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COMPARING BLOOD PRESSURE MEASUREMENT OVER A SLEEVED ARM VERSES ROLLED-UP SLEEVE IN EMERGENCY DEPARTMENT

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ABSTRACT

A Blood Pressure (BP) measurement is an essential and routine nursing practice in all healthcare settings. In public emergency departments, nurses are extremely busy with many tasks to accomplish in a limited timeframe, including BP and other vital signs taking. Nurses often are challenged whether to ask patients to roll-up their arm sleeve to place the BP cuff or apply the cuff over the sleeved arm. This study aims to examine whether a difference exists in BP measurements over sleeved arms against rolled-up arms. A prospective clinical study was conducted on 115 patients, who visited two emergency departments in two public hospitals in Saudi Arabia. The study adopted paired t-test to parallel the measured BP through the measurement conditions and the multiple ANOVA adjusting for age group and hospital. Out of the 115 participants with mean age of 30.58 years, the mean BP of the sleeved arm and rolled-up sleeve arm was 124.94 (SD 11.372)/ 78.11 (SD 10.420) mmHg and 125.42 (SD 12.223)/ 79.09 (SD 9.864) mmHg respectively. There was no clinically significant difference between BP measurements over a sleeved arm compared to a bare arm. The outcomes were in agreement with previous studies.

Keywords: Blood pressure, Sleeved arms, Emergency room

INTRODUCTION

Accurate BP measurement is an increasingly important issue in nursing practice, and one of the most significant and frequent vital signs undertaken in Emergency Department (ED). The correct measurement of BP is crucial for nurses during emergency care and is consequential to the management of the patient's health, which dictates control over all factors that interfere with BP reading. These factors include the type and quality of BP reading device, cuff size, environmental factors such as room temperature, stress level and dress of the patient, position of the patient and the arm used for reading, emotional state, smoking habits and caffeine use (Dougherty & Lister, 2015). When some of these factors are combined the accuracy of BP reading may be altered.

There are three basic BP measurement devices, the Mercury sphygmomanometric device, which has been replaced by more sophisticated automated devices, the Aneroid manometer, which has a small gauge and its accuracy varies among manufacturers; and the Oscillometric device, which is the most commonly used device in hospitals today (McKay, 2008).

Routinely, ED nurses follow their workplace policy and utilise the available equipment to measure BP. Nurses are well trained to prepare patients for the BP measurement procedure by correct identification, verbal consent and climate control. However, some factors related to the type of clothes that patients wear are being overlooked, such as the type of dress and wearing sleeve over arms when taking BP reading. EDs are busy workplaces for nurses, who have limited time to triage and manage every patient according to priority level. When taking BP measurements, ED nurses are often challenged whether to ask patients to roll up their arms' sleeves or not for BP taking purposes. The present study aims to compare BP measurement over sleeved arm and rolled-up (sleeveless) arm in adult patients in an emergency care setting. The study sought to investigate if a significant difference in systolic and diastolic BP measurement over sleeved arm and roll up arm exist. In addition, the study intends to highlight the demographical factors that contribute to different BP measurement over sleeved arm and rolled up arm.

Indeed there are essential and practical benefits of using automated BP measuring devices. In the right working conditions, these computerised machines do not produce terminal digit bias, provide the correct rate of inflation and deflation and produce consistent results over time. In addition, they are not affected by background noise and can be operated with minimal training to staff. Often the manual of a specific equipment outlines that the cuff should be placed on a bare arm because sleeves may lead to a weak pulse, causing errors in measurement. However, this has not been agreed upon nor adhered to in clinical practice (Holland & Lewis, 2014).

Several studies have compared BP measurements over sleeved and rolled-up arms in various clinical settings. Kahan *et al.*, (2003) conducted a study on adult population and found out that the mean difference in BP measurements between sleeved and bare arms for diastolic BP was 1 mmHg (SD 5) and for systolic BP was 0.5 mmHg (SD 7.5), which is clinically insignificant. In Canada, researchers conducted a study on 376 adult patients using automatic oscillometric device and took two separate BP readings (Zuger, 2008). BP reading was in a random order among patients, leaving three minutes of rest time in-between. The results show that the second reading was slightly lower than the first as patients took rest. Therefore, the sleeves did not affect BP readings but the order of reading affected, nevertheless it was a clinically insignificant difference. A similar study that recruited 376 adult patients from a family medicine clinic came to the same conclusion that BP measurement using the automatic oscillometric device over sleeved or bare arms made no clinically-significant difference, irrespective of the order of reading (Grace, Sabin & Dawes, 2008).

Moreover, a study conducted in the Netherlands on 133 outpatients using a validated oscillometric BP device under three conditions; a) with one layer of own clothing underneath the cuff, b) with one layer of standardized clothing underneath the cuff, and c) with the cuff on a bare arm, in a randomized fashion. Patients were seated on a chair with their right arm on the table and their feet flat on the floor during BP measurement (Thien *et al.*, 2015). The differences in systolic BP, diastolic BP, and mean arterial pressure in all the three conditions were not statistically significant, with no critical effect of the measurement order. The results were also not affected by some demographical variables such as age, sex, BMI, and arm circumference. The study assumes that in an outpatient setting, BP can be measured correctly with one layer of clothing underneath the cuff to save the time of both the patients and clinicians.

Automated BP measuring devices have become more reliably accurate, accessible and widely utilised for use in various clinical settings, pharmacies and peoples' homes. However, some clinical settings still utilise the conventional method of BP measurement by using a stethoscope and sphygmomanometer. One study used a traditional mercury sphygmomanometer on 162 nursing college students in Turkey to investigate if a difference exists in BP results when measured over a sleeved or sleeveless arm. It found out that sleeves have no statistically significant effect on BP reading (Ertug *et al.*, 2017). Likewise, a clinical study was conducted on 258 known hypertensive patients (Pinar, Ataalkin & Watson, 2010). BP was measured three times by experienced emergency department nurses over a non-sleeved arm, a sleeved arm and a third time over a non-sleeved arm. A mercury sphygmomanometric device was used. Again, no statically significant differences were noted between all the approaches taken. The researchers argued that BP reading over sleeves is a more practical approach, because it saves emergency nurses time during crowdedness and disasters. Besides, it is safer from an infection control standpoint; it maintains patients' privacy and respects religious beliefs.

On the contrary, a study by Ozone *et al.*, (2016) on aged population (mean age was 74.6) in Japan shows opposing results. The researchers measured BP in three conditions, bare arm, sleeved and rolled-up arm. The Mean BP with bare arms was 128.9 (SD 19.1)/67.4 (10.8) mmHg, sleeved arms was 132.8 (21.0)/72.6 (11.5) mmHg, and rolled-up sleeved arms was 133.4 (21.3)/74.4 (12.1) mmHg. The study revealed that systolic and diastolic BP measurements with sleeved and rolled-up sleeved arms were significantly higher than measurements with bare arms ($P<0.001$). The mean difference in systolic BP readings was 3.76 mmHg (SD 9.96) between bare and sleeved arms and 4.39 mmHg (SD 11.89) between bare and rolled-up sleeved arms. There was no significant difference between BP measured on sleeved and rolled-up sleeved arms. The Japanese study suggests taking BP over bare

arms on the elderly population.

RESEARCH METHODOLOGY

A prospective clinical study was conducted to measure BP over sleeved arm versus bare (sleeveless) arm. The purpose of the study was to investigate if there were any systolic or diastolic BP differences when nurses place BP cuff over a sleeved versus bare arm in emergency department settings. The study adopted a non-invasive BP measurement using automated Oscillometric BP device in two EDs in Aljouf region, Saudi Arabia (SA). Both hospitals used the same automated device. Ethical approval was granted from the local committee of bioethics at Jouf University. At the beginning of the procedure patients were invited to participate in the study, once verbally agreed, a written informed consent was obtained, and the procedure was further explained. Patients were assured that participation is voluntary and if chose to refuse or withdraw, no consequences on the care and treatment they receive would be affected.

Before BP measurements, participants were instructed to empty their bladder, if required, rest for five minutes on a chair in the triage waiting area, uncrossed legs while some demographic data about the participant were collected. These data included Body Mass Index BMI, age, smoking habits, and coffee consumption before their arrival to the ED.

Data collection took place between May to October 2017. Patients, who attended the EDs in the participating hospitals were included if they met the following criteria; a) Age between 18-80 years, b) Triage acuity level of 3, 4 or 5 using the Canadian Triage Acuity Scale (Bullard *et al.*, 2008). Patients were excluded if any of the following criteria were present, a) their Triage level was 1 (Resuscitation) or 2 (Emergent) using the same Triage system, b) patients who presented to the EDs with sleeveless arms, c) patients with peripheral arterial disease, d) patients with chronic or acute renal failure, e) patients who were agitated or those who had aggressive behavior and f) arrhythmic patients and g) patients with mental illness, retardation or substance abuse.

All patients had their BP taken two times using the same oscillometric device over a sleeved arm and rolled-up arm. The sample consisted of 115 adult patients including male and female, who visited the EDs at both hospitals. All measurements were taken by the primary researcher and two registered nurses, who were trained on the procedure and documentation of data by the primary researcher. The order of BP measurements was random, beginning with whichever was more convenient. A rolled-up sleeve and bare (sleeveless) arm are used interchangeably in this research, and both were treated as the same variable. No follow up was required, and no identifying data were collected.

Data Analysis

The mean BP between sleeved and rolled-up sleeve arm of the systolic and diastolic BP was compared using the paired *t*-test. The *t*-test was used to analyze the BP across variables. The ANOVA was also used to relate the BP values by age group (below 30, 30 to 39, 40 to 49 and 50 to 60) and EDS.

Multivariate ANOVA was used to estimate the variation in BP across the measurement methods while making adjustments for age group, the interaction between sleeved and rolled-up systolic and diastolic BP measurements and EDs. All analyses were carried out using Statistical Package for Social Sciences (SPSS) software version 20.

RESULTS

The mean age of the 115 participants was 30.58 with SD of 12.119. The BMI mean was 27.3945 (SD 5.35320). The primary demographic variables of the participants are summarised on table1. Scatter Bland-Altman plots of the variation in the systolic BP between sleeved and rolled-up arm situations and the Bland-Altman plots differences in diastolic BP between sleeved and rolled-up arm are summarised in figures 1 and 2.

Table 1: Baseline Characteristics of the patients aged between 18 – 80 years whose BP was recorded

Variables	*N*	Range	Mean	Std. Deviation
Age in years	115	44	30.58	12.119
Body Mass Index	115	28.40	27.3945	5.35320
Took coffee last 24 h	115	1	0.10	0.307
Smoked last 24 hrs	115	1	0.19	0.395
Valid N (listwise)	115			

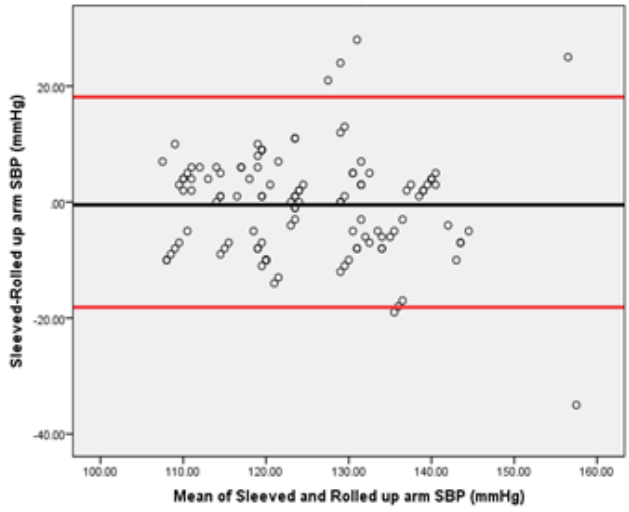

Figure 1: Bland-Altman plots of the variation in the systolic blood pressure between sleeved and rolled up arm Conditions

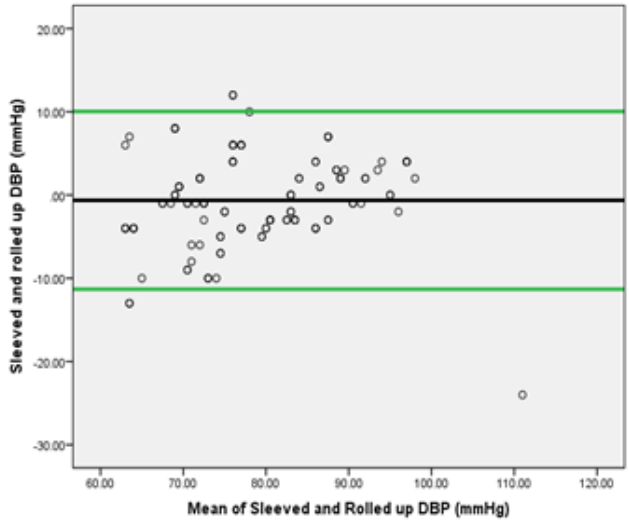

Figure 2: Bland-Altman plots of the variation in the diastolic blood pressure between sleeved and rolled up arm conditions

The systolic BP of the participants was calculated, and the difference between measurements was found to be less than 5 mmHg. The mean BP measured over sleeved and rolled-up arms for all participants was 124.94 (SD 11.372)/78.11 (SD 10.420) mmHg and 125.42 (SD 12.223)/79.09 (SD 9.864) mmHg respectively. The variations in the BP values over rolled-up arms were slightly higher than the measurements over sleeved arms (systolic and diastolic BP). There was no significant difference both in systolic and diastolic BP measurements between sleeved arms and rolled-up arms (p>0.05). The Association of Advancement of Medical Instrumentation (AAMI) standard for comparing methods of BP measurement outlines the accepted range of readings as a mean variance of 5 mmHg or below and a SD of 8 mmHg or less (Frese, Fick & Sadowsky, 2011).

The mean BP on sleeved arms for participants below 30 years was 124.85/77.42 mmHg, for 30 to 39 years was 118.53/ 73.00 mmHg, for 40 to 49 years was 130.57/87.79 mmHg and for 50 to 60 years was 127.77/81.15 mmHg. The mean BP on rolled-up sleeves for participants below 30 years was 124.41/78.11 mmHg, for 30 to 39 years was 120.24/73.18 mmHg, for 40 to 49 years was 133.43/89.86 mmHg, and for 50 to 60 years was 129.08/80.92 mmHg. In all the age groups, the mean BP figures for sleeved arms were slightly lower than those for rolled-up sleeves. The Bland-Altman plots by regression lines of systolic BP and diastolic BP changes between sleeved arms and rolled-up arms with age are shown in figures 3 and 4.

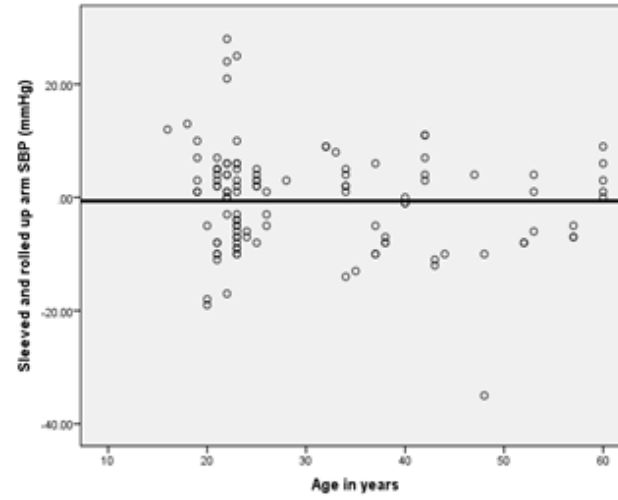

Figure 3: Systolic blood pressure difference between sleeved and rolled up arm by age

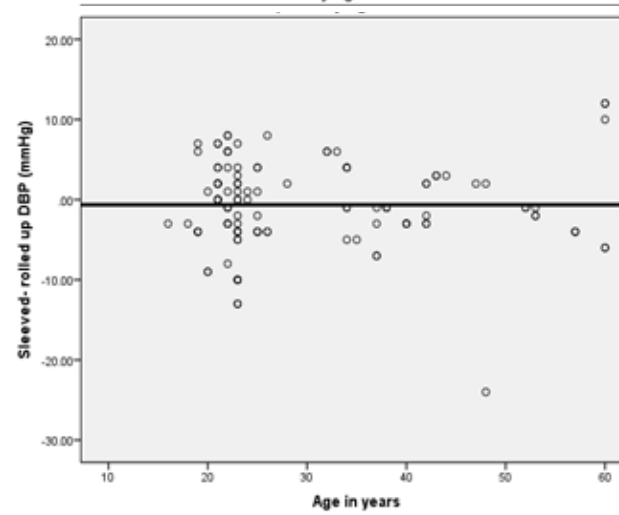

Figure 4: Diastolic blood pressure difference between sleeved arm and rolled up arm by age

With the use of multivariate ANOVA, the difference in the mean scores of the BP measurement methods was insignificant: sleeved and rolled-up arms (p >0.05). Their difference was insignificant in BP measurements between the sleeved and rolled-up arms systolic BP values (p >0.05) and the sleeved and rolled-up arms diastolic BP values (p >0.05)as shown in Table 2.

Table 2: Mean differences in systolic and diastolic sleeved and rolled-up BP measurements

Pairwise Comparisons						
Measure: BP						
(I) Measurement method		Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference [b]	
					Lower Bound	Upper Bound
1	2	-0.478	0.840	1.000	-2.734	1.777
	3	46.487*	0.680	0.000	44.661	48.313
	4	45.852*	0.768	0.000	43.789	47.915
2	1	0.478	0.840	1.000	-1.777	2.734
	3	46.965*	0.949	0.000	44.416	49.515
	4	46.330*	0.792	0.000	44.205	48.456
3	1	-46.487*	0.680	0.000	-48.313	-44.661
	2	-46.965*	0.949	0.000	-49.515	-44.416
	4	-0.635	0.508	1.000	-1.999	0.730
4	1	-45.852*	0.768	0.000	-47.915	-43.789
	2	-46.330*	0.792	0.000	-48.456	-44.205
	3	0.635	0.508	1.000	-0.730	1.999
Based on estimated marginal means						
*. The mean difference is significant at the .05 level.						
b. Adjustment for multiple comparisons: Bonferroni.						

DISCUSSION

The outcomes in the present study are consistent with the results of previous investigations that the difference between BP measurements values over a rolled-up (bare) arm versus over a sleeved arm is statistically insignificant. The mean systolic BP difference of the participants was 0.478 mmHg and 0.635 mmHg for the diastolic BP. This slight variation was not clinically significant. Thus, the outcomes were in agreement with previous studies that revealed similar insignificant variations when measuring BP over sleeved or bare arms (Zuger, 2008; Grace, Sabin & Dawes, 2008; Ki, Oh & Lee, 2013 & Thien *et al.*, 2015).

However, some variation of current results can be attributed to the age factor. As shown in Bland-Altman plots (figures 3 and 4), the variation in BP differences between the sleeved and rolled-up arms seems to correlate positively with age. Hence, BP measurements in the younger cohort are likely to be less susceptible to clothing conditions. This corroborates with findings in the earlier Japanese study on aged population (Ozone *et al.*, 2016). Another justification for such variation may be due to the study design, which may have masked the exact discrepancies by clothing condition. The present study did not attempt to standardise clothing for each participant when measuring the BP over sleeves. The thickness of the cloth might as well affect the measurements of BP values, where thicker sleeves result in high BP variations (Ozone *et al.*, 2016). For sleeved arm readings, the patients wore different clothes with varying thickness, whereas, for the rolled-up sleeve measurements, the patients rolled-up the same cloth up beyond the elbow or removed their garments. The thickness of the fabric after folding was not measured, and it also varied depending on the point of measurement. Thus the readings over the rolled-up arms might be accurate owing to the variation in the thickness of the cloth. Nevertheless, a relatively uniform thick clothing layer for each participant was maintained by the investigator.

The order of measurement might as well have influenced the BP readings. The study by Parati *et al.*, (2013) demonstrated that BP could be substantially reduced within the initial ten minutes before stabilisation in the clinic setting. In this study, the multivariate ANOVA model demonstrated that rolled-up arm recordings differed less importantly from sleeved arm measurements. Because of the changes in the difference in BP through the clothing conditions is somehow negligible, the increase of the rest time before the measurement of BP may not be consequential for actual BP measurements in the regular clinical practice.

The mean Body Mass Index (BMI) of participants was 27.3945 kg/m2, had no significant impact on the BP difference over sleeved or rolled-up arms. Furthermore, the Bland-Altman plots of the variations in the systolic BP between the sleeved and rolled-up arms were not reliant on the mean systolic BP (figures 1 and 2). While a mean-variance below 4 mmHg appears insignificant, the differences demonstrated in the Bland-Altman plots shows that BP readings of some participants measured over a sleeve could either be lower or higher than when taken over a bare arm by 10 mmHg, particularly in older

patients.

Automated Oscillometric BP devices are globally used and recommended over Aneroid and other manual devices for non-invasive BP measurement (O'brien, 2003). Because manual BP devices are affected by many extraneous factors including those related to the patient (e.g., rest), the nurse recording BP (improper technique), and patient-nurse interaction (e.g., talking) (Myers, 2010). In general, the authentication standards and devices' validation is based on their performance against a total of many recordings instead of basing their performance on individual persons. A margin error of 5 mmHg or more on some devices has been found based on some investigation despite these devices having passed the validation tests (Amoore, 2012). It is crucial that the standardised procedures for BP measurements are followed; however, that is not usually the case in some clinical settings, which often results in the misclassification of patients (Van der Wel *et al.*, 2011). The reasons for such variation with some individuals and not others are not well known. Probably, part of the issue may be the conduction of the pulse to the cuff from patients' arms. So if this was the case, then a bare arm might be more accurate than a sleeved one in some cohorts.

Current findings, in addition to other studies, are sufficient evidence of the suggestion that nurses and other healthcare providers could take BP measurement for adults over a sleeved, rolled-up or sleeveless arm, whichever is more convenient, and not worrying about inaccurate BP readings. Even though this may be factual for thin clothing and the measurements were taken with one specific oscillometric BP measuring equipment, the outcomes may not be applicable across the board. As much as it can be true that under some garment's width or a mixture of width and type of cloth, the transmission of the pulse to the cuff will not be adequate, the combination of such aspects is unexplored at present.

RECOMMENDATIONS

The instructions behind the equipment that records BP demand reconsideration because such assumptions were made during the era of outdated technologies. For instance, the majority of the hypertension practice procedures outline the specific BP cuffs sizes to be used under various upper-arm sizes. Up till now, the present cuffs that come with the conventional oscillometric machines are not in conformity with the suggested dimensions for BP measurement by auscultation. Until sufficient research is done on the interactions between machines and clothing, the most appropriate clinical recommendation is to take initial BP readings over a sleeved arm as a standard practice in emergency and outpatient settings. If further monitoring of BP is required, clinicians may opt to take BP measurements over a bare arm. Ideally, some patients may not be willing to remove their clothing during the measurement of BP. Those patients typically stand up, roll up their sleeve, set down and then their BP is taken instantly; instead of first being seated for the recommended five minutes. Because of such complications, for patients who present with sleeves on, it may be more practical to have them rest for few minutes, and then place the cuff over the sleeved arm to take BP reading.

Additional studies are required to ascertain the level at which a sleeve on the arm is agreeable for achieving standard clinical BP measurements, and to determine other factors associated with the differences in BP measurements when patients put on various types of garments. It is also recommended for future researchers to investigate the effect of sleeves on the accuracy of BP measurements in geriatric patients.

LIMITATIONS

The current findings are subject to some limitations. For instance, the research did not have sufficient geriatric patients to determine the age impact on the BP change over a sleeved or rolled-up arm. Besides, patients in the emergency department have no uniform cloth to standardise thickness, and this is coupled with the fact that patients had different arm circumferences. Another possible limitation was that the BP of patients might have been affected by their already conceived opinions on the impact of clothing on BP values. While the participants were not blinded of the group task, the resulting bias due to lack of concealment during recruitment was very minimal.

CONCLUSION

This research has compared BP measurements between sleeved and rolled-up arms in an emergency department. The findings add to our understanding that there is no clinically significant difference in BP measurements when taken on a sleeved or a rolled-up arm. Although the study did not focus on older patients,

it did substantiate the age factor to correlate positively with BP readings. The study has shown that BP measurements in older patients to be more susceptible to clothing conditions. In general, it has been conclusively shown that nurses and other healthcare providers can rest assured that BP measurements undertaken over sleeved arms are less likely to be significantly different from BP measurements when taken on a rolled-up or sleeveless arm.

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REFERENCES

Amoore, J.N. (2012). Oscillometric sphygmomanometers: a critical appraisal of current technology. *Blood pressure monitoring*, 17(2), pp 80-88.

Bullard, M.J., Unger, B., Spence, J., Grafstein, E. & CTAS National Working Group. (2008). Revisions to the Canadian emergency department triage and acuity scale (CTAS) adult guidelines. *Canadian Journal of Emergency Medicine*, 10(2), pp 136-142.

Dougherty, L. & Lister, S. (2015). *The Royal Marsden manual of clinical nursing procedures*. 9th Edition, John Wiley & Sons, UK.

Ertug, N., Cakal, T., Ozturk, S.B. & Verim, M. (2017). The effect of clothes on blood pressure measurement. *Pakistan Journal of Medical Sciences Quarterly*, 33(1), pp 205-209.

Frese, E.M., Fick, A. & Sadowsky, H.S. (2011). Blood pressure measurement guidelines for physical therapists. *Cardiopulmonary physical therapy Journal*, 22(2), pp 5-12.

Grace, M., Sabin, N. & Dawes, M. (2008). A comparison of blood pressure measurement over a sleeved arm versus a bare arm. *Canadian Medical Association Journal*, 178(5), pp585-589.

Holland, M. & Lewis, P.S. (2014). An audit and suggested guidelines for in-patient blood pressure measurement. *Journal of Hypertension*, 32(11), pp 2166–2170.

Kahan, E., Yaphe, J., Knaani-Levinz, H. & Weingarten, M.A. (2003). Comparison of blood pressure measurements on the bare arm, below a rolled-up sleeve, or over a sleeve. *Family Practice*, 20(6),pp 730-732.

Ki, J.H., Oh, M.K. & Lee, S.H. (2013). Differences in blood pressure measurements obtained using an automatic oscillometric sphygmomanometer depending on clothes-wearing status. *Korean Journal of Family Medicine*, 34(2), pp 145-151.

McKay, D. W. (2008). Measuring blood pressure: A call to bare arms?. *Canadian Medical Association Journal*, 178(5), pp 591-593.

Myers, M.G. (2010). Why Automated Office Blood Pressure Should Now Replace the Mercury Sphygmomanometer. *The Journal of Clinical Hypertension*, 12(7), pp 478-480.

O'brien, E. (2003). Demise of the mercury sphygmomanometer and the dawning of a new era in blood pressure measurement. Blood Pressure Monitoring, 8(1),pp 19-21.

Ozone, S., Shaku, F., Sato, M., Takayashiki, A., Tsutsumi, M. & Maeno, T.(2016). Comparison of blood pressure measurements on the bare arm, over a sleeve and a rolled-up sleeve in the elderly. *Family Practice*, 33(5), pp 517-522.

Parati, G., Ochoa, J. E., Lombardi, C. & Bilo, G. (2013). Assessment and management of blood-pressure variability. *Nature Reviews Cardiology*, 10(3), pp 143-155.

Pinar, R., Ataalkin, S. & Watson, R. (2010). The effect of clothes on sphygmomanometric blood pressure

measurement in hypertensive patients. *Journal of Clinical Nursing*, 19(13-14), pp 1861-1864.

Thien, T., Keltjens, E., Lenders, J. W. & Deinum, J. (2015). Should Blood Pressure Be Measured With The Cuff On A Bare Arm? *Blood Pressure Monitoring*, 20(6),pp 320-324.

Van der Wel, M. C., Buunk, I. E., Van Weel, C., Thien, T. A., & Bakx, J. C. (2011). A novel approach to office blood pressure measurement: 30-minute office blood pressure vs daytime ambulatory blood pressure. *The Annals of Family Medicine*, 9(2), pp 128-135.

Zuger, A. (2008).Do I have to take off my shirt?. NEJM Journal Watch. Retrieved from: https://www.jwatch.org/jw200803130000001/2008/03/13/do-i-have-take-my-shirt.