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Performance Comparison of Dymind DH-76 and Sysmex Xn-1000 Automated Hematology Analyzers

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ABSTRACT

An automatic hematology analyzer is an essential instrument for the modern laboratory. A new hematology analyzer must undergo comparability testing with a currently used hematology analyzer. This study aimed to compare the performance of the Dymind DH-76 and Sysmex XN-1000 hematology analyzers. This study involved 96 EDTA blood samples from patients aged 18 to 85 years old at a hospital in Jakarta. A complete blood count was performed on each blood sample using two above-mentioned analyzers Dymind DH-76 and Sysmex XN-1000. The results from both instruments were compared by using the Pearson correlation test and the Passing-Bablok regression analysis to determine the agreement in performance between the two instruments. Between the Dymind DH-76 and Sysmex XN-1000, there was a high degree of agreement and correlation concerning the investigated parameters with $r > 0.900$ and $p<0.001$ for the parameters RBC, HGB, WBC, HCT, MCV, MCH, and neutrophil, monocyte, and eosinophil counts. The MCHC parameter had the values of $r=0.797$; $p=0.0001$, while the lymphocytes parameter had $r=0.734$ and $p=0.0001$. Only the basophils parameter showed a different result between the two aforementioned analyzers, with $r=-0.179$ and $p=0.102$. The majority of complete blood count parameters showed an excellent correlation and a high degree of agreement between the two instruments. The Dymind DH-76 hematology analyzer meets international standards (National Committee for Clinical Laboratory Standards/NCCLS) and can be used for hematological assay in the laboratory.

Keywords: Dymind DH-76, Sysmex XN-1000, hematology analyzer, basophils

INTRODUCTION

The use of an automatic hematology analyzer in the laboratory is a necessity, particularly in the modern laboratory, because it can improve the accuracy and speed of the complete blood count.[1] The complete blood count parameters that may be generated by the hematology analyzer are among others hemoglobin concentration (HGB), Red Blood Cell count (RBC), hematocrit (HCT), mean erythrocyte indices, White Blood Cell count (WBC), absolute and relative differential counts, and platelet count (PLT).[1,2] Hematology analyzers of a variety of brands have different specifications and working methods for the determination of hematology results. There is number of different types of hematology analyzer available in Indonesia, one of them being the Dymind DH-76. This instrument uses three working principles, namely colorimetry for the determination of HGB, and the impedance method for the determination of WBC, RBC, and PLT, and triangle laser scatter flow cytometry for the 5-part white blood cell differential count.

The DH-76 analyzer has a throughput of 80 tests per hour with 29 parameters that can be examined.[3] Increasing the number of parameters that may be produced will affect the reliability and utility of the parameter of interest for the clinical interpretation required by the clinicians.[2] The presence of a new hematology analyzer such as the Dymind DH-76 should be supported such that several brands are available in Indonesia, in accordance with the capability of the laboratory that will be using the instrument. The results from a hematology analyzer that is used in a laboratory must be comparable and have the same degree of accuracy and precision as the hematology analyzers used in other laboratories.[4]

The Sysmex brand hematology analyzer is the most frequently circulating instrument in Indonesia and one of its types is the Sysmex XN-1000. This study aimed to compare the performance of the Dymind DH-76 and Sysmex XN-1000 hematology analyzers.

METHODS

To compare the Dymind DH-76 and Sysmex XN-1000 hematology analyzers, a total of 96 EDTA blood samples were taken, originating from adult patients aged 18 to 85 years old who had complete blood counts at a private hospital in Central Jakarta. A blood sample of two mL per tube was drawn using a K2EDTA vacutainer tube. The EDTA samples were stored at room temperature before analysis and were subsequently examined on the Dymind DH-76 and Sysmex XN-1000 hematology analyzers. The blood counts were completed on these analyzers within four hours from the time of sample collection. The collected samples were from patients with normal, low, and high hemoglobin concentrations and platelet counts. The examinations were carried out for 10 days in July 2021. Every day 9-10 samples were collected, resulting in a total of 96 samples.

Calibration of the two analyzers was performed at the time of installation of the instruments and after each analyzer had been calibrated, the instrument was serviced. The calibration had to meet the targets of the instrument manufacturer and was performed with a calibrator from each of the respective manufacturers.[5] Before performing hematological examinations on the two instruments, quality control was performed by the controls used for each analyzer, by using low, normal, and high levels of control, both within-run, and between-day, each day for the duration of the study. The control material from both analyzers was stored in the refrigerator at a temperature of 2-80C.[3,6] The control material was taken out of the refrigerator and left to stand at room temperature for 30 minutes before being used. The quality control material was homogenized before assay in the hematology analyzer. The dimensions of the Dymind DH-76 hematology analyzer are 52.5 cm x 62 cm x 62 cm (height x length x width) and the instrument requires an optimal temperature of 15-300C, the humidity of 30%-85%, and a 100-240 V power supply, whereas the Sysmex XN-1000 measures 85.5 cm x 75.5 cm x 64.5 cm (height x length x width) and requires an optimal temperature of 15-300C, the humidity of 20-85% and a 100-240 V power supply.[3,6]

The Sysmex XN-1000 (Sysmex, Kobe, Japan) uses fluorescent flow cytometry, impedance, and optical cytometry. Fluorescent flow cytometry is used to detect white blood cells in all examination channels and is based on scattered laser light (forward and side scatter). The impedance method is used to count red blood cells and platelets. In addition to the impedance method, the red blood cells and platelets are also examined by the hydrodynamic focusing method.[7] There is also an optical channel for reticulocyte and platelet counts. The volume of the blood sample aspirated is 88 μL in all modes. The capacity of this analyzer is 100 samples per hour. The Sysmex XN-1000, can detect 28 parameters (complete blood count + differential count and nucleated erythrocytes). There are 16 other parameters that can be detected with this instrument. In addition, there is also a channel for detecting immature granulocytes.

The Dymind DH-76 (Dymind Biotech, Shenzen, China) uses colorimetry, triangle laser scatters flow cytometry, and the impedance method. In colorimetry for the assay of hemoglobin, the blood samples are subjected to hemolysis by the lysing reagent, such that the hemoglobin passes out of the erythrocytes and is bound by lysing to stabilize it. The binding between the hemoglobin and lyse is measured at a wavelength of 525 nm. Triangle laser scatters flow cytometry is used to detect various types of leukocytes in the differential count (5-part white blood cell count).

The principle of this method is that there are three angles of light scatters, namely low angle scatter to indicate volume and number of cells; middle angle scatters to show number and information about the cell nuclei (granularity), and high angle scatter to show the complexity of the cell nuclei. The impedance method is used for determining the WBC, RBC, and PLT. The working principle of the impedance method is that cells passing through the aperture will change the impedance thus producing a pulse. The height of the pulse indicates the size of the cells, whereas the number of pulses indicates the number of cells. The volume of the blood sample aspirated is 20 μL in all modes, with the Dymind DH-76, which can detect 29 parameters, including the 5-part white blood cell differential count with a capacity of 80 samples per hour. In addition, the Dymind DH-76 can detect Abnormal Lymphocytes (ALY; %/#), Large Immature Cells (LIC; %/#), Platelet Large Cell Ratio (P-LCR), and Platelet Large Cell Count (P-LCC).[1,3]

Table 1. Limits of detection of Sysmex XN-1000 and Dymind DH-76

Parameter (unit)	Sysmex XN-1000	Dymind DH-76
WBC (10^9/L)	0.00-440	0.00-300
RBC (10^{12}/L)	0.0-8.8	0.0-8.5
HGB (g/dL)	0.0-24.5	0.0 -25
PLT (10^9/L)	0.0-5000	0.0-3000

References: Sysmex and Dymind DH-76 manuals'

The linearity of the two analyzers is shown in Table 1. Statistical analysis to determine the correlation between the results of the two instruments was carried out using the Spearman correlation test at p<0.05. To determine the degree of agreement between the two instruments the Passing-Bablok and Bland-Altman regression analyses were done.

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RESULTS AND DISCUSSIONS

Table 2 shows the results of the within-run quality control tests replicated 10 times for each level. Examination of the agreement of within-run quality controls is urgently needed to determine analyzer quality, particularly agreement in replications with minimal differences. The within-run test results for Dymind DH-76 show a high degree of agreement with those given in the user manual of the instrument (Table 2). When compared with the allowable CV, all parameters were still within the respective CV ranges, except for the low-level PLT parameter, which showed a CV of 6.56%. This figure is still below the CV given in the manual of the instrument, which is 8%, but for the recommended CV of 4.5%, the obtained results were slightly above the recommended range. The resulting CV of 6.56% was still within the range recommended for the category of platelets in the lower range, with the maximum limit of CV < 10%.[5] For normal PLT levels, the results of this study are in agreement with the study results for the DH-76 in Bulgaria, with CV 2.3% vs. 2.5%. For the results of high PLT level, this study shows a better CV as compared with those from Bulgaria with CV of 1.52% vs. 9.4%.[1]

Table 3 shows the between-day quality control results during the course of this study. These quality control results were all still within the range given in the manual of the instrument. The between-day tests showed corresponding results for all parameters, in comparison with those printed on the instrument as well as from the recommended references, as can be

Table 2. Imprecision of within-run quality control results for Dymind DH-76

Parameter	X±SD	CV(%)	CV(%) Printed on the Instrument*	Allowable CV(%)**
WBC low level (2.78 – 3.78 x10^9 /L)	3.23±0.06	1.83	5	6
WBC normal level (6.35-8.35 x10^9 /L)	7.33±0.13	1.76	2	2.5
WBC high level (13.83-18.83 x 10^9 /L)	16.33±0.16	0.99	5	1.5
RBC low level (2.23-2.59x10^{12} /L)	2.43±0.01	0.64	-	-
RBC normal level (4.43-4.91x10^{12} /L)	4.69±0.02	0.44	1.5	1.1
RBC high level (4.81-5.81x10^{12} /L)	5.38±0.04	0.73	-	-
HGB low level (5.4-6.2 g /dL)	5.88±0.04	0.68	-	-
HGB normal level (12.6-13.8 g /dL)	13.29±0.08	0.63	1.5	0.9
HGB high level (15.9-17.5 g /dL)	16.81±0.05	0.32	-	-
HCT low level (18.4-18.8 %)	18.67±0.11	0.59		
HCT normal level (40.9-44.2 %)	41.18±0.17	0.40	-	1.2
HCT high level (47.7-55.7 %)	52.16±0.38	0.72		
PLT low level (31-71x10^9 /L)	53.7±3.52	6.56	8.0	4.5
PLT normal level (213-293x10^9 /L)	246.2±5.65	2.30	4.0	3.0
PLT high level (440-560x10^9 /L)	506.4±7.69	1.52	8.0	3.0
MCV low level (72.1-82.1 fL)	76.8±0.24	0.32	-	-
MCV normal level (83.2-93.2 fL)	87.69±0.13	0.15	1.0	0.6
MCV high level (91.4-103.4 fL)	96.95±0.08	0.08	-	-
MCH low level (21.6-26.6 pg)	24.19±0.10	0.43	-	
MCH normal level (25.8-30.8 pg)	28.32±0.19	0.68	-	1.1
MCH high level (29-34 pg)	31.25±0.24	0.79	-	-
MCHC low level (28.2-34.2g/dL)	31.49±0.14	0.44	-	-
MCHC normal level (29.1-35.1 g/dL)	32.28±0.19	0.62	-	-
MCHC high level (29.3-35.3 g/dL)	32.24±0.24	0.74	-	-

WBC, White Blood Cell count; RBC, Red Blood Cell count; HGB, hemoglobin; MCV, Mean Corpuscular Volume; MCH, Mean Corpuscular Hemoglobin; MCHC, Mean Corpuscular Hemoglobin Concentration; PLT, platelet count.
*CV(%) printed on the DYMIND DH-76
**Allowable detection limit for within-run imprecision[4,8-10]

Table 3. Imprecision of between-day quality control results for Dymind DH-76

Parameter	X±SD	CV(%)	CV(%) printed on the instrument *	Allowable CV(%)**
WBC low level (2.78 - 3.78 $x10^9$/L)	3.30±0.07	2.26	5	-
WBC normal level (6.35-8.35 $x10^9$/L)	7.36±0.11	1.56	2	1.5
WBC high level (13.83-18.83 x 10^9/L)	16.41±0.20	1.21	5	-
RBC low level (2.23-2.59$x10^{12}$/L)	2.44±0.03	1.24	-	-
RBC normal level (4.43-4.91$x10^{12}$/L)	4.68±0.03	0.64	1.5	1.1
RBC high level (4.81-5.81$x10^{12}$/L)	5.30±0.05	1.01	-	-
HGB low level (5.4-6.2 g /dL)	6.03±0.06	1.07	-	-
HGB normal level (12.6-13.8 g /dL)	13.50±0.13	0.94	1.5	1.0
HGB high level (15.9-17.5 g /dL)	16.96±0.11	0.66	-	-
HCT low level (18.4-18.8 %)	19.10±0.3	1.7	-	-
HCT normal level (40.9-44.2 %)	41.6±0.5	1.2	-	1.4
HCT high level (47.7-55.7 %)	52.1±0.5	0.9	-	-
PLT low level (31-71$x10^9$/L)	56.55±3.39	5.99	8.0	-
PLT normal level (213-293$x10^9$/L)	246.64±6.77	2.75	4.0	3
PLT high level (440-560$x10^9$/L)	490.18±8.69	1.77	8.0	-
MCV low level (72.1-82.1 fL)	78.17±0.70	0.89	-	-
MCV normal level (83.2-93.2 fL)	88.82±0.60	0.68	1.0	0.8
MCV high level (91.4-103.4 fL)	98.32±0.54	0.55	-	-
MCH low level (21.6-26.6 pg)	24.65±0.31	1.27	-	-
MCH normal level (25.8-30.8 pg)	28.87±0.22	0.76	-	1.5
MCH high level (29-34 pg)	32.01±0.36	1.13	-	-
MCHC low level (28.2-34.2 g/dL)	31.57±0.33	1.06	-	-
MCHC normal level (29.1-35.1 g/dL)	32.50±0.25	0.78	-	-
MCHC high level (29.3-35.3 g/dL)	32.55±0.26	0.81	-	-

WBC, White Blood Cell count; RBC, Red Blood Cell count; HGB, Hemoglobin; MCV, Mean Corpuscular Volume; MCH, Mean Corpuscular Hemoglobin; MCHC, Mean Corpuscular Hemoglobin Concentration; PLT, platelet count.
*CV(%) printed on the DYMIND DH-76
**Allowable detection limits for within-run imprecision[4,8-10]

seen in Table 3. The highest variability of the between-day test was also seen in the low PLT level parameter with a CV of 5.99%, which was still below that printed on the instrument and below the recommended value of < 10%.[4] The study results of Velizarova *et al.* showed a PLT CV of 6.1% for imprecision between batches in normal level controls, whereas in the present study the CV value was 2.75%.[1]

Table 4 shows the correlation results of the hematology examinations on the two instruments. All parameters had an r of >0.900 and p=0.001 except for the MCHC and lymphocyte differential count, with r=0.797 and r=0.734, respectively, and p=0.0001. These results show that the two analyzers had a good correlation. Only the basophil differential count showed the values of r=-0.179 and p=0.102, signifying that there was a significant difference between the basophil differential count results on the two instruments.

Table 4. Results of the Spearman correlation test between Dymind DH-76 and Sysmex XN-1000

Parameter	R	p
WBC	0.998	0.0001
RBC	0.997	0.0001
HGB	0.998	0.0001
HCT	0.936	0.0001
PLT	0.982	0.0001
MCV	0.963	0.0001
MCH	0.941	0.0001
MCHC	0.797	0.0001
Neutrophils	0.958	0.0001
Lymphocytes	0.734	0.0001
Monocytes	0.926	0.0001
Eosinophils	0.986	0.0001
Basophils	-0.179	0.102*

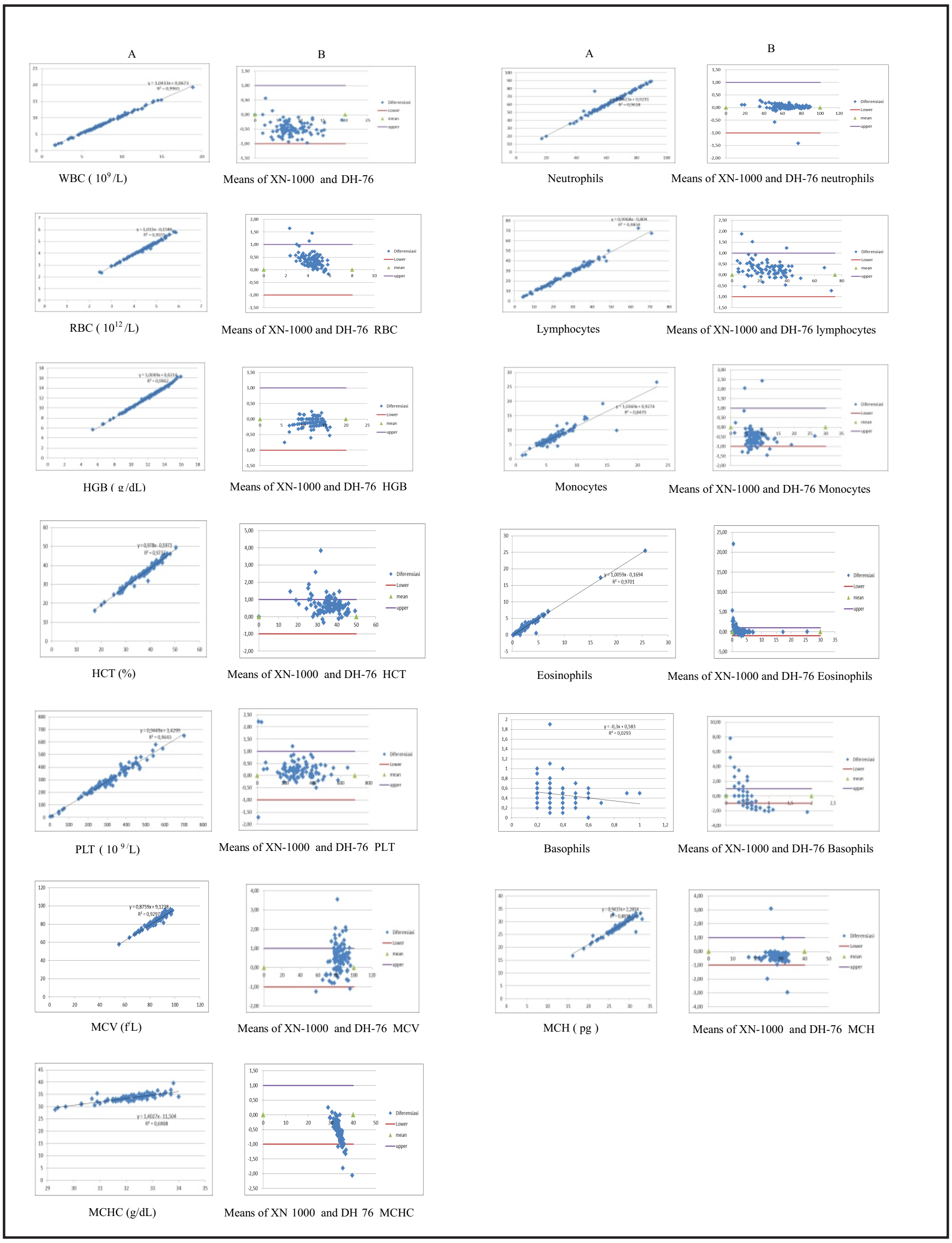

Figure 1. Passing-Bablok regression (A) and differentiation plots with Bland-Altman (B). X-axis: Sysmex XN-1000; Y-axis: DH-76

The results of the tests of agreement between the two hematology analyzers may be seen in Fig. 1, showing a good degree of agreement between these instruments, except for the MCHC and basophil parameters. These results are supported by the study of Velizarova *et al.* who compared the same pair of hematology analyzers, but obtained different results as compared with those of the present study, particularly in the basophil differential count, showing disagreement between the two analyzers.[1] This may have been caused by differences in the methods of reading the differential count in the two instruments.[3,6] As is well-known, basophils are cells with the lowest number in the peripheral blood. The fewer cells present in the peripheral blood, the lower the correlation.[11,12] Sysmex XN-1000 uses the more sensitive fluorescein method.[1,11] Differences in correlation for the differential count between hematology analyzers were also found in the studies reported by Ciepiela *et al.* and Kweon *et al.*[13,14]

Even studies of hematology analyzers from the same manufacturer show a low correlation for the basophil parameter. This is mainly due to the small basophil population in the peripheral blood.[11] The analysis of similarities between leukocyte differential counts on the Dymind DH-76 and the manual leukocyte differential counts performed by two of the investigators showed extremely good results for lymphocyte and neutrophil differential counts with correlations of r>0.97), but for monocyte and basophil differential counts, a slightly lower correlation was found, with r=0.836 and r=0.625), respectively.[1] Difference in MCHC were also found in the study by Malecka *et al*., but reportedly these parameters were not crucial patients conditions and were mainly used to determine various types of anemia.[2] MCHC is a parameter determined by the hematocrit and hemoglobin concentration. The Dymind DH-76 uses colorimetry to detect hemoglobin and calculated HCT (RBC x MCV:10), whereas Sysmex XN-1000 uses colorimetry to detect hemoglobin with (SLS-HGB method) and the impedance method with hydrodynamic focusing for counting RBC and HCT.[3,6]

The occurrence of differences in these detection methods results in a relatively lower correlation for MCHC. Differences in the parameters MCHC, monocytes, and basophils were also shown in the results of the evaluation between the Sysmex XN-3100 and XE-2100 hematology analyzers.[9] A limitation of the present study is that the number of samples for the detection of low WBC was 7 samples and for platelet counts 6 samples, whereas for the high level of the HGB parameter there were 6 samples; for WBC there were 15 samples and for PLT 11 samples, such that the comparability between the two instruments was predominantly represented by samples with normal levels. For the samples of leukopenia and thrombocytopenia as well as leukocytosis and thrombocytosis and high HBG level, the results of this study cannot yet be generalized and require a separate evaluation.

CONCLUSIONS AND SUGGESTIONS

The results of the evaluation of comparability between the Dymind DH-76 and Sysmex XN-1000 hematology analyzers showed excellent correlation and agreement for most of the parameters. There is a need for further research using pathological samples of HGB, WBC, or PLT, such that the performance of the analyzers under abnormal conditions may be determined.

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