Customer Information

Paediatric reference intervals on the Sysmex XE-2100 haematological analyser

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Subject:	Paediatric reference intervals on XE-2100
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Paediatric reference intervals are difficult to obtain by individual laboratories due to limited access to "normal" paediatric samples. The determination of reference intervals is not trivial and provides many sources for pitfalls and errors if not done properly[1,2]. For a very limited number of well standardised haematological parameters age-dependent paediatric reference intervals can be found in the scientific literature, including textbooks. However, often it remains unclear how these reference intervals were obtained and whether data obtained with instruments from a particular manufacturer can be used for instruments of a different manufacturer (or even for different instrument series of the same manufacturer).

A quite comprehensive study on age-dependent paediatric reference intervals (including a limited number of adult samples) on the Sysmex XE-2100 haematological analyser has been performed at the *Children's National Medical Center*, Washington, DC, USA[3]. Reference individuals were selected among outpatients and patients admitted to the emergency room with exclusion of patients attending haematology and oncology clinics. The generation of the reference intervals included removal of outliers, followed by elimination of a certain percentage of the highest and lowest values (variable for different haematological parameters), and calculation of the 2.5th and 97.5th percentile from the remaining data (for details see reference). This procedure differs from the "traditional" method of determining reference intervals as recommended e.g. by the *International Federation for Clinical Chemistry and Laboratory Medicine* (IFCC)[4-8] or by the US-based *Clinical and Laboratory Standards Institute* (CLSI)[9] by including non-healthy subjects in the reference population combined with removal of very high and low values by truncation.

Since these reference intervals were not determined by Sysmex they are not officialised reference intervals and Sysmex cannot take any responsibility for them. Each laboratory should confirm that these reference intervals are applicable to their own reference population, which is by far easier and less time consuming for the laboratory than

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determining its own reference intervals. Methods for this verification procedure have been described in the literature[7,9,1].

For the parameter reticulocyte haemoglobin content (Ret-H_e) no reference intervals for the Sysmex XE-2100 are provided in the quoted publication. However, in the same publication *C Brugnara* reports reference intervals for CHr, a parameter describing reticulocyte haemoglobin content on the Siemens ADVIA 120[3]. For normal (and most pathological) samples from adults it has been proven that the numerical values of Ret-H_e and CHr are virtually identical[10]. There is a high probability that this is also true for paediatric samples. Verification of these reference intervals is particularly recommended before using them.

Since Sysmex X-Class haematological analysers (XE-, XT- and XS-series) are using very similar or even identical analytical measurement procedures for the parameters discussed here, the use of the reference intervals determined on a Sysmex XE-2100 on these analysers should be possible after appropriate verification.

In the following tables N reflects the number of individuals investigated for a particular gender and age group.

WBC				
White blood cell concentration				
	Male		Female	
Age	N	x 10^9/L	N	x 10^9/L
0 - 14 days	56	8.04 - 15.40	44	8.16 - 14.56
15 - 30 days	53	7.80 - 15.91	35	8.36 - 14.42
31 - 60 days	111	8.14 - 14.99	75	7.05 - 14.68
61 - 180 days	67	6.51 - 13.32	44	6.00 - 13.25
0.5 - <2 years	537	5.98 - 13.51	466	6.48 - 13.02
2 - <6 years	1194	5.14 - 13.38	1075	4.86 - 13.18
6 - <12 years	1276	4.31 - 11.00	1068	4.27 - 11.40
12 - <18 years	1454	3.84 - 9.84	1736	4.19 - 9.43
≥18 years	261	3.91 - 8.77	458	4.37 - 9.68

RBC				
Red blood cell concentration				
	Male		Female	
Age	N	x 10^{12}/L	N	x 10^{12}/L
0 - 14 days	59	4.10 - 5.55	47	4.12 - 5.74
15 - 30 days	53	3.16 - 4.63	39	3.32 - 4.80
31 - 60 days	111	3.02 - 4.22	72	2.93 - 3.87
61 - 180 days	282	3.43 - 4.80	214	3.45 - 4.75
0.5 - <2 years	1210	4.03 - 5.07	1049	3.97 - 5.01
2 - <6 years	1198	3.89 - 4.97	1087	3.84 - 4.92
6 - <12 years	1278	3.96 - 5.03	1084	3.90 - 4.96
12 - <18 years	1467	4.03 - 5.29	1762	3.93 - 4.90
≥18 years	264	4.18 - 5.48	467	3.70 - 4.87

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Hgb				
Haemoglobin concentration				
	Male		Female	
Age	N	g/L	N	g/L
1 - 14 days	60	139 - 191	48	134 - 200
15 - 30 days	55	100 - 153	37	108 - 146
31 - 60 days	110	89 - 127	71	92 - 114
61 - 180 days	277	96 - 124	209	99 - 124
0.5 - <2 years	1350	101 - 125	1171	102 - 127
2 - <6 years	1383	102 - 127	1281	102 - 127
6 - <12 years	1420	107 - 134	1207	106 - 132
12 - <18 years	1569	110 - 145	1872	108 - 133
≥ 18 years	268	119 - 154	471	106 - 135

Hct				
Haematocrit				
	Male		Female	
Age	N	%	N	%
0 - 14 days	68	39.8 - 53.6	51	39.6 - 57.2
15 - 30 days	58	30.5 - 45.0	42	32.0 - 44.5
31 - 60 days	116	26.8 - 37.5	77	27.7 - 35.1
61 - 180 days	305	28.6 - 37.2	231	29.5 - 37.1
0.5 - <2 years	1538	30.8 - 37.8	1343	30.9 - 37.9
2 - <6 years	1765	31.0 - 37.7	1680	31.2 - 37.8
6 - <12 years	1520	32.2 - 39.8	1304	32.4 - 39.5
12 - 18 years	1598	33.9 - 43.5	1944	33.4 - 40.4
>18 years	275	36.2 - 46.3	486	32.9 - 41.2

MCV				
Mean corpuscular volume				
	Male		Female	
Age	N	fL	N	fL
0 - 14 days	63	91.3 - 103.1	48	92.7 - 106.4
15 - 30 days	56	89.4 - 99.7	39	90.1 - 103.0
31 - 60 days	110	84.3 - 94.2	78	83.4 - 96.4
61 - 180 days	298	74.1 - 87.5	229	74.8 - 88.3
0.5 - <2 years	1260	69.5 - 81.7	1081	71.3 - 82.6
2 - <6 years	1279	71.3 - 84.0	1133	72.3 - 85.0
6 - <12 years	1349	74.4 - 86.1	1140	75.9 - 87.6
12 - <18 years	1543	76.7 - 89.2	1840	76.9 - 90.6
≥18 years	273	80.0 - 93.6	477	77.7 - 93.7

MCH				
Mean corpuscular haemoglobin				
	Male		Female	
Age	N	pg	N	pg
1 - 14 days	62	31.3 - 35.6	44	31.1 - 35.9
15 - 30 days	58	29.9 - 34.1	39	30.4 - 35.3
31 - 60 days	104	27.8 - 32.0	78	28.0 - 32.5
61 - 180 days	292	24.4 - 28.9	219	24.4 - 29.5
0.5 - <2 years	1262	22.7 - 27.2	1086	23.2 - 27.5
2 - <6 years	1266	23.7 - 28.3	1132	23.7 - 28.6
6 - <12 years	1341	24.9 - 29.2	1146	24.8 - 29.5
12 - <18 years	1536	25.2 - 30.2	1848	24.8 - 30.2
≥18 years	268	26.5 - 31.4	475	25.3 - 30.9

MCHC				
Mean corpuscular haemoglobin concentration				
	Male		Female	
Age	N	g/L	N	g/L
0 - 14 days	64	330 - 357	49	334 - 354
15 - 30 days	59	327 - 351	39	332 - 350
31 - 60 days	116	323 - 348	76	325 - 349
61 - 180 days	301	319 - 344	227	321 - 344
0.5 - <2 years	1260	316 - 344	1088	319 - 342
2 - <6 years	1273	320 - 347	1143	318 - 346
6 - <12 years	1360	322 - 349	1148	318 - 346
12 - <18 years	1553	318 - 348	1845	315 - 342
≥18 years	271	319 - 348	483	310 - 341

PLT				
Platelet concentration				
	Male		Female	
Age	N	x 10^9/L	N	x 10^9/L
0 - 14 days	56	218 - 419	46	144 - 449
15 - 30 days	51	248 - 586	39	279 - 571
31 - 60 days	115	229 - 562	72	331 - 597
61 - 180 days	280	244 - 529	208	247 - 580
0.5 - <2 years	1208	206 - 445	1058	214 - 459
2 - <6 years	1218	202 - 403	1099	189 - 394
6 - <12 years	1289	206 - 369	1084	199 - 367
12 - <18 years	1481	175 - 332	1773	194 - 345
≥18 years	263	151 - 304	458	186 - 353

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RDW-SD				
Red cell distribution width (standard deviation)				
	Male		Female	
Age	N	fL	N	fL
0 - 14 days	57	51.0 - 61.7	47	51.4 - 65.7
15 - 30 days	47	46.3 - 57.3	42	47.2 - 59.8
31 - 60 days	110	43.9 - 52.8	75	43.0 - 55.0
61 - 180 days	273	35.3 - 45.7	210	35.2 - 45.1
0.5 - <2 years	1179	35.3 - 42.8	1030	34.9 - 42.4
2 - <6 years	1146	35.1 - 41.7	1042	34.9 - 42.0
6 - <12 years	1224	35.1 - 41.7	1036	35.5 - 41.8
12 - <18 years	1391	36.7 - 43.8	1704	37.1 - 44.2
≥18 years	255	37.8 - 46.1	449	38.4 - 47.7

RDW-CV				
Red cell distribution width (coefficient of variation)				
	Male		Female	
Age	N	%	N	%
0 - 14 days	66	14.8 - 17.0	49	14.6 - 17.3
15 - 30 days	56	14.3 - 16.8	43	14.4 - 16.2
31 - 60 days	111	13.8 - 16.1	75	13.6 - 15.8
61 - <180 days	298	12.4 - 15.3	223	12.2 - 14.3
0.5 - <2 years	1212	12.9 - 15.6	1064	12.7 - 15.1
2 - <6 years	1179	12.5 - 14.9	1074	12.4 - 14.9
6 - <12 years	1243	12.3 - 14.1	1090	12.2 - 14.4
12 - <18 years	1423	12.4 - 14.5	1737	12.3 - 14.6
≥18 years	257	12.3 - 14.3	155	12.4 - 15.1

MPV				
Mean platelet volume				
	Male		Female	
Age	N	fL	N	fL
0 - 14 days	57	10.2 - 11.9	41	10.4 - 12.0
15 - 30 days	51	10.1 - 12.1	38	10.0 - 12.2
31 - 60 days	100	9.2 - 10.8	69	9.4 - 11.1
61 - 180 days	264	8.9 - 10.6	204	9.0 - 10.9
0.5 - <2 years	1100	8.7 - 10.5	981	8.8 - 10.6
2 - <6 years	1138	9.0 - 10.9	999	8.9 - 11.0
6 - <12 years	1248	9.2 - 11.4	1057	9.3 - 11.3
12 - <18 years	1403	9.6 - 11.8	1705	9.6 - 11.7
≥18 years	240	9.7 - 11.9	431	9.6 - 12.0

Neut#				
Neutrophil concentration				
	Male		Female	
Age	N	x 10^9/L	N	x 10^9/L
0 - 14 days	104	1.60 - 6.06	73	1.73 - 6.75
15 - 30 days	147	1.18 - 5.45	99	1.23 - 4.80
31 - 60 days	200	0.83 - 4.23	171	1.00 - 4.68
61 - <180 days	564	0.97 - 5.45	548	1.04 - 7.20
0.5 - <2 years	2012	1.19 - 7.21	1870	1.27 - 7.18
2 - <6 years	2842	1.54 - 7.92	2281	1.60 - 8.29
6 - <12 years	3497	1.63 - 7.55	3065	1.64 - 7.87
12 - <18 years	4487	1.54 - 7.04	5506	1.82 - 7.47
≥18 years	1100	1.82 - 7.42	1615	2.00 - 7.15

Lymph#				
Lymphocyte concentration				
	Male		Female	
Age	N	x 10^9/L	N	x 10^9/L
0 - 14 days	107	2.07 - 7.53	73	1.75 - 8.00
15 - 30 days	148	2.11 - 8.38	99	2.42 - 8.20
31 - 60 days	200	2.47 - 7.95	171	2.29 - 9.14
61 - <180 days	564	2.45 - 8.89	548	2.14 - 8.99
0.5 - <2 years	2012	1.56 - 7.83	1860	1.52 - 8.09
2 - <6 years	2841	1.13 - 5.52	2281	1.25 - 5.77
6 - <12 years	3482	0.97 - 3.96	3062	1.16 - 4.28
12 - <18 years	4484	0.97 - 3.26	5499	1.16 - 3.33
≥18 years	1106	0.85 - 3.00	1615	1.16 - 3.18

Mono#				
Monocyte concentration				
	Male		Female	
Age	N	x 10^9/L	N	x 10^9/L
0 - 14 days	101	0.52 - 1.77	72	0.57 - 1.72
15 - 30 days	143	0.28 - 1.38	93	0.42 - 1.21
31 - 60 days	189	0.28 - 1.05	161	0.28 - 1.21
61 - <180 days	511	0.28 - 1.07	493	0.24 - 1.17
0.5 - <2 years	1840	0.25 - 1.15	1674	0.26 - 1.08
2 - <6 years	2567	0.19 - 0.94	2072	0.24 - 0.92
6 - <12 years	3153	0.19 - 0.85	2756	0.19 - 0.81
12 - <18 years	4059	0.18 - 0.78	4934	0.19 - 0.72
≥18 years	960	0.19 - 0.77	1402	0.29 - 0.71

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Eo#				
Eosinophil concentration				
	Male		Female	
Age	N	x 10^9/L	N	x 10^9/L
0 - 14 days	101	0.12 - 0.66	73	0.09 - 0.64
15 - 30 days	143	0.08 - 0.80	93	0.06 - 0.75
31 - 60 days	189	0.05 - 0.57	161	0.04 - 0.63
61 - <180 days	511	0.03 - 0.61	493	0.02 - 0.74
0.5 - <2 years	1840	0.02 - 0.82	1674	0.02 - 0.58
2 - <6 years	2567	0.03 - 0.53	2072	0.03 - 0.46
6 - <12 years	3154	0.03 - 0.52	2756	0.03 - 0.47
12 - <18 years	4059	0.04 - 0.38	4934	0.02 - 0.32
≥18 years	956	0.03 - 0.44	1402	0.03 - 0.27

Baso#				
Basophil concentration				
	Male		Female	
Age	N	x 10^9/L	N	x 10^9/L
0 - <14 days	101	0.02 - 0.11	72	0.02 - 0.07
15 - 30 days	143	0.01 - 0.07	93	0.01 - 0.06
31 - 60 days	189	0.01 - 0.07	161	0.01 - 0.05
61 - <180 days	1005	0.01 - 0.06	493	0.01 - 0.07
0.5 - <2 years	1840	0.01 - 0.06	1674	0.01 - 0.06
2 - <6 years	2567	0.01 - 0.06	2072	0.01 - 0.06
6 - <12 years	3154	0.01 - 0.06	2756	0.01 - 0.05
12 - <18 years	4059	0.01 - 0.05	4935	0.01 - 0.05
≥18 years	975	0.01 - 0.05	1402	0.01 - 0.05

Neut%				
Percentage of neutrophils				
	Male		Female	
Age	N	%	N	% of WBC
0 - 14 days	54	20.2 - 46.2	53	15.2 - 66.1
15 - 30 days	80	14.0 - 54.6	61	10.6 - 57.3
31 - 60 days	69	10.2 - 48.7	63	8.9 - 68.2
61 - <180 days	164	10.9 - 47.8	159	14.1 - 76.0
0.5 - <2 years	596	17.5 - 69.5	502	16.9 - 74.0
2 - <6 years	802	22.4 - 69.0	700	22.4 - 69.0
6 - <12 years	1006	28.6 - 74.5	866	29.8 - 71.4
12 - <18 years	1186	32.5 - 74.7	1504	39.0 - 73.6
≥18 years	270	40.3 - 74.8	413	42.5 - 73.2

Lymph%				
Percentage of lymphocytes				
	Male		Female	
Age	N	%	N	% of WBC
0 - 14 days	98	33.7 - 67.6	74	24.9 - 68.5
15 - 30 days	142	33.6 - 76.8	90	31.9 - 82.7
31 - 60 days	193	42.5 - 85.7	164	37.8 - 86.7
61 - <180 days	518	40.7 - 83.7	499	30.4 - 85.6
0.5 - <2 years	1856	26.0 - 79.6	1694	27.4 - 79.9
2 - <6 years	2587	18.4 - 66.6	2097	18.1 - 68.6
6 - <12 years	3190	15.5 - 56.6	2783	16.7 - 57.8
12 - <18 years	4073	16.4 - 52.7	4952	18.2 - 49.8
≥18 years	976	12.2 - 47.1	1407	18.2 - 47.4

Mono%				
Percentage of monocytes				
	Male		Female	
Age	N	%	N	% of WBC
0 - 14 days	98	6.7 - 19.9	77	5.2 - 20.6
15 - 30 days	144	4.3 - 18.3	91	5.6 - 13.8
31 - 60 days	193	4.4. - 14.0	166	3.8 - 15.5
61 - <180 days	518	3.8 - 13.4	497	3.8 - 12.6
0.5 - <2 years	1856	4.4 - 13.4	1696	3.8 - 12.8
2 - <6 years	2589	4.2 - 12.2	2097	4.1 - 11.4
6 - <12 years	3193	4.2 - 12.3	2783	4.2 - 11.3
12 - <18 years	4074	4.4 - 12.3	4960	4.1 - 10.9
≥18 years	976	4.4 - 12.3	1405	4.3 - 11.0

Eo%				
Percentage of eosinophils				
	Male		Female	
Age	N	x 10^9/L	N	x 10^9/L
0 - 14 days	104	0.3 – 5.2	79	0.4 – 4.6
15 - 30 days	148	0.2 – 5.4	98	0.0 – 5.3
31 - 60 days	204	0.0 – 4.5	176	0.0 – 4.1
61 - <180 days	570	0.0 – 4.0	552	0.0 – 3.6
0.5 - <2 years	2029	0.0 - 3.7	1888	0.0 – 3.2
2 - <6 years	2864	0.0 – 4.1	2303	0.0 – 3.3
6 - <12 years	3512	0.0 – 4.7	3085	0.0 – 4.0
12 - <18 years	4503	0.0 - 4.0	5518	0.0 – 3.4
≥18 years	1107	0.0 – 4.4	1619	0.0 – 3.0

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Baso%				
Percentage of basophils				
	Male		Female	
Age	N	%	N	% of WBC
0 - 14 days	100	0.1 - 0.8	76	0.1 - 0.6
15 - 30 days	142	0.0 - 0.6	91	0.0 - 0.5
31 - 60 days	192	0.0 - 0.6	165	0.0 - 0.5
61 - <180 days	518	0.0 - 0.6	496	0.0 - 0.6
0.5 - <2 years	1854	0.0 - 0.6	1690	0.0 - 0.6
2 - <6 years	2586	0.1 - 0.6	2092	0.0 - 0.6
6 - <12 years	3180	0.0 - 0.7	2777	0.0 - 0.6
12 - <18 years	4073	0.0 - 0.7	4953	0.0 - 0.6
≥18 years	975	0.0 - 0.7	1405	0.0 - 0.7

NRBC#		
Nucleated red blood cell concentration		
	Male and Female	
Age	N	10^9/L
1 - 3 days	50	0.06 - 1.30
4 - 30 days	31	0.04 - 0.11
31 - 60 days	43	0.03 - 0.09
61 - 180 days	50	0.03 - 0.13
0.5 - <2 years	106	0.03 - 0.12
2 - <6 years	92	0.03 - 0.32
6 - <12 years	154	0.03 - 0.15
12 - <18 years	153	0.03 - 0.13
≥18 years	41	0.03 - 0.11

NRBC%		
Percentage of nucleated red blood cells		
	Male and Female	
Age	N	per 100 WBC's
1 - 3 days	52	0.1 - 8.3
4 - 30 days	31	0.0 - 0.0
31 - 60 days	43	0.0 - 0.0
61 - 180 days	89	0.0 - 0.0
0.5 - <2 years	223	0.0 - 0.0
2 - <6 years	256	0.0 - 0.0
6 - <12 years	375	0.0 - 0.0
12 - <18 years	347	0.0 - 0.0
≥18 years	90	0.0 - 0.0

Ret#		
Reticulocyte concentration		
	Male and Female	
Age	N	x 10^{12}/L
1 - 3 days	55	0.148 - 0.216
4 - 30 days	46	0.051 - 0.110
31 - 60 days	21	0.052 - 0.078
61 - 180 days	31	0.048 - 0.088
0.5 - <2 years	120	0.044 - 0.111
2 - <6 years	111	0.036 - 0.068
6 - <12 years	91	0.042 - 0.070
12 - <18 years	130	0.042 - 0.065
≥18 years	29	0.039 - 0.057

Ret%		
Percentage of reticulocytes		
	Male and Female	
Age	N	% of RBC
1 - 3 days	65	3.47 - 5.40
4 - 30 days	45	1.06 - 2.37
31 - 60 days	24	2.12 - 3.47
61 - 180 days	32	1.55 - 2.70
0.5 - <2 years	104	0.99 - 1.82
2 - <6 years	99	0.82 - 1.45
6 - <12 years	90	0.98 - 1.94
12 - <18 years	125	0.90 - 1.49
≥18 years	30	0.86 - 1.36

IRF		
Immature reticulocyte fraction		
	Male and Female	
Age	N	% of Ret
1 - 3 days	55	30.5 - 35.1
4 - 30 days	46	14.5 - 24.6
31 - 60 days	24	19.1 - 28.9
61 - 180 days	33	13.4 - 23.3
0.5 - <2 years	123	11.4 - 25.8
2 - <6 years	123	8.4 - 21.7
6 - <12 years	115	8.9 - 24.1
12 - <18 years	152	9.0 - 18.7
≥18 years	30	9.3 - 17.4

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IG#		
Immature granulocyte concentration		
	Male and Female	
Age	N	x 10^9/L
≤2 days	87	0.00 - 0.28
2 - <14 days	100	0.00 - 0.27
14 - 30 days	98	0.00 - 0.22
31 - 90 days	86	0.00 - 0.09
91 - 180 days	87	0.00 - 0.06
0.5 - <2 years	100	0.00 - 0.14
2 - <6 years	91	0.00 - 0.06
6 - <12 years	100	0.00 - 0.04
12 - <18 years	100	0.00 - 0.03
>18 years	91	0.00 - 0.09

IG%		
Percentage of immature granulocytes		
	Male and Female	
Age	N	% of WBC
≤2 days	87	0.0 - 1.7
2 - <14 days	100	0.0 - 1.9
14 - 30 days	98	0.0 - 1.3
31 - 90 days	86	0.0 - 0.9
91 - 180 days	87	0.0 - 0.5
0.5 - <2 years	100	0.0 - 0.9
2 - <6 years	91	0.0 - 0.8
6 - <12 years	100	0.0 - 0.3
12 - <18 years	100	0.0 - 0.3
>18 years	91	0.0 - 0.6

HPC#		
Haematopoietic progenitor cell concentration		
	Male and Female	
Age	N	x 10^9/L
≤2 days	87	0.00 - 0.007
2 - <14 days	100	0.00 - 0.008
14 - 30 days	98	0.00 - 0.008
31 - 90 days	86	0.00 - 0.005
91 - 180 days	87	0.00 - 0.001
0.5 - <2 years	100	0.00 - 0.001
2 - <6 years	91	0.00 - 0.001
6 - <12 years	100	0.00 - 0.001
12 - <18 years	100	0.00 - 0.000
>18 years	91	0.00 - 0.000

CHr (see note!)				
Reticulocyte cellular haemoglobin content				
	Male		Female	
Age	N	pg/cell	N	pg/cell
1 day - <2 years	132	22.5 - 31.8	104	23.9 - 30.9
2 - <6 years	127	25.1 - 32.0	92	26.4 - 32.1
6 - <12 years	133	23.6 - 33.9	116	25.1 - 33.3
12 - <18 years	211	27.0 - 33.2	221	28.2 - 33.9
≥18 years	214	30.1 - 34.6	402	27.1 - 35.2

Note: These reference intervals were not determined on a Sysmex XE-2100 but on a Siemens ADVIA 120. For details see introduction.

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