Mechanisms of Blood Pressure Measurement Inaccuracy: A Comparative Analysis of the Role of Occupation and Attire

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Abstract

Objectives: White coat hypertension (WCH) is defined as high blood pressure (BP) when measured by health care providers in medical environments, but normal BP in other settings. In this study, we examine the effects of occupation and attire on the accuracy of BP readings and WCH.

Methods: 50 individuals were recruited and had their BP assessed twice by a cardiologist, a cardiac nurse, and a cardiovascular technician, once wearing a white lab coat, and once without, in random order. All individuals underwent a 24 hour ambulatory BP monitoring (ABPM). The mean of the daytime measurements of the ABPM served as the control.

Results: Compared to the ABPM, the cardiologist recorded a 23.7 mm Hg higher systolic BP reading wearing a white coat and 13.3 mmHg without a white coat (p<0.0001). The cardiac nurse recorded a 14.2 mmHg higher reading with a white coat and 5.7 mmHg without a white coat (p<0.0001). There was no statistically significant difference between the measurements of the cardiovascular technician and the ABPM with a white coat, 2.8 mmHg, or without a white coat, -1.8 mmHg.

Conclusions: This study demonstrates that the incidence of WCH and BP measurement inaccuracy occurs more frequently when assessed by a cardiologist or nurse than when assessed by a cardiovascular technician. Wearing a white coat aggravates blood pressure measurement inaccuracy. It may be advisable for healthcare providers to avoid wearing white lab coats or attire that identifies their occupation when measuring blood pressure.

Keywords: White coat hypertension; Blood pressure; Accuracy; Attire; Occupation

Introduction

White Coat Hypertension describes individuals with elevated BP in medical environments, such as clinics or hospitals, but whose BP is normal when they are going about their daily activities [1-6]. 24-hour ambulatory blood pressure monitoring (ABPM) using an automated machine that records BP every 30 minutes while awake and every 60 minutes while asleep has been determined to be the most accurate method for BP recording [6-10]. It is also the most accurate method to distinguish White Coat Hypertension from “true” hypertension, because it records BP elevations that occur regardless of the external environment [6]. Due to barriers such as cost and a lack of availability, ABPMs are not readily available in many jurisdictions, and often blood pressure measurements taken by health care providers, conventionally nurses or physicians, are used for clinical diagnosis and treatment [11,12].

Prior studies show that White Coat Hypertension occurs in more than 20% of the hypertensive population, with some studies citing its incidence to be above 40% [1-6,13]. In such patients, the BP elevation responses in a medical setting may lead to misclassification and mistreatment of patients [1-6,13-18]. Studies show that individuals with white coat hypertension have a significantly lower number of cardiovascular events than true hypertensive, but a higher number of events than normotensive patients without white coat hypertension [1,14-18]. Thus, it is important to distinguish the difference between these three groups: true hypertensive, white coat hypertensive, and true normotensives.

This study assessed whether the profession and attire of the individual measuring the BP impacted the incidence of White Coat Hypertension. The specific question asked in this study was “How does the accuracy of BP recordings by a physician, a nurse and a technician compare to the ABPM gold standard and what is the impact of wearing a white lab coat on the accuracy of BP measurements and the incidence of white coat hypertension?” The environment, time of day, method of BP measurement, and device used to measure BP were all controlled variables in this study.

Methods

Design

This was a single-centre, observational study of 50 consecutive volunteers over a period of 4 months.
Data collection
Baseline demographics, including age, gender, education levels, disease states, presence or absence of the diagnosis of hypertension, duration of hypertension, medications, height, weight, abdominal girth, BP readings by each healthcare provider with and without wearing a white lab coat, and 24 hour BP readings using ABPM were collected.

Subgroup analysis
We pre-specified specific subgroups for analysis to determine if they may be at a higher risk for WCH. These subgroups included males, females, non-elderly, elderly, extreme elderly (80+), normotensives, hypertensive for less than 1 year, hypertensive for more than one year, those with secondary education or less education and those with post-secondary education. The average results of the BP measurements in each of these groups were compared to the average results of the entire study population.

Statistical analysis
Statistical analysis was performed using Graphpad Instat 3.10 Statistical Analysis software. Paired, two-tailed Students t-tests were used for comparisons of two variables, such as the difference between the measurements of the physician with a white coat vs. the measurements of the physician without a white coat. ANOVA with Bonferroni correction was used for all comparisons with three or more variables with multiple comparisons, such as the subgroup analysis performed. A p-value of 0.05 or less was considered statistically significant.

Results
No study participants dropped out, or withdrew consent at any point in the study.

Figure 1 displays a direct comparison between the average BP measurements of the physician, technician and nurse, compared to the control ABPM. This analysis was performed with the data from both measurements taken with, and without a white lab coat. The physician was observed to have the most inaccurate BP readings, with an average systolic BP reading 23.7 mmHg higher than that of the ABPM while wearing a white lab coat, and 13.3 mmHg higher while not wearing a white lab coat (p<0.0001 versus ABPM control). Through a paired, two-tailed Student’s t-Test, a p-value of less than 0.0001 was obtained. The nurses’ readings were modestly more accurate, with an average systolic BP reading 14.2 mmHg higher than that of the ABPM while wearing a white lab coat, and 5.7 mm Hg higher while not wearing a white lab coat (p<0.0001 versus ABPM control). The technician was observed to have the most accurate BP readings, with an average systolic BP reading 2.8 mmHg higher than that of the ABPM, while wearing a white lab coat, and 1.8 mmHg lower than that of the ABPM while not wearing a white lab coat (p=NS versus ABPM control). There was no statistically significant difference between the results of the ABPM and those of the technician.

Figure 1 illustrates that wearing a white lab coat appeared to result in elevations of blood pressure readings by all health care providers resulting in greater inaccuracy compared to the ABPM control. The difference between the average systolic BP measurement of the physician wearing a white lab coat, and the average BP measurement of the physician not wearing a white lab coat was 10.4 mmHg.
The difference between the average systolic BP measurement of the nurse wearing a white lab coat, and the average BP measurement of the nurse not wearing a white lab coat was 8.5 mmHg (p=0.002). The difference between the average systolic BP measurement of the technician wearing a white lab coat, and the average BP measurement of the technician not wearing a white lab coat was 4.0 mmHg (p=0.02).

Figure 1: Average BP readings of physicians, nurses, and CVTs with and without a white lab coat compared to control ABPM. This graph shows a comparison between the BP measurements of various health care providers compared to the daytime readings of a 24-hour ambulatory blood pressure monitor in 50 patients. Health care providers measured the blood pressure twice using a standardized method; once with a white lab coat, and once without. These results are displayed in separate columns. Abbreviations- ABPM: Ambulatory Blood Pressure Monitor, BP: Blood Pressure, CVTs: Technicians, mmHg: Millimeters of Mercury.

Figure 2 illustrates a comparison of percentage of accurate blood pressure readings, defined as a systolic blood pressure reading within 5 mm Hg of the reading of the ABPM. The physician was observed to have recorded the fewest percent of accurate BP readings. Only 14% of readings while wearing a white lab coat, and 38% of readings while not wearing a white lab coat by the physician were within 5 mmHg of the daytime readings of the ABPM. 42% of readings while wearing a white lab coat, and 68% of readings while not wearing a white lab coat by the nurse were within 5 mm Hg of the daytime readings of the ABPM. The technician was observed to have recorded the greatest percent of accurate BP readings. 86% of readings while wearing a white lab coat, and 90% of readings while not wearing a white lab coat by the technician were within 5 mmHg of the daytime readings of the ABPM.

Sub-group analysis stratified by age, gender, and individuals with comorbidity disease states (prior MI, CHF, COPD, AFIB, Stroke, and Renal Failure), as well as sub-groups stratified based on the amount of BP medications prescribed, were observed to have similar results to that of the entire study population (p<ns.).

Educational status (Figure 3) and prolonged history of hypertension (Figure 4) did appear to affect the differences in blood pressure readings of various health care providers. Individuals with post-secondary education had similar blood pressure readings by all 3 types of health care providers. These readings were also closer to the readings obtained by the ABPM. Similarly, individuals with a history of hypertension of longer than one year’s duration appeared to have fewer differences in BP readings by the various health care providers.

The percentage of individuals each healthcare provider caused to be white coat hypertensive was additionally analysed (Figure 5). Patients whose BP was greater than or equal to 140/90 mmHg when assessed by a healthcare provider but less than 135/85 mmHg compared to the daytime readings of the control ABPM were classified as white coat hypertensive.
Physicians caused 33% of participants while wearing a white lab coat and 24% of participants while not to be white coat hypertensive. Nurses caused 24% of participants while wearing a white lab coat and 15% of participants while not to be white coat hypertensive. Technicians caused 6% of participants while wearing a white lab coat and 0% while not to be white coat hypertensive (p<0.0001).

Discussion

Sources of error

Participants were informed in advance of each health care provider’s occupation; however visual differences, such as gender, size and age of the health care provider may have impacted the results.

This study was conducted in a random group of individuals with varying BPs. Some were normotensive, some were mildly hypertensive and some were severely hypertensive. This resulted in a great deal of variability and large standard deviations for the average or mathematical means of BP readings as taken by the ABPM device as well as the various health care providers.

Conclusion

The accuracy of systolic BP readings varied based on the type of health care provider taking the BP measurements and independently whether the health care provider wore a white lab coat or not.

The measurements taken by the physician were the most erroneously elevated when compared to the gold standard ABPM. Readings taken by the technician were closest to the ABPM. Readings by the nurse were intermediate in accuracy; closer to the ABPM readings than the physician, although not as accurate as the technician. Similarly, in the second analysis, the physician recorded the fewest number of accurate readings (within 5 mmHg of the ABPM). The nurse recorded an intermediate amount of accurate readings, and the technician recorded the largest percentage of accurate readings, with only 10% of all readings without a white coat diverging greater than 5 mmHg from those of the ABPM. Potential explanations of the observed results may include that patients may be more stressed or
The inaccuracy of the blood pressure readings was further exaggerated when each of the health care providers wore a white lab coat. Similarly, the number of accurate readings (within 5 mmHg of the ABPM) was significantly less when each of the health care providers wore a white lab coat compared to when they did not. An explanation for these results may be that individuals develop more stress and anxiety when a professional sporting a white lab coat. Similarly, the number of accurate readings (within 5 mmHg of the ABPM) was significantly less when each of the health care providers wore a white lab coat compared to when they did not. An explanation for these results may be that individuals develop more stress and anxiety when a professional sporting a white lab coat.

All but two sub-groups displayed similar trends to those of the entire study population. Individuals with a history of hypertension for more than one year had significantly more accurate recordings by all health care providers, compared to those with less than post-secondary education. Perhaps people with less education may be more intimidated by health care providers.

This data suggests that perhaps health care facilities should have blood pressures measured, where possible, by technicians rather than nurses or physicians to ensure more accurate readings. Also, it may be advisable for health care providers measuring blood pressure to refrain from wearing a white lab coat or attire that identifies the occupation of the measurer to reduce erroneous results.

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