced. Inferential statistical tests were also employed. Means were compared using a *t* test. Pearson correlation and linear regression were used to evaluate associations between student and machine measurements. A chi-square test was used for goodness of fit tests.

RESULTS

Eighty-three students (100% of class enrollment) in the *Patient Assessment* course participated in the study. The mean student-measured systolic blood pressure (SBP) was 122 ± 12 mmHg and the mean diastolic blood pressure (DBP) was 77 ± 9 mmHg. Mean heat rate (HR) readings were 79 ± 13 beats per minute (bpm). The mean SBP, DBP, and HR readings as measured by the Omron 711-AC were 122 ± 13 mmHg, 75 ± 8 mmHg, and 83 ± 15 bpm, respectively. The ranges of SBP, DBP, and HR values as measured by the Omron 711-AC were 85 to 161 mmHg, 54 to 100 mmHg, and 54 to 137 bpm, respectively. The ranges of student-measured SBP, DBP, and HR values were 98 to 156 mmHg, 60 to 100 mmHg, and 58 to 128 bpm, respectively. The distributions of the machine-measured and student-measured variables were approximately normal, as verified by Normal P-P plots.

There was a significant correlation between student and machine measurements of SBP, DBP, and HR (r = 0.793, 0.624, and 0.919, respectively; $p < 0.001$ for each). The student-device disagreement was 6.5 ± 4.8 mmHg for SBP (range 0-18), 6.2 ± 4.5 mmHg for DBP (range 0-20), and 5.3 ± 4.0 bpm for HR (range 0-18). The cumulative percentage of student readings agreeing to within 5, 10, 15, and 20 units (mmHg or bpm) of the machine are presented in Table 1. Applying the British Society of Hypertension grading criteria, the agreement between the student and device measurements rated a grade of B for systolic blood pressure measurement, a grade of C for diastolic blood pressure measurement, and a grade of B for heart rate measurement (Table 2).[9] Forty-five of 83 (54%) SBP readings by students were below the Omron measurement ($p = 0.27$). Forty-nine of 83 (59%) DBP readings by students were above the Omron measurement ($p = 0.08$). Fifty-nine of 83 (71%) HR readings by students were below the Omron measurement ($p < 0.001$), which indicated a significant student underestimation of HR.

In order to evaluate differences between machine and student measurements over the range of blood pressure and heart rate values, we plotted each machine reported variable (SBP, DBP, or HR) against the absolute difference between the machine and student measurement of that variable. The machine-reported SBP was not significantly correlated with the absolute difference between machine and student SBP readings ($r = 0.209$; $p = 0.057$). Likewise, the machine-reported DBP was not significantly correlated with the absolute difference between machine and student DBP readings ($r = -0.123$; $p = 0.267$). However, the machine reported HR was significantly correlated with the absolute difference between machine and student HR readings ($r = 0.390$; $p < 0.001$). This positive correlation fit a linear regression model such that for every increase in HR of 10 bpm as measured by the machine, the absolute difference between student and machine readings increased by 1.1 bpm. Thus, for every 10 pulse beats measured by the machine, the students detected approximately 9 pulse beats.

Table 1. Difference Between Blood Pressure and Heart Rate Measurements Obtained by Pharmacy Students Manually and Using a Machine

	Absolute Difference Between Student and Machine Measurements (%)				
Vital Sign	≤5 units	≤10 units	≤15 units	≤20 units	Grade*
SBP (mmHg)	51	76	95	100	B
DBP (mmHg)	47	84	95	100	C
HR (bpm)	59	88	99	100	B

*British Society of Hypertension grading criteria
SBP = systolic blood pressure; DBP = diastolic blood pressure; HR = heart rate

Table 2. British Society of Hypertension Grading Criteria for Blood Pressure and Heart Rate Measurements*

	Cumulative Percentage of Readings Agreeing to Within 5, 10, and 15 mmHg of the Standard		
Grade	≤5 mmHg	≤10 mmHg	≤15 mmHg
A	60	85	95
B	50	75	90
C	40	65	85
D		Worse than C	

*For each grade, all 3 percentages must be greater than or equal to the values shown

The number and percentages of the final digits recorded by students for the manual measurement of SBP and DBP are presented in Table 3. Since the aneroid dial of the blood pressure cuff is marked in even number increments, the final digit of the SBP and DBP values should not be an odd number. Based on the assumption that each of the 5 even-number final digits should be equally likely to occur, a goodness of fit test revealed that the distribution of final digits for SBP did not significantly differ from a uniform distribution ($p = 0.192$). However, the distribution of final digits for DBP did significantly differ from a uniform distribution ($p = 0.032$).

DISCUSSION

Blood pressure and heart rate measurements are a routine and vital component of patient assessment. Unfortunately, in many healthcare settings, these measurements are performed by those with the least training. Furthermore, quality control related to equipment selection, equipment calibration, and personnel training are often less than ideal. For example, a survey of 105 healthcare professionals (predominantly nurses and physicians) revealed that calibration of sphygmomanometers was performed "when a defect occurs" by 58% of respondents and "ignored" by 33% of respondents.[10] Additionally, only 7 of these 105 healthcare professionals were observed selecting an adequate cuff size based upon the circumference of the patient's arm.[10] Given the challenge of controlling blood pressure as reported in the National Health and Nutrition Examination Survey (NHANES) results, improved attention to equipment quality and personnel performance should be emphasized.[11]

In past years as well as the current year of the *Pharmacy Assessment* course, student BP and HR skills were assessed by student demonstration and faculty observation against a procedure checklist adapted from American Heart Association recommendations.[8,12] The vast majority of students performed this type of assessment perfectly. However, the new assessment described in this study involving a comparison between student and

Table 3. Comparison of Final Digits of Manually Obtained Blood Pressure Readings to Determine Whether Pharmacy Students' Results Reflected a Uniform Distribution of Data (N = 83)

	Final Digits, No. (%)							
Measure	**0**	**2**	**4**	**6**	**8**	**Odd**	**Total**	***P***
SBP	16 (19.3)	21 (25.3)	17 (20.5)	8 (9.6)	19 (22.9)	2 (2.4)	83 (100)	0.192
DBP	23 (27.7)	22 (26.5)	9 (10.8)	10 (12.0)	17 (20.5)	2 (2.4)	83 (100)	0.032

SBP = systolic blood pressure; DBP = diastolic blood pressure

machine measurements reveals significant room for improvement in skill mastery. As a class, students were unable to score an "A" grade for accuracy of SBP, DBP, and HR measurements.

Student measurement of HR more closely correlated to the machine reading than SBP and DBP. The mean student-device disagreement was lower for HR (5.3 bpm) than SBP (6.5 mmHg) or DBP (6.2 mmHg). Furthermore, a greater percent of student HR readings were within 5 units of the machine reading compared to SBP and DBP measurements. These observations are intuitive since the skill of measuring a HR via palpation of the radial artery is less complex than the skill of measuring a SBP and DBP via auscultation of the brachial artery.

Student measurement of DBP less closely correlated to the machine reading than SBP and HR. Furthermore, a lesser percent of student DBP readings were within 5 units of the machine reading compared to SBP and HR measurements. Consequently, DBP measurement by students received the lowest grade on the British Society of Hypertension grading criteria. This observation is consistent with the distribution of the final digits for DBP as measured by students not being uniformly distributed across all even numbers. Altogether, this may indicate the area in greatest need of improvement in blood pressure and heart rate measurement among these students is the DBP reading. Common problems in BP measurement that cause inaccurate DBP readings include digit preference or bias, inappropriate cuff size, a too slow inflation rate, and a too fast deflation rate.[8,12]

The *Pharmacy Assessment* teaching team is considering several course revisions based upon the results of this study. These revisions include more facilitators per laboratory session to improve skill-based teaching and a BP and HR accuracy assessment at the midterm of the course to provider earlier feedback and more opportunity to improve. Purchase of a mannequin arm with programmable SBP, DBP, and HR settings is begin considered. Also, more standardized patient activities may need to be added to the course to improve the application and mastery of these skills. The TTUHSC School of Pharmacy will also consider adding BP and HR measurement to the annual student assessment as described in previous publications.[13,14]

The validity of the study may have been improved if students measured a BP and HR of a standardized patient rather than a classmate, especially if these standardized patients had been screened to include individuals with a wide range of BP and HR values. Another area of potential improvement in study design would have been to compare the student measurements to 2 or 3 measurements taken by clinicians rather than to machine measurements. These improvements would have required additional resources that were not available in the course at that time. In order to verify the consistency of the Omron 711-AC monitor, 2 sequential measurements could be taken after each manual measurement. This would allow for an evaluation of the level of agreement between the 2 machine readings. Although both devices are used commonly in practice, a mercury sphygmomanometer may have been preferred to an aneroid manometer for manual BP measurement as it is the gold standard.[8,12] Aneroid manometers are more portable than mercury-gravity manometers and can provide accurate measurements if properly calibrated.[8]

Although limited in scope, the value of this study must be placed in context with several factors. Approximately 50 million Americans have hypertension and the prevalence of this condition is increasing.[11,15] Based upon the 1999-2000 NHANES survey, only two thirds of these patients are aware of their hypertension and less than one third are controlled.[11] In several studies, pharmacists have demonstrated models of care that improve outcomes among patients with hypertension.[16-24] In order to implement these models of care on a larger scale, pharmacy students must demonstrate mastery of certain skills. Accurate and reliable blood pressure measurement is such a skill. The results of this study's assessment of student learning reveals room for improvement in course design and curricular effectiveness.

CONCLUSIONS

Near the completion of a patient assessment course, pharmacy students were unable to score a grade of "A" for accuracy of SBP, DBP, and HR measurements. The area in greatest need of improvement was the DBP reading. Several course improvements are suggested. The addition of BP and HR measurement in the annual student assessment is also proposed and would evaluate the improvement of these skills as students advance through third- and fourth-professional year clerkships.

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