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Digital (DU-150) Sphygmomanometer: Total Reprodusibility Standard and The Influence of Blood Pressure Measurement on Sample Arm Selection

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Abstract-*There are three types of Sphygmomanometer (Hg, aneroid, digital), but only digital types that cannot be standarized directly are related to the accurancy and precision of the standard institutions. Other than that, the standard only contains calibration, tune-up, and retune-up but not yet familiar with reproducibility standards and sample arm selection. In the case of the distance of the heart to the left arm for adults is shorter about 20 cm compared to the distance from the heart to the right arm. In this study, the DU-150 type digital sphygmomanometer is calibrated wth standarized SPY aneroids (type 476226). The reproducibility of the sphygmomanometer is determined according to the ANOVA standard involving 3 people measuring, 10 measuring samples, and each sample measured 2 times and obtained a total reprucibility value of 93%. That is, this tool is feasible to test effect of blood pressure on sample arm selection. Sample arm selection test is carried out on 24 samples (= 48 arms) in various ages of female and male. The results showed that the value of blood pressure on the left arm was different from the right arm for both systole and diastole. The value of blood pressure in a person tends to be greater on the right arm for non-right-handed people, and on the left arm for children and those who are left-handed. Concluded that the DU-150 type digital sphygmomanometer used has met the standards of accurancy, precision, and total reproducibility. In general, the value of blood pressure in the arm to the heart but is more sensitive to the effective diameter of the artery by the habit of physical activity and the events of blood flow based on Pouiseuille law and Continuity law.*

Key words: *digital sphygmomanometer, total reproducibility, arm selection*

I. INTRODUCTION

Sphygmomanometer (SPY) is a blood pressure measuring device that most widely used by audiences. Happened because the measurement of blood pressure with SPY is indirect (non-invasive), the device is mobile, and the price is affordable. Non-invasive blood pressure measurement techniques mean that measurements occur outside the body's tissues so that it does not damage the tissue which means the technique is very safe. Called mobile because the SPY is small in dimension and light, so it is easily moved. Then, and also called affordable prices because it has been proven that SPY is owned by many citizens. However, SPY is deemed inaccurate especially for diastolic determination. Since SPY is only

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sensitive to systolic determination, this tool is usually used to test whether a person has hypertension, hypotension, or normal blood pressure. Hence, this tool is commonly used for measuring blood pressure values for healthy people **[1,2,3]**.

SPY on fabrication product consists of three types, namely: Hg, aneroid, and digital. The three types of SPY, it is only a digital SPY that canot be calibrated by medical device calibrator. As for SPY type Hg and aneroid can be calibrated and even recalibrated. However, digital SPY can be used for blood pressure measurements more efficiently when compared to the other two spies. Based on the background, the digital SPY needs to be indirectly calibrated against the calibrated SPY. Futher information on total reproducibility and also the technique of measuring blood pressure with digital SPY can be obtained.

This study aimed at three things, namely being able to calibrated digital SPY by a SPY calibrator, obtained the level of feasibility of digital SPY to be used as a blood pressure measuring instrument, can be as certained the selection of sample arms against their blood pressure values. Digital SPY is calibrated by aneroid SPY, in order eliminate systematic error in measurements with digital SPY. The feasibility of a digital SPY as a measure of blood pressure based on its total reproducibility value. As for the influence of arm selection (left or right) from the same sample when the sample is without physical activity and the difference in time of measurement is less than one minute **[4,5,6]**.

II. MATERIALS AND EXPERIMENTAL METHODS

This study uses samples in the form of arms (right and left) from 24 randomly selected people, at various ages and genders. As for the tools used are two types of SPY, namely SPY aneroid (as calibrator) and digital SPY type DU-150 (as calibrated) and that is shown in Figure-1. Blood pressure measured samples consisted of 10 arms to determine the total reproducibility of the digital SPY, and 24 people to determine the effect of the arm type (left or right) on the value of blood pressure (Figure-2).

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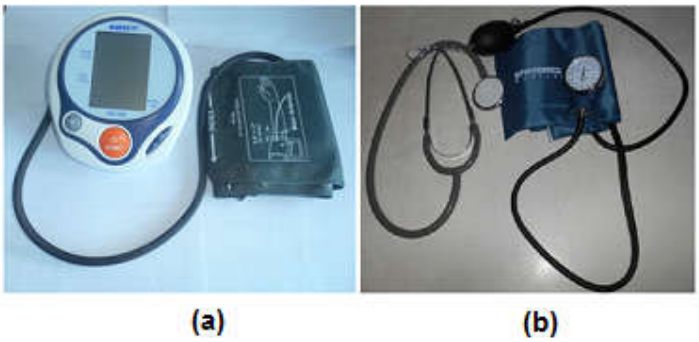

Figure-1(a) digital SPY-DU-150 (as calibrated), and (b) aneroid SPY (as calibrator).

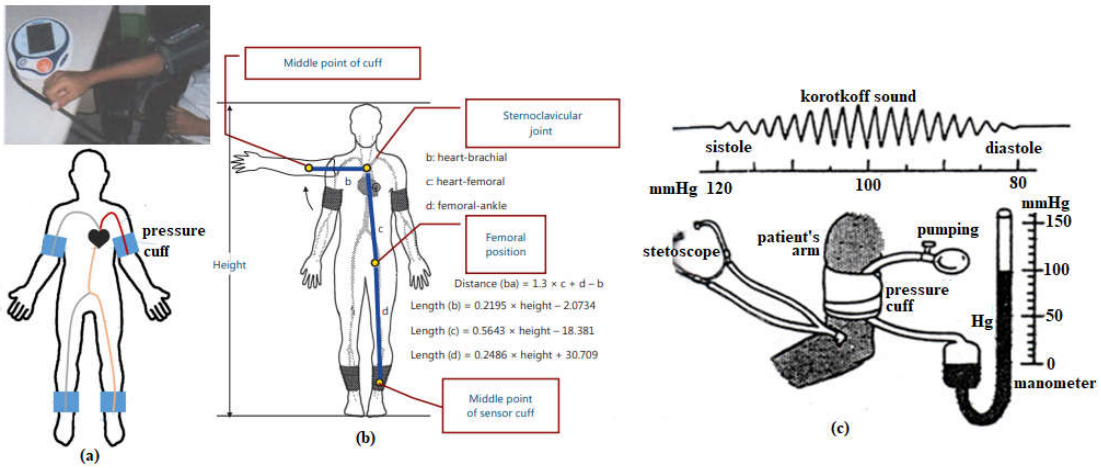

Figure-2(a) SPY usage, (b) length of brachial artery, and (b) SPY work method**[7,8]**.

As for this research carried out in three steps. **First**, it is intended to calibrate digital SPY. Aneroid SPY has been calibrated by the calibrator agency (LPPT-UGM) and has obtained a feasibility certificate for service. Aneroid SPY and digital SPY were used to measure sample blood pressure on the left and right arms respectively, then the arm position was replaced so that the results obtained in the form of systematic error values on digital SPY. **Second**, intended to obtain the total reproducibility of digital SPY. That is, blood pressure measurement were carried out on 10 arm samples, carried out by 3 persons, and each sample measured blood pressure twice by each person who measured it (Figure-3). The results of the measurements were analyzed by analysis of variance (ANOVA) method and results were obtained in the form of repeatability (R_{pet}), reproducibility (R_{prod}), and total reproducibility ($R\&R$). The values of R_{pet}, R_{prod}, and $R\&R$ occur for systole and also diastole. **Third**, blood pressure was measured in 24 samples with digital SPY both the right

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arm and the left arm. Next, plotted the graph of the systole blood pressure comparison between the right arm and the left arm in each sample. The same is done for diastole blood pressure in the sample arm **[9,10,11]**.

Figure-3 Experimentation of determining the total reproducibility of digital SPY.

III. EXPERIMENTAL RESULTS

It was mentioned that this research was carried out in three steps. The first step (S-1) results in a systematic correction of the digital SPY of -1 mmHg for systole and -2 mmHg for diastole. The results were obtained from the blood pressure of a 13-year-old man (Table-1,2).

Table-1 Digital SPY Calibration against aneroid SPY

Arm	Digital SPY (mmHg)		Aneroid SPY (mmHg)	
	Systole	Diastole	Systole	Diastole
Right	107 110	68 71	100 102	65 60
Left	90 95	65 61	100 95	70 60

Table-2 Calibration Result on Digital SPY

Blood Pressure	Digital SPY (mean pressure) (mmHg)	Aneroid SPY (average pressure) (mmHg)	Systematic Correction of Digital SPY (mmHg)
Systole	100,5	99,2	-1
Diastole	66,2	63,8	-2

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Step-2 (S-2), the total reproducibility of the digital SPY is generated. This determination uses data from 10 sample arms measured by three observer and each arm measured twice by each observer (Table-3). From the table the result for systole $R_{pet} = 16{,}4$; $R_{prod} = 14{,}8$, and $R\&R = 22{,}1$ are obtained. As for diastole is obtained that $R_{pet} = 28{,}8$; $R_{prod} = 16{,}4$; and $R\&R = 33{,}1$. Futhermore, the combination of R_{pet}; P_{prod}; and $R\&R$ from systole and diastole yields $R_{pet} = (23 \pm 6), R_{prod} = (16 \pm 1)$, and $R\&R = (28 \pm 5)$. The results show that the total reproducibility of digital SPY is$(\frac{28}{30})$ 93%. And also, the results show that digital SPY, besides being corrected by systematic error, is trusted to be used as a blood pressure measurement tool, and is used for S-3.

Table-3 Data for Determining Total Reproducibility on Digital SPY Type DU-150

Sample (age)	No	First surveyor (mmHg)		Second surveyor (mmHg)		Third surveyor (mmHg)	
		systole	diastole	systole	diastole	systole	diastole
FK (boys, 13 years old)	1	111; 115	68; 67	109; 110	96; 75	111; 117	74; 67
	2	111; 108	67; 67	101; 95	57; 64	96; 101	61; 58
LTF (boys, 15 years old)	3	110; 103	62; 62	102; 105	56; 90	100; 100	53; 58
	4	100; 101	59; 62	98; 92	56; 63	95; 97	59; 61
PNK (ladies, 17 years old)	5	106; 106	69; 74	96; 101	72; 76	96; 94	69; 65
	6	104; 95	70; 68	95; 95	65; 67	97; 90	63; 65
HNF (boys, 21 years old)	7	118; 117	76; 77	118; 119	72; 73	117; 116	72; 73
	8	108; 118	77; 77	119; 119	68; 73	122; 115	69; 62
HNI (grandma, 51 years old)	9	149; 142	91; 93	142; 140	89; 110	147; 147	88; 92
	10	138; 136	83; 99	136; 143	86; 95	141; 138	89; 96

S-3, based on the feasibility of a digital SPY as a blood pressure monitoring device, then the device is used to measure the blood pressure of 24 sample arms for both the left and right arm. In addition, it is also measured heart rate counts per minute when the blood sample arm is measured. The results of these experiment for systole are shown in Figure-4, for diastole in Figure-5, and the heart rate is shown in Figure-6. In addition, the difference in blood pressure values between the left arm and the right arm is displayed for both systole and diastole. On the three graphs (Figure-4,5,6) the order of the test samplest located on the horizontal axis is no different.

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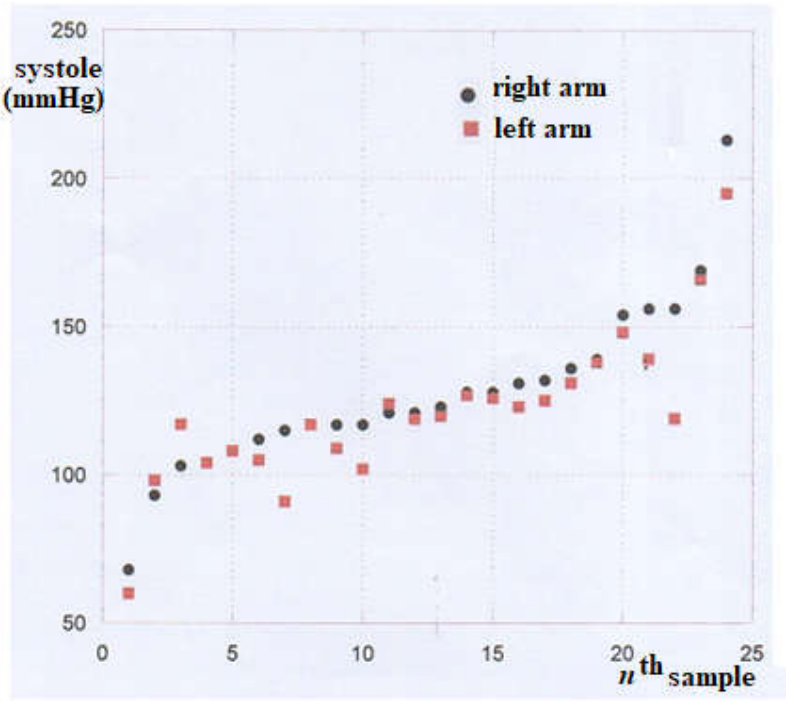

Figure-4 Systole values by the left and right arms in a number of samples.

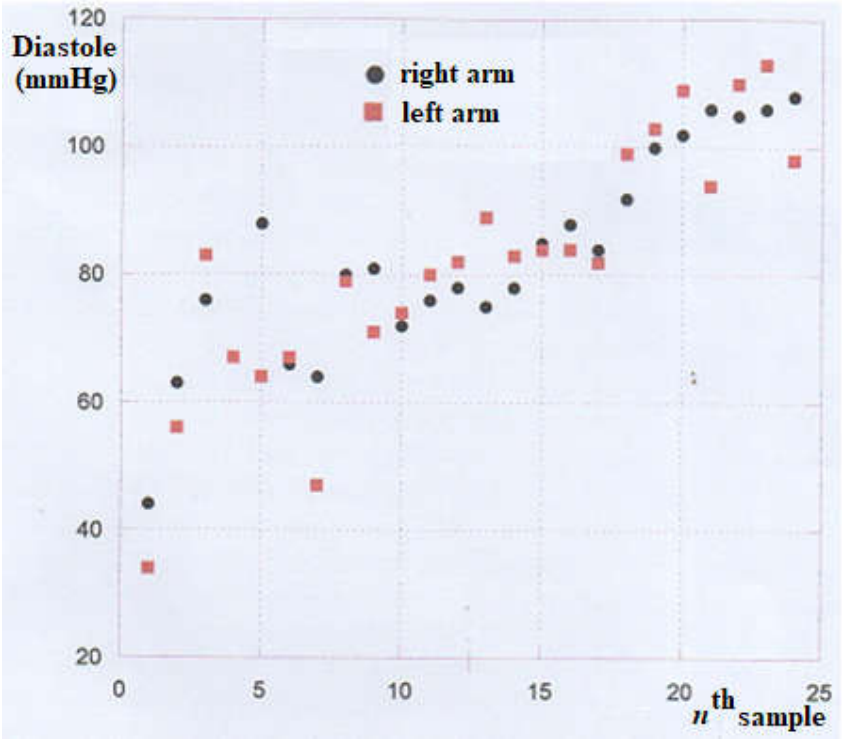

Figure-5 Systole values by the left and right arms in a number of samples.

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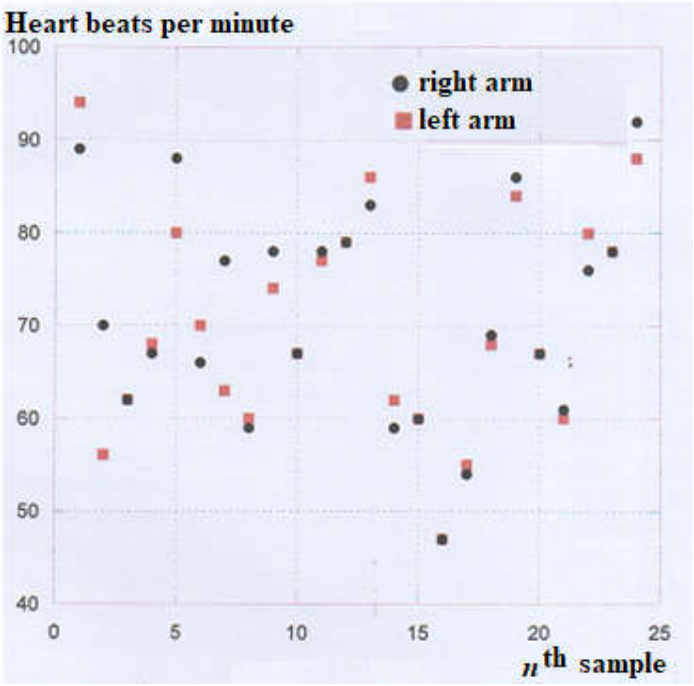

Figure-6 Heart rate counts per minute in the left and right arms in a number of samples.

IV. DISCUSSION

Based on the experimental results, a number of dynamics can be discussed. The results of the experiment step-1 (S-1) provides the conclusion that the actual measurement value is the measurement value that is read on digital SPY and corrected by systematic error with comparative aneroid SPY. For systole, the readable correction value is -1 mmHg. Which means that the reading value on digital SPY is 1 mmHg in excess of the actual value, whereas for diastole it provides a correction of -2 mmHg. Correction in diastole is greater than in systole because uncertainty also contributes to korotkoff sound's too weak to diastole. This step gives the meaning that the value of measuring SPY has been freed from systematic error.

S-2, with the standard ANOVA method which involves statistical factors has been able to show digital SPY has advantages when used to measure diastole when compared with two other types of SPY. In addition, digital SPY is able to provide a total reproducibility of 93%, which means that out of 30 data, only 3 of the measurement data are worthy of doubt. That is, this tool (digital SPY DU-150) is suitable for the service of measuring blood pressure samples.

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S-3 shows that in the same sample, the systole blood pressure of a right-handed person may be greater in the right arm than his or her left arm. However, the difference is not significant because it is no more than 10 mmHg (Figure-4). That is because non-left-handed people are more used to using the right hand for physical activity when compared to the left hand. As a result, blood flows more profusely in the arteries of the right arm to distribute nutrient's and oxygen, so that the flow of blood flow is greater (at the diameter of the artery and the viscocity of blood remains constant) so that blood pressure become greater. It is consistent with the law of Pouiseuille and the law of continuity in physics. But for children, blood pressure in the left arm is greater than blood pressure in the right arm. Such a think may happen to those who are left-handed. As for diastole (Figure-5), the results of the comparison of blood pressure between the left arm with the right are indeed varied. That result may be due to the measurement of diastole with SPY is inaccurate. Figure-4 and 5 show a tendency that blood pressure values for both systole and diastole tend to be greater when the heart rate is faster (Figure-6).

V. CONCLUSION

It was concluded that digital SPY type DU-150 that was obtained randomly from the market was eligible to be utilized in blood pressure measurement service. That's because the digital SPY has been able to be calibrated indirectly and has great reproducibility. In addition, the selection of the arm for blood pressure measurement by sampling turns out that the left arm is no different from the sample's right arm. Wise blood pressure measurement with a SPY is not related to the selection of the arm (left or right) but the sample should be relaxed and lying down so that the hight of the arm is equal to the height of the head of the sample.

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