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Factors Overlooked in Blood Pressure Measurement: The Effect of Back, Feet and Arm Support

Kan Basıncı Ölçümünde Gözden Kaçan Faktörler: Sırt, Ayak ve Kol Desteğinin Etkisi

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ABSTRACT

In the guidelines, it is recommended that the patient's back should be supported, that the lower part of the arm should be supported at the heart level, and the feet should be kept flat on the floor. However, the effects of errors stemming from ignoring these recommendations are unknown because the number of studies conducted on this issue is limited. In this study, the authors aimed to investigate the effect of arm, back and feet support on blood pressure values during blood pressure measurement in healthy individuals.

In the study, 111 individuals were included. Their mean age was 21.95±1.57 years. Their systolic and diastolic blood pressures were measured using four measurement procedures, three of which were erroneous measurements (feet without support, back without support, and arm without support) and one of which was the standard procedure recommended by the guidelines. Procedures were randomized and the participants' blood pressures were measured three times for each procedure.

While the mean systolic values determined with the measurements performed without feet support and back support were higher than were those determined with the standard measurements (t=-4.872, p<0.001 and t=-2.152, p=0.034, respectively), the mean diastolic value determined with the measurement performed without feet support was higher than was that determined with the standard measurement (t=-5.635, p<0.001). According to the results of the study, the mean systolic/diastolic blood pressure values measured when the feet and the back were left unsupported were higher than were those measured by the standard procedure.

Keywords: Blood pressure measurement, Unsupported arm, Unsupported back, Unsupported feet.

ÖZ

Kılavuzlarda hastanın sırtının desteklenmesi, kolun alt kısmının kalp hizasında desteklenmesi ve ayakların yere düz basması önerilmektedir. Ancak bu konuda yapılan çalışma sayısı sınırlı olduğundan, bu önerilerin dikkate alınmamasından kaynaklanan hataların etkileri bilinmemektedir. Bu çalışmada sağlıklı bireylerde kan basıncı ölçümü sırasında kol, sırt ve ayak desteğinin kan basıncı değerlerine etkisinin araştırılması amaçlandı.

Araştırmaya 111 kişi dahil edildi. Katılımcıların ortalama yaşları 21.95±1.57 idi. Sistolik ve diyastolik kan basınçları, üçü hatalı ölçüm (desteksiz ayaklar, desteksiz sırt ve desteksiz kol) ve biri kılavuzların önerdiği standart prosedür olan dört ölçüm prosedürü kullanılarak ölçüldü. Prosedürler randomize edildi ve katılımcıların kan basınçları her prosedür için üç kez ölçüldü.

Ayak desteği ve sırt desteği olmadan yapılan ölçümlerde belirlenen ortalama sistolik değerler, standart ölçümlerle belirlenenlerden daha yüksek olduğu belirlendi (sırasıyla t=-4.872, p<0.001 ve t=-2.152, p=0.034). Ayrıca ayak desteği olmadan yapılan ölçümde belirlenen diyastolik değer, standart ölçüme göre yüksek bulundu (t=-5.635, p<0.001). Araştırma sonuçlarına göre ayaklar ve sırt desteksiz bırakıldığında ölçülen ortalama sistolik/diyastolik kan basıncı değerleri standart prosedürle ölçülenlerden daha yüksekti.

Anahtar Kelimeler: Desteksiz ayak, Desteksiz kol, Desteksiz sırt, Kan basıncı ölçümü.

This study was created from a doctoral thesis. Institutional permission was obtained from Ege University Faculty of Nursing, where the research was conducted, and ethics committee approval was obtained from the Scientific Research and Publication Ethics Board (EGEBAYEK).

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INTRODUCTION

Blood pressure measurement is the first step in the diagnosis and treatment of hypertension.[1, 2] Errors in the blood pressure measurement process are often overlooked, which can lead to an incorrect assessment of the blood pressure level of the patients.[3,4] While high measurements of 5 mmHg in systolic and diastolic blood pressures due to incorrect measurement methods increases the number of patients with misdiagnosis by 26% and 73%, respectively, a low measurement of 5 mmHg in systolic and diastolic blood pressures may cause 21% and 47% of patients who should be diagnosed with hypertension to be missed.[5] Due to such erroneous measurements, patients who should receive treatment do not receive treatment, or patients who should not receive treatment may receive treatment unnecessarily.[5, 6]

If blood pressure, which is one of the most common practices carried out by nurses and other health personnel, is to be measured in accordance with correct techniques and principles, it is of great importance to address common and often overlooked mistakes.[1, 3, 7, 8] Standardization of these variables and their compliance with the principles, which may cause deviations in blood pressure values, are important in terms of hypertension diagnosis criteria.[9,10] In the guidelines, it is recommended that while the patient's blood pressure is measured in a sitting position, the patient should lean his or her back against somewhere or his or her back should be supported, that the lower part of his or her arm being measured should be supported at the heart level, and that his or her feet should be kept flat on the floor.[11, 12]

The number of studies in which the effects of supporting the back, arm and feet on blood pressure are investigated is limited. In studies in which the effect of supporting the arm under it was investigated, both systolic and diastolic blood pressure averages increased when the arm was left unsupported at the heart level.[13–16] According to studies in which the effect of back support was investigated, both systolic and diastolic blood pressure averages changed in measurements made without back support.[1, 6, 17] According to a study in which the effect of keeping the feet flat on the ground was investigated, the mean values of systolic and diastolic blood pressures decreased slightly when the feet did not touch the ground.[1] Although the differences are not statistically significant in some studies, they can be regarded as clinically significant because even 1 mmHg higher or lower results due to incorrect measurement may cause one out of every five patients to be misdiagnosed.[5] In addition, these errors, combined with other errors in blood pressure measurement, may deviate further from the true measurement value.

In the present study, we aimed to investigate the effect of supporting the arm, back and feet on blood pressure values in healthy individuals while their blood pressure was measured using the oscillometric technique.

MATERIALS AND METHOD

Study Design and Participants

This descriptive study was approved by the University Health Sciences Scientific Research and Publication Ethics Committee. In the present study conducted between April 2020 and April 2023, 111 healthy individuals aged 19-30 years were included. Their mean age was 21.95±1.57 years. Of them, 93 were women. Data on their age, sex, and body mass index were collected. According to the exclusion criteria, those who were diagnosed with hypertension, heart failure, coronary and peripheral artery disease, who had a history of acute pain, respiratory distress and postural hypotension, and whose blood pressure was not measured from the right

arm brachial artery for any reason (amputation, fistula) were not included in the study.

Data Collection Tools

The study data were collected with the "Descriptive Information Form" and “Follow-up Form”.

Descriptive Information Form: The form developed by the researcher in line with the literature consists of items questioning the socio-demographic characteristics and medical history of the participants.

Follow-up Form: The form was used to record the participants’ blood pressure measurements. In the measurements, four different methods were used. In each measurement method, three measurements were performed. Therefore, each participant’s blood pressure was measured twelve times. The Omron i-C10 - HEM-7070-E Upper Arm Blood Pressure monitor was used to measure the participants’ blood pressures. The device was calibrated to avoid erroneous blood pressure measurements. Blood pressure measurements were performed in accordance with the guidelines published by the American Heart Association. To ensure that blood pressure was measured correctly, the upper arm diameter was measured with a tape measure and the appropriate cuff was selected.

Data Collection Process

All the participants' blood pressures were measured by the same person according to American Heart Association standards. They were told not to exercise, not to smoke, and not to consume coffee during the last 30 minutes before the measurement. They were also told not to speak before the start of the measurement and during the entire procedure, to silence their mobile phones completely and to put them away from themselves and not to look at the screen of the blood pressure measuring device in order to prevent physiological reactions. The upper arm circumference of each patient was measured and the appropriate cuff was placed. After a 5-minute rest, the participant’s blood pressure was measured from the right arm brachial artery using the aforementioned device.

For the measurements, the participants were taken to the room where the measurements were to be made one by one. They rested in the room for five minutes in a sitting position. In the measurements, four different methods were used. The procedures were randomized to reduce bias. In each procedure, 3 measurements were made at one-minute intervals. Then the average of the three measurements was calculated. There was a five-minute interval between the procedures (Fig. 1).

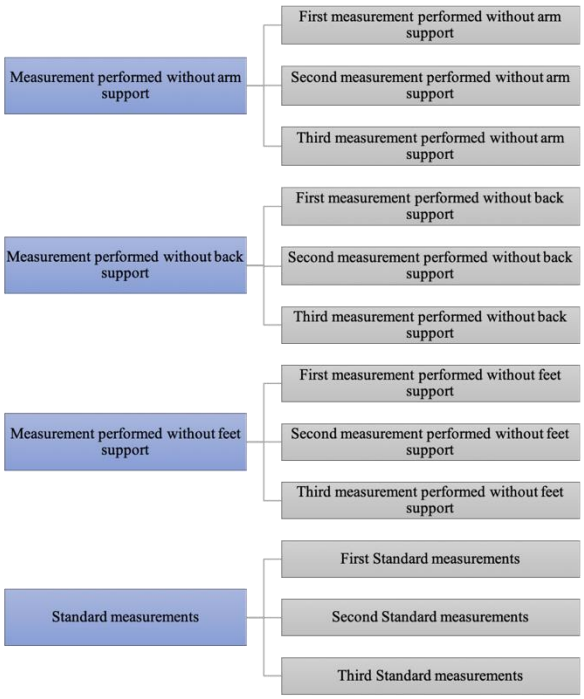

Figure 1. Blood pressure measurement process

Standard Measurement Procedure: In this position, the participant was in a sitting position, his or her feet were flat on the ground, he or she leaned back, and the arm to be measured was kept at the heart level with a support under it. Three measurements were taken on the same arm at one-minute intervals, and the average of the three measurements was calculated. This position is the correct measuring position recommended in the manuals.

Arm without a Support: In this position, the participant’s arm was held at the heart level,

but there was no support under the arm. However, his or her back and feet were supported as recommended in the guidelines. Three measurements were taken on the same arm at one-minute intervals, and the average of the three measurements was calculated.

Back without a Support: In this position, the participant did not lean back, or his or her back was not supported. However, his or her arm and feet were supported as recommended in the guidelines. Three measurements were taken on the same arm at one-minute intervals, and the average of the three measurements was calculated.

Feet without a Support: In this position, the participant did not touch his or her feet on the ground, or the feet were not supported by any material. To maintain this position, the office chair on which the participant was sitting was elevated to keep his or her feet off the ground. However, his or her back and feet were supported as recommended in the guidelines. Three measurements were taken on the same arm at one-minute intervals, and the average of the three measurements was calculated. Each participant underwent all the four procedures and 12 measurements were taken from each participant.

Statistical Analysis

SPSS 23.0 (Statistical Package for the Social Sciences) program was used to analyze the data. Numbers, percentages and arithmetic mean were used to present the sociodemographic data of the participants and to calculate the mean values of the blood pressure measurements. In order to find out the difference between the mean values of blood pressure measurements, the dependent samples t-test was performed.

Ethical Approval

Ethical approval to carry out the study was obtained from the Health Sciences Scientific Research and Publication Ethics Committee of a university (decision date: April 14, 2020; decision number: 03/13, protocol number: 582). In addition, institutional permission to collect data was obtained from the nursing faculty of a university where the study was to be conducted (decision date: June 12, 2020; decision number: 27344949-100). Before the data collection, the participants were informed about the study and their informed consent was obtained.

RESULTS AND DISCUSSION

Differences between systolic mean values of different measurement types were determined with the dependent samples t test. The mean systolic values determined with the measurements performed without feet support and back support were higher than were those determined with the standard measurements ($t=-4.872$, $p<0.001$ and $t=-2.152$, $p=0.034$, respectively). There was no statistically significant difference between the mean systolic value determined with the standard measurement and that determined with the measurement performed without arm support ($p>0.05$).

The comparison of the measurement errors revealed that the mean systolic value determined with the measurement performed without feet support was higher than were those determined with the measurements performed without arm support ($t=2.405$, $p=0.018$) and without back support ($t=-2.431$, $p=0.017$). There was no statistically significant difference between the mean systolic value determined with the measurement performed without back support and that determined with the measurement performed without arm support ($p>0.05$) (Table 1).

Table 1. Difference between Systolic Mean Values of different Measurement Types

		Measurement performed without arm support		Measurement performed without feet support		Measurement performed without back support		Standard measurement	
Systolic values	**X±SD**	104.76±9.39		106.26±9.27		105.00±8.91		103.98±8.28	
		t*	**p**	**t**	**p**	**t**	**p**	**t**	**p**
Measurement performed without arm support	104.76± 9.39	-	-						
Measurement performed without feet support	106.26±9.27	**2.405**	**.018****	-	-				
Measurement performed without back support	105.00±8.91	.392	.696	**-2.431**	**.017****	-	-		
Standard measurement	103.98±8.28	-1.306	.194	**-4.872**	**.000****	**-2.152**	**.034****	-	-

*dependent samples t test, **p<0,05

Differences between diastolic mean values determined with different measurement types were revealed with the dependent samples t test. There was a statistically significant difference between the mean systolic value determined with the standard measurement and that determined with the measurement performed without feet support. The mean diastolic value determined with the measurement performed without feet support was higher than was that determined with the standard measurement (t=-5.635, p<0.001). There was no statistically significant difference between the mean diastolic value determined with the standard measurement and those determined with the measurements performed without back support and without arm support (p>0,05). The comparison of the measurement errors revealed that the mean systolic value determined with the measurement performed without feet support was higher than were those determined with the measurements performed without arm support (t=-4.044, p<0.001) and without back support (t=-.044, p<0.001). There was no statistically significant difference between the mean diastolic value determined with the measurement performed without back support and that determined with the measurement performed without arm support (p>0.05)(Table2).

Table 2. Differences between Diastolic Mean Values Determined with different Measurement Types

		Measurement performed without arm support		Measurement performed without feet support		Measurement performed without back support		Standard measurement	
Diastolic Values	**X±SD**	70.21±8.06		72.91±8.15		70.80±7.50		70.33±7.05	
		t*	**p**	**t**	**p**	**t**	**p**	**t**	**p**
Measurement performed without arm support	70.21±8.06	-	-						
Measurement performed without feet support	72.91±8.15	**4.447**	**.000****	-	-				
Measurement performed without back support	70.80±7.50	1.120	.265	**-4.044**	**.000****	-	-		
Standard measurement	70.33±7.05	.219	.827	**-5.635**	**.000****	-1.136	.258	-	-

*dependent samples t test, **p<0.05

Unsupported Back

In the population whose mean oscillometric measurements of systolic blood pressure (SBP) and diastolic blood pressure (DBP) were 103.98 and 70.33 mmHg, respectively, SBP and DBP were only 1.02 and 0.47 mmHg higher, respectively in measurements performed without back support. These differences were close to the values reported by Ringrose et al. (2017) and Wan et al.

(2021).[1,6] The differences in SBP and DBP values were 0.7 and 1.8 mmHg, respectively in Ringrose et al.'s study and 2.3 and 1.0 mmHg, respectively in Wan et al.' study (2021). In our study, these differences were considered significant for systolic blood pressure, but not for diastolic blood pressure.

However, these values were significantly lower than were those reported in the study conducted by Cushman et al. (1990). In their study conducted with 48 male hypertensive participants.[17] Cushman et al. (1990) stated that when the participants sat on the examination table without back support, the difference in the mean SBP value was 1.3 mmHg higher, similar to the results obtained in our and other studies. The mean DBP value when their backs were unsupported was 6.5 mmHg higher was that when their backs were supported. In their study, unlike other studies, they used a mercury sphygmomanometer.[17] It is known that the technique used in blood pressure measurement can affect the white coat syndrome.[18] The use of automated blood pressure measurements may reduce white coat syndrome, which explains the difference between the values obtained by Cushman et al. (1990) and those obtained in our and other studies.[1,6,17] The fact that the participants in Cushman et al.'s (1990) study were hypertensive individuals and that their mean age was higher may have led to this difference. As is known, blood pressure tends to rise with age.[19] It should be investigated to what extent individuals can tolerate sitting positions without support as their age increases. The decrease in body muscle mass with age may affect relatively older individuals' ability to maintain their body postures in unsupported blood pressure measurements.[20] More studies should be conducted to reveal these age-related differences in unsupported blood pressure measurements.

Unsupported Arm

In published guidelines for accurate measurement of blood pressure, it was recommend that the arm should be supported under it and kept at the heart level during measurement.[12, 21] In our study, the mean SBP and DBP values were 0.78 and 0.12 mmHg higher, respectively, when the measured arm was left unsupported at the heart level. However, these differences were not statistically significant. Our search revealed that in only four studies in the literature, the arm was supported under it and it was kept at the heart level during the measurement while blood pressure was measured. The chronological analysis of these studies demonstrated that in their study, Beck et al. (1983) compared the measurement made when the arm was kept at the heart level and supported under it with the measurement made when the arm was kept at the heart level but not supported under it.[14] According to their results, the mean systolic and diastolic blood pressure values were 0.7 mmHg and 2.7 mmHg higher, respectively when the arm was not supported. Similarly, in their study conducted with 20 adults, Silverberg et al. (1977) compared the measurement made when the arm was kept at the heart level and supported under it with the measurement made when the arm was kept at the heart level but not supported under it.[15] According to the results, the mean systolic and diastolic blood pressure values were 2.2 mmHg and 1 mmHg higher, respectively when the arm was not supported. In their study conducted with 120 normotensive individuals, Familoni et al. (2005) found that when the arm was unsupported, systolic and diastolic blood pressures were 7.61 mmHg and 2.83 mmHg higher, respectively.[13] Finally, in their study conducted with 116 individuals, Güneş and Efteli (2016) found that systolic and diastolic blood pressures were 3 mmHg and 1.5 mmHg higher, respectively, when the arm was unsupported.[16] The results of the studies in which blood pressures were measured when the arm was supported were consistent with each other. In all the studies, both systolic and diastolic blood pressures increased when the arm was unsupported.

Providing arm with support during measurement is important because it prevents isometric contractions in the arm,

and thus prevents increases in blood pressure and in turn incorrect measurements.[15, 16] Moreover, in cases where the arm is not supported under it, there is a risk that the arm will not remain stable and will move, which may cause an increase in blood pressure. In addition, supporting the arm under it helps to keep the arm at the heart level. When the measured arm is not supported under it, the patient will need to exert muscle effort to keep his arm at the heart level. Otherwise, the patient may not be able to keep his or her arm at the heart level and may keep it below the heart level, which leads to an erroneous measurement.

Unsupported Feet

Our search revealed that in the literature, there was only one study in which the measurement performed when the patient's feet were flat but neither on the ground or nor supported by any other material; in other words, suspended in the air was compared with the measurement performed when the patient's feet were flat on the ground and supported.[1] In their study conducted with 85 patients with a mean age was 52.0±20.7 years 42% of whom were hypertensive, Ringrose et al. found that the mean SBP and DBP values were 0.9 and 03 mmHg lower, respectively, when the feet were not supported. The results of our study were different from those of Ringrose et al.'s study (2017); however, the differences were minor. In our study, the mean SBP and DBP values were 2.28 and 2.58 mmHg higher, respectively, when the feet were not supported.

This difference between our results and the results of Ringrose et al.'s study (2017) may have been due to the fact that their sample included patients older than our participants and that 42% of them were hypertensive. Differences due to measurement error may be more significant in hypertensive individuals than in normotensive individuals.[17,22] Unsupported feet can increase muscle tension. Body weight cannot be distributed proportionally because feet do not receive support from the ground. In the legs, both muscle activity increases and there is pressure on the legs due to the weight of the feet affected by gravity, which can increase blood pressure. Isometric contractions are known to increase blood pressure by increasing heart rate and cardiac output.[23–25] Another risk factor related to the situation where the feet not supported and suspended in the air are moved voluntarily or involuntarily. Even the slight movement of the feet increases cardiac output and thus causes a change in heart rate, and as a result, there may be, although minimal, fluctuations in the blood pressure.

CONCLUSION AND RECOMMENDATIONS

The mean values obtained with the blood pressure measurements when the back and feet were not supported were higher than were those obtained with the standard measurements recommended in the guidelines. In the measurements without arm support, the mean values, although statistically not significant, were higher. In addition, the measurement without feet support gave higher results than other measurement errors (without arm support, without back support).

Even if the differences between blood pressure values determined with the erroneous measurement methods are not great, they may cause errors in the diagnosis and treatment of hypertension. Due to these errors, the diagnosis of hypertension is prevented or delayed, which causes patients to receive no or delayed treatment, or due to these errors, patients can be diagnosed with hypertension and receive unnecessary treatment, which causes individuals to have side effects and to undergo financial burden. Therefore, measuring blood pressure in accordance with the guidelines is of great importance.

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