기초간호자연과학회지: 제13권 제3호 2011
J Korean Biol Nurs Sci 2011; 13(3): 238-244

ISSN: 1229-6155
www.bionursing.or.kr

Differences in Blood Pressure according to Body Position by Age Groups

Mi Ryeong Song[1], Young-Shin Lee[2]

[1]Associate Professor, Department of Nursing, Hoseo University, Asan, Korea; [2]Associate Professor, School of Nursing, San Diego State University, California, USA

연령별 신체자세에 따른 혈압의 차이분석

송미령[1] · 이영신[2]

[1]호서대학교 간호학과 부교수, [2]샌디에고 주립대학 간호대학 부교수

목적: 이 연구의 목적은 성인의 연령군별 측정자세 변화에 따른 혈압의 변화 정도를 살펴보기 위한 것이다. **방법:** 이 연구는 탐색적 조사연구로서 연구대상자는 20세에서 59세까지 성인 136명을 대상으로 만성질병이 없고 연구 목적과 연구방법에 대한 설명을 듣고 연구 참여에 동의한 자를 대상으로 하였다. 수집된 자료는 연령군을 나누어 앙와위, 좌위, 직립위에서 혈압의 차이를 paired t-test로 분석하였으며, 연령군에 따라 운동여부와 건강상태에 차이가 있었으므로 연령과 측정자세에 따른 혈압 변화의 상호작용을 확인하기 위해 repeated measure ANCOVA를 실시하였다. **결과:** 초기 성인군(20대와 30대)에서는 자세의 변화에 따른 수축기 및 이완기 혈압의 변화가 없었으나40대와 50대에서는 수축기 혈압에서 앙와위에 비해 좌위(p = .007, p < .001)와 직립위(p < .001, p = .001)에서 유의한 감소가 있었다. 수축기(p = .004)와 이완기(p = .019) 모두에서 연령과 측정자세에 따른 혈압 변화에 유의한 상호작용이 있어 연령군에 따라 자세로 인한 혈압의 변화에 유의한 차이가 있는 것으로 나타났다. **결론:** 40세 이후에는 혈압측정시에 자세를 기록하는 것이 중요하며 중년기 이후 자세의 변화에 따른 혈역동의 변화에 특별한 주의를 기울일 필요성이 있다.

Key Words: *Blood pressure; Patient positioning; Supine position; Age groups*
국문주요어: 혈압, 환자 자세, 앙와위, 연령군

INTRODUCTION

Accurate measurement and recording of blood pressure (BP) has become more important in a multidisciplinary health care environment. BP reflects physiologic conditions and monitors critical changes (Pickering et al., 2005). It can be correctly gauged by trained persons such as registered nurses with special skills, knowledge, and awareness of the correct process (Dickson & Hajjar, 2007). Traditional measuring of BP, as well as other vital signs, has been a fundamental task of nurses (Potter & Perry, 2005). However, while multidisciplinary care personnel in a complex health care system are allowed to measure BP, the accuracy of BP readings has been a concern.

The literature reveals several concerns about yielding accurate BP with regard to knowledge, skills, procedure, and recordings (Pickering et al., 2005). Some studies have shown that recorded BP measurements seemed to be inaccurate (Armstrong, 2002; Kim & Kim, 2000), and determinations for systolic and diastolic turning points of BP were not accurate (Pickering et al., 2005). Phase 1 (systolic) and Phase 5 (diastolic) Korot-

Corresponding author:
Mi Ryeong Song, Associate Professor, Department of Nursing, Hoseo University, 165 Sechul-ri, Baebang-eup, Asan 336-851, Korea
Tel: +82-41-540-9531 Fax: +82-41-540-9558 E-mail: songmr@hoseo.edu

*This research was supported by the Academic Research fund of Hoseo University in 2008 (2008-0026).

투고일: 2011년 9월 8일 **심사의뢰일:** 2011년 9월 10일 **게재확정일:** 2011년 12월 23일

koff sounds are best heard using the bell of the stethoscope over the palpated brachial artery in the antecubital fossa (Pickering et al., 2005).

Selection of the appropriate cuff size is also a concern. Overestimation of BP for small arms or underestimation of BP for large arms in the relation to the cuff size have been reported (Marks & Groch, 2000). Appropriate cuff size, cuff placement and body position should be taken into consideration when trying to obtain an accurate measurement of BP. The variances of BP according to cuff size are 4.16-8.14 mmHg for systolic blood pressure (SBP) and 3.30-9.28 mmHg for diastolic blood pressure (DBP) (Song & Kim, 2009).

Evidence based research identified the selection of appropriate size of cuff and the placement of cuff on the body as important. On the other hand, the importance of the position of the body during BP measurement has not been well agreed on (Pickering et al., 2005). Netea, Lenders, Smits, and Thien (2003) reported both SBP and DBP were significantly higher in the supine than in the sitting position among hypertensive patients. Another study indicated no differences in DBPs according to body positions though SBPs were significantly different in healthy young people (Eser, Khorshid, Gunes, & Demir, 2007). Further more, age is positively associated with BP (Miall & Lovell, 1967; Lee, Oh, & Jung, 2003), but, there have been relatively few research finding spublished with regard to differences in the change in BP according to body position in relation to age groups. There cording of body position and the problem of recordin go missions with regard to body position when measuring BP have also been mentioned (Eser et al., 2007).

In addition to knowledge, skills, and devices, age is reflected in one's BP even though it is not a normal aging phenomenon. There is evidence that age is positively associated with BP, that is, older age groups have more frequently higher BP (Lee, Oh, & Jung, 2003). Furthermore, older adults experience orthostatic stress more frequently than young adults when changing their positions (Barnet et al., 1999). However, research studies have not identified the changes in BP between and within age groups in relation to body position (Pickering et al., 2005), which might yield important information both for the early detection and prevention of high BP and chronic illnesses related to hemodynamic change.

Attention to the condition of 'prehypertension,' that is, people with blood pressures at the high end of the normal range has increased. The target BP for patients using antihypertensive treatment has recently been lowered for those with diabetes or renal disease, and this emphasizes the importance of accurately detecting small differences in BP (Pickering et al., 2005).

There is no consensus on research findings as to whether BP changes or not according to the BP measuring position, and the range of change of BP is not well known even though it is known that BP changes with age. In particular, there have been no studies concerning the differences in BP according to body position by age groups. But for effective nursing intervention, knowledge about hemodynamic change during changes in position is essential. So, studies on differences in BP according to body position by age groups are needed.

The purpose of this study was to identify differences in BP changes according to body position by age groups. In order to accomplish this objective, the study hypothesized the following:

1) There will be differences in SBP and DBP according to body position.

2) There will be differences in the change of SBP and DBP according to different body positions by age groups.

METHODS

1. Research design

This study used an explorative cross-sectional design to identify whether SBP and DBP are changed by body position among different age groups among 136 South Korean adults.

2. Sample and settings

The data were collected from September through November, 2008 in a university laboratory room. Adults who expressed a willingness to participate in the research study were provided with a description of the purpose and method of this study, and then they signed a consent agreement to participate. A power analysis indicated that a sample size of 136 had a 99% power in the medium effect size ($f = 0.25$), with the number of groups 4, at $\alpha = .05$ (Fall, Erdfelder, Buchner, & Lang, 2009).

Participants in the study were above twenty years of age and had no medical diagnoses. Among the potential participants, some were excluded. Exclusion criteria were as follows.

- Those whose arm circumference was ≤ 23 cm or ≥ 33 cm so that an adult cuff with a width of 12 cm could be used, the size deemed the most appropriate for measurement in Korea (Kim et al., 2005)
- Those who had smoked or consumed alcohol 30 minutes prior to measuring BP
- Those who had no diagnosis of hypertension

• Those who were not taking any prescribed medications

3. Measurements

1) Blood pressure

Blood pressure was measured with a calibrated V-LOK sphygmomanometer (Baumanometer®, W.A. Baum Co. Inc., Copiague, NY) in accordance with the proper guidelines (National Heart, Lung, and Blood Institute, 2000). The cuff was inflated by pressing the valve until the blood flow stopped and then was deflated slowly while the researcher watched the aneroid indicator and simultaneously listened to the sound of the blood pumping through a stethoscope. Blood pressures were measured from 2PM to 5PM in order to take into account daily changes in BP. Participants rested on a chair for 5 minutes in a laboratory room before having their BP taken. To decrease sampling errors, a sphygmomanometer was located at the level of the heart according to body position (Pickering, et al., 2005). A cuff was applied 2-3 cm above the palpation site on the brachial artery on the right arm.

The nurse elevated the pressure until the pulse could not be palpated and then deflated the cuff. After pausing for 60 seconds, the nurse re-inflated the cuff pressure over 30 mmHg above the reading point, and read the number on the mercury barometer at eye level while the cuff pressure was deflated at a velocity of 2-4 mmHg a second (Potter & Perry, 2005). Sounds were classified into 5 phases: Phase 1 and 5 were used for recording systolic and diastolic BP (Pickering et al., 2005). Blood pressure was read in millimeters of mercury (mmHg) and was recorded as SBP and DBP. An individual's BPs was measured in the following same order.

- The process was explained to the participants.
- BP was measured in the supine position.
- The participants rested for 2 minutes (Potter & Perry, 2005).
- The participants then sat on a chair and had their BP taken.
- The participants rested for 2 minutes.
- The participants stood up and had their BP taken within 2 minutes.
- Each participant was informed of the conclusions of the observations, and their general characteristics were recorded.

2) General characteristics

General characteristics included age, gender, exercise activity, and health status. Age was classified into four groups: 20 to 29, 30 to 39, 40 to 49 and 50 to 59 years. Level of exercise was defined by the answer to the question: "1) Do you exercise?" and the responses were simply recorded as 'yes' or 'no'. Self-reported health status was determined by the answer to the question: "How do you rate your current health status?" with five options given: very good, good, ordinary, not bad and bad. No subject answered: "Bad." Responses were classified into two groups: good (very good, good), average (ordinary, not bad).

4. Data analysis

The collected data were analyzed using the SPSS WIN14.0 program. Descriptive statistics (frequency and percentage) were used to obtain characteristics for gender, exercise level, and health status and a Chi-square analysis was used to determine the differences between groups (men and women, exercisers vs. non-exercisers, health status) by age. A paired t-test was used to yield differences in BP between supine position, the sitting position and the standing position in each age group. Since BP data were not satisfactory for sphericity conditions, Greenhouse-Geisser's error compensation of degree of freedom was applied. Since the exercise engagement and the level of health status were differ by age groups, a MANOVA (Repeated measure ANCOVA) was used to determine the overall main and interaction effect for BP. Differences were considered significant when the p value of the position by group interaction effect was less than .05.

5. Ethical considerations

The subjects participated in this study voluntarily after hearing an explanation about the purposes and the processes of the study. The subjects were informed that they had the right to refuse to participate, that they could stop participating at anytime during the study, that their confidentiality would be respected, and that they could expect some reward for participating in the study. The subjects then signed an agreement consenting to participating in the study. And then the study proceeded on the basis of the consent given and with the dignity of the participants respected at all times.

RESULTS

1. General characteristics of participants

Of the 136 participants, 47 were aged 20 to 29 years, 18 were aged 30 to 39, 41 were aged 40 to 49, and 30 were aged 50 to 59. 58 were male and 78 were female. 58.1% of the total reported engaging in some exercise and

55.1% felt their health conditions were good. Results of the Chi-square test showed no significant differences between men and women, and health status between the four age groups (young and old). With regard to exercise, 94.4% of the 30 to 39 age group answered "yes" to the question whether they engaged in exercise or not, while 46.8% of the 20 to 29 age group answered "yes." More than half of the participants answered the question about health status with the response"good"(Table 1).

2. Differences in BP status according to body position

The overall averages of SBPs were 117.02 mmHg (SD = 9.99), 115.24 mmHg (SD = 9.76), and 114.85 mmHg (SD = 9.76) for the supine, sitting, and standing positions, respectively. The SBP measurements for the sitting ($p < .001$) and standing positions ($p < .001$) were significantly lower than those for the supine position (Table 2). The hypothesis that there would be differences in SBP resulting from different body positions was accepted.

The overall averages of DBPs were 73.11 mmHg (SD = 7.60), 72.78 mmHg (SD = 6.96), and 72.82 mmHg (SD = 6.77) for the supine, sitting, and standing positions, respectively, and no statistically significant differences were shown among the different positions. The hypothesis that there would be differences in the DBPs by body positions was discarded at a significance level of .05.

3. Differences in BP status by age

In the 20 to 29 group, average SBPs were from 113.80 to 113.87 mmHg and the average DBPs were between 69.99 mmHg and 70.39 mmHg for the supine, sitting and standing positions. In the 30 to 39 group, average SBPs were from 115.22 to 113.89 mmHg and the average DBPs were between 71.94 mmHg and 72.14 mmHg for the supine, sitting and standing positions. There were no statistical differences in both SBP and DBP with regard to changes in body position in the younger groups (Table 2).

In the 40 to 49 group, average SBPs were 118.28, 116.46, and 114.63 mmHg, and average DBPs were 75.29, 75.66, and 74.29 mmHg for the supine, sitting, and standing positions respectively. In the 50 to 59 group, average SBPs were 121.43, 117.90, and 117.23 mmHg, and average DBPs were 76.80, 75.47, and 75.00 mmHg for the supine, sitting, and standing positions respectively. In contrast to the younger group, the older group's average SBPs were statistically significantly lower for the sitting ($p = .007$ in 40 to 49, $p < .001$ in 50 to 59) and standing positions ($p < .001$ in 40 to 49, $p = .001$ in 50 to 59) in comparison with the supine position. For the average DBPs, the BP in the 50 to 59 age group was significantly lower in the standing position ($p < .05$) than in the spine position, but not in the sitting position.

The hypotheses that there would be differences in SBPs and DBPs by position and age were partially accepted with regard to the older age group

Table 1. Characteristics of Participants

Variable	Classification	Total n (%)	Age				χ^2 (p)
			20-29 (n = 47)	30-39 (n = 18)	40-49 (n = 41)	50-59 (n = 30)	
Gender	Female	78 (57.4)	24 (51.1)	14 (77.8)	24 (58.5)	16 (53.3)	4.052 (.256)
	Male	58 (42.6)	23 (48.9)	4 (22.2)	17 (41.5)	14 (46.7)	
Exercise	Yes	79 (58.1)	22 (46.8)	17 (94.4)	23 (56.1)	17 (56.7)	12.320 (.006)
	No	57 (41.9)	25 (53.2)	1 (5.6)	18 (43.9)	13 (43.3)	
Health status	Good	75 (55.1)	33 (70.2)	8 (44.4)	17 (41.5)	17 (56.7)	8.278 (.041)
	Average	61 (44.9)	14 (29.8)	10 (55.6)	24 (58.5)	13 (43.3)	

Table 2. Comparison of Blood Pressure According to Body Position

Age (yr)	n	SBP (mmHg)			DBP (mmHg)		
		Supine (Referent) M±SD	Sitting M±SD	Standing M±SD	Supine (Referent) M±SD	Sitting M±SD	Standing M±SD
20-29	47	113.80±7.99	112.87±9.17	113.87±9.87	69.99±7.74	68.77±5.82	70.39±6.33
30-39	18	115.22±10.79	114.17±11.34	113.89±8.79	71.94±7.44	72.22±7.47	72.14±7.49
40-49	41	118.28±11.08	116.46±9.97*	114.63±10.69†	75.29±6.46	75.66±6.73	74.29±6.76
50-59	30	121.43±9.19	117.90±8.85†	117.23±8.80*	76.80±5.88	75.47±5.58	75.00±6.01‡
Total	136	117.02±9.99	115.24±9.76†	114.85±9.76†	73.00±7.60	72.78±6.96	72.82±6.77

*$p < .01$; †$p < .001$; ‡$p < .05$.
SBP = systolic blood pressure; DBP = diastolic blood pressure.

but not for the younger age group (Table 2).

4. Differences in BP status by body position and age

Results of the MANOVA revealed significant effects caused by body position and age and significant interaction between age groups by body position with regard to SBPs and DBPs (Table 3, Figures 1, 2).

With regard to SBP, there was an interaction according to age and position change (F = 4.63, p = .004). With regard to DBP, there was an interaction according to age and position change (F = 3.42, p = .019). The hypothesis that there would be a difference in the level of BP change according to position by age groups was accepted.

Table 3. Differences in SBP and DBP by Body Position and Age Groups

Type	Source of variance	SS	df	MS	F	p
SBP	Covariates (exercise)	22.20	1.81	12.30	1.38	.242
	Covariate (health status)	43.08	1.81	23.87	1.56	.214
	Within age groups					
	Position	31.27	1.81	17.33	.27	.607
	Position × age	225.45	5.42	41.64	4.63	.004
	Error	2,983.88	234.65	12.72		
	Between age groups					
	Age groups	2,240.97	3	813.66	3.43	.019
	Error	30,872.13	130	237.48		
DBP	Covariates (exercise)	42.77	1.72	24.88	3.87	.051
	Covariate (health status)	6.78	1.72	3.95	.62	.433
	Within age groups					
	Position	27.60	1.72	16.05	2.55	.113
	Position × age	155.19	5.16	30.09	3.42	.019
	Error	2,003.94	223.51	8.97		
	Between age groups					
	Age groups	4,024.90	3	1,341.63	13.28	< .001
	Error	13,135.26	130	101.04		

SBP = Systolic blood pressure; DBP = Diastolic blood pressure.

These findings indicate that there is an interaction between age and position change with regard to both SBP and DBP. So, we know the level of change with regard to BP is different according to position by age groups (Table 3). In fact, we can see the differences according to age group. The younger age group didn't reveal any change in SBP, as seen in the graph, but the older age group revealed a notable decrease in SBP, as seen in the graph. Also, there was a different feature in the BP curve for DBP (Figures 1, 2).

DISCUSSION

In our study, the older group, aged over 40, revealed significant BP changes in SBP by positions (from supine to sitting to standing) which is consistent with the findings of the study conducted by Netea et al. (2003), which postulated that most hypertensives are middle aged or elderly adults. On the other hand, the BP changes in the young adult group were different in comparison with previous studies. The younger age group in our study revealed no significant changes in both SBP and DBP by position changes, while healthy university students had significant changes in their SBP by position change according to Eser et al. (2007). As age and hypertension are very important factors in the mechanism associated with blood pressure change, comparisons between studies involving different age groups and participants with different diseases must be tentative. Further research study targeting young adults is needed to clarify the results.

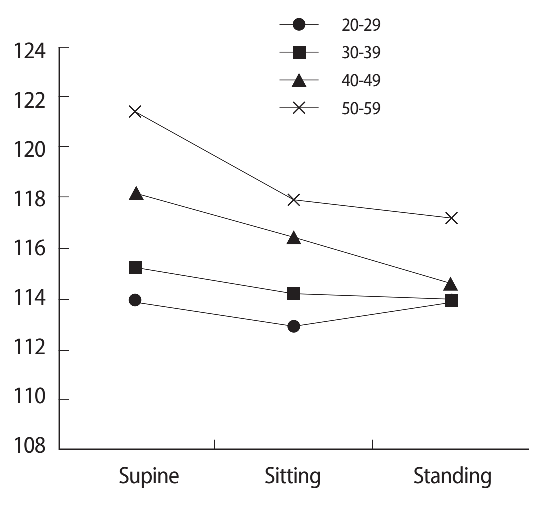

Figure 1. SBP change saccording to body position by age groups.

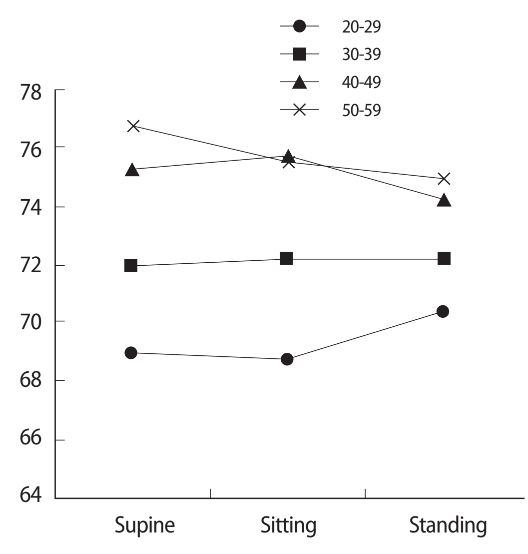

Figure 2. DBP changes according to body position by age groups.

With regard to the analysis of repeated ANCOVA reflecting age and position, BP changes could be better demonstrated. SBP was significantly different by position, and interaction between age and position, which indicates that SBP is sensitive to changes in body position as well as age. This is consistent with research findings (Kusuma, Babu, & Naidu, 2001). In particular, SBP readings in the older age groups were more sensitive in relation to position than among the younger age groups. This result can be explained by the change in pathophysiologic phenomena, that is, individuals have decreased vasomotor sympathetic responsiveness as they get older as well as weaker large and small vessel compliance. In addition, individuals experience increased vascular resistance as they age (Barnett et al., 1999; Hyoung & Kim, 2008; Weinberger, Fineberg, & Fineberg, 2002). In the published literature, older women have a wide range of BP variability that can put them at high risk for end-organ damage such as silent cerebrovascular damage (Jaquet, Goldstein, & Shapiro, 1998; Song, Park, &Hwang, 2004). Therefore, detecting BP changes, even small differences, is important to prevent the further progress of diseases.

With regard to body position, there are several studies that reveal BP changes between the supine, sitting, and standing positions. Studies have shown that SBP becomes lower by approximately 8 mmHg when individuals change their position from lying down to sitting or standing (Eser et al., 2007; Terent & Breig-Asberg, 1994).

Even in the sitting position, the place where the person sits influences blood pressure. Sala, Santin, Rescaldani, Cuspidi, & Magrini (2004) reported that SBP and DBP readings in elderly people with mild hypertension were overestimated in the bed-seated position in comparison with the recommended chair-seated position. Turner et al. (2008) reported a significant influence on SBP when measurements were taken while participants were seated in a chair with both feet resting on the floor - lower than measurements taken when participants were seated on an exam table with legs dangling and without back support. However, no significant differences existed in DBP changes over time in either the chair seated or exam table seated positions.

In our research, the gap in SBP in older groups between supine and standing positions was approximately 4mmHg. This small difference in comparison to previous reports can be explained by the age scope of the participants - aged 40 to 59 years - which is a middle aged group rather than a group of elderly individuals, who usually evidence more characteristics of high BP than young or middle age groups. However, it can exacerbate the process of orthostatic stress as age increases.

Orthostatic hypotension could be related to the increase in orthostatic stress among older adults. Orthostatic hypotension is another common problem among older adults and the positive correlation between postural hypotension and old age is well known (Medow et al., 2008). A study conducted with adults in middle age (45-64 years old) showed that those who had a greater gap in SBP between supine and standing had a 15% greater prevalence of hypertension, and a 22% greater prevalence for peripheral vascular disease and congestive heart disease than those who had relatively small changes (Nardo et al., 1999).

Our findings and the literature suggest that health care providers need to pay attention to those who show a decrease in SBP by position change, especially in the age group over 40 in order to detect early hypertension and prevent orthostatic hypotension.

CONCLUSION

This is an explorative study to identify differences in SBP and DBP according to body position and also differences in the level of change in blood pressure according to body position by age groups. The participants included 78 females and 58 males, 65 younger age participants (20 to 39) and 71 older age participants (40 to 59). There were no statistical differences within the younger age groups for SBP and DBP. In contrast, there were significant differences in SBP and DBP according to body positions within the older age groups. Finally, there is a significant interaction effect between age and change in position for both SBP and DBP.

Recording positions during the measurement of BP is important, especially in subjects aged over 40. Special attention needs to be paid when observing hemodynamic change that results from changes in position during the measurement of BP in those over 40 years of age. Further research on hemodynamic change in relation to people with various health problems, especially conditions such as cardiovascular disease, is needed.

REFERENCES

Armstrong, R. S. (2002). Nurses' knowledge of error in blood pressure measurement technique. *International Journal of Nursing Practice, 8,* 118-126.

Barnett, S. R., Morin, R. J., Kiely, D. K., Gagnon, M., Azhar, G., Knight, E. L., et al. (1999). Effects of age and gender on autonomic control of blood pressure dynamics. *Hypertension, 33,* 1195-1200.

Dickson, B. K., & Hajjar, I. (2007). Blood Pressure Measurement Education and Evaluation Program improves measurement accuracy in community-based nurses:

apilot study. *Journal of the American Academy of Nurse Practitioners, 19,* 93-102.

Eser, I., Khorshid, L., Gunes, U. Y., & Demir, Y. (2007). The effect of different body position son blood pressure. *Journal of Clinical Nursing, 16,* 137-140.

Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods, 41,* 1149-1160.

Hyoung, H. K., & Kim, H. S. (2008). The effect of brisk walking exercise program on body composition, blood pressure, blood glucose and blood lipid for middle-aged woman with obesity. *The Journal of Korean Biological Nursing Science, 10,* 62-68.

Jaquet, F., Goldstein, I. B., & Shapiro, D. (1998). Effects of age and gender on ambulatory blood pressure and heart rate. *Journal of Human Hypertension, 12,* 253-257.

Kim, J. S., & Kim, S. S. (2000). Evaluating the accuracy of blood pressure measurement in general hospital nurses. *Journal of Korean Academy of Fundamentals of Nursing, 7,* 7-15.

Kim, M. J., Park, H. S., Choi, S. H., Song, K. A., Kim, H. S., Nam, J. J., et al. (2005). *Fundamentals of nursing.* Seoul: Hyunmoonsa.

Kusuma, Y. S., Babu, B. V., & Naidu, J. M. (2001). Group- and sex-specific effects of age, body composition and pulse rate on blood pressure variability in some cross-cultural populations of Visakhapatnam District; South India. *Journal of Cardiovascular Risk, 8,* 337-347.

Lee, C. H., Oh, H. S., & Jung, Y. A. (2003). A study of fitness, blood pressure and body fat changes on aging. *The Korean Journal of Physical Education, 42,* 717-725.

Marks, L. A., & Groch, A. (2000). Optimizing cuff width for noninvasive measurement of blood pressure. *Blood Pressure Monitoring, 5,* 153-158.

Medow, M. S., Stewart, J. M., Sanyal, S., Mumtaz, A., Sica, D., & Frishman, W. H. (2008). Pathophysiology, diagnosis, and treatment of orthostatic hypotension and vasovagal syncope. *Cardiology in Review, 16,* 4-20.

Miall, W. E., & Lovell, H. G. (1967). Relation between change of blood pressure and age. *British Medical Journal, 2,* 660-664.

Nardo, C. J., Chambless, L. E., Light, K. C., Rosamond, W. D., Sharrett, A. R., Tell, G. S., et al. (1999). Descriptive epidemiology of blood pressure response to change in body position. The ARIC study. *Hypertension, 33,* 1123-1129.

National Heart, Lung, and Blood Institute (NHLBI). (2000). *Facts about lowering blood pressure* (NIH publication No. 00-3281). Bethesda, MD: National Institutes of Health, National Heart, Lung, & Blood Institute.

Netea, R. T., Lenders, J. W., Smits, P., & Thien, T. (2003). Both body and arm position significantly influence blood pressure measurement. *Journal of Human Hypertension, 17,* 459-462.

Pickering, T. G., Hall, J. E., Appel, L. J., Falkner, B. E., Graves, J., Hill, M. N., et al. (2005). Recommendations for blood pressure measurement in humans and experimental animals. *Hypertension, 45,* 142-161.

Potter, P. A., & Perry, A. G. (2005). *Fundamentals of nursing.* 6th ed, St. Louis: Elsevier Mosby.

Sala, C., Santin, E., Rescaldani, M., Cuspidi, C., & Magrini, F. (2004). What is the accuracy of clinic blood pressure measurement? *American Journal of Hypertension, 18,* 244-248.

Song, H. Y., Park, S. M., & Hwang, S. O. (2004). Risk factors of cerebrovascular disease according to the level of blood pressure among the prospective tele-medicine users. *The Journal of Korean Biological Nursing Science, 6,* 31-42.

Song, M. R., & Kim, E. K. (2009). A comparative study of blood pressure according to cuff size and measurement site. *Journal of Korean Academy of Fundamentals of Nursing, 16,* 6-13.

Terent, A., & Breig-Asberg, E. (1994). Epidemiological perspective of body position and arm level in blood pressure measurement. *Blood Pressure, 3,* 156-163.

Turner, M., Burns, S. M., Chaney, C., Conaway, M., Dame, M., Parks, C., et al. (2008). Measuring blood pressure accurately in an ambulatory cardiology clinic setting: do patient position and timing really matter? *Medsurg Nursing, 17,* 93-98.

Wan, Y., Heneghan, C., Stevens, R., McManus, R. J., Ward, A., Perera, R., et al. (2010). Determining which automatic digital blood pressure device performs adequately: a systematic review. *Journal of Human Hypertension, 24,* 431-438.

Weinberger, M. H., Fineberg, N. S., & Fineberg, S. E. (2002). Effects of age, race, gender, blood pressure, and estrogen on arterial compliance. *American Journal of Hypertension, 15,* 358-363.

Whitcomb, B. L., Prochazka, A., LoVerde, M., & Byyny, R. L. (1995). Failure of the community-based Vita-Stat automated blood pressure device to accurately measure blood pressure. *Archieves of Family Medicine, 4,* 419-424.