

Haemostasis and Paediatrics

Reference ranges in children

Haemostatic Screening tests are commonly used in children for:

- **Investigation of bleeding.**
- Pre-operative assessment.
- Assessment of potential non accidental injuries.
- Analysis of asymptomatic children with positive family histories.

Pre-analytical variables can confound haemostatic screening tests in children as:

- Difficult sample collection often leads to sample activation.
- Small volume collections necessitate appropriate sized collection tubes.
- Polycythaemia in neonates frequently requires adjusted citrate volume tubes.
- Jaundice and lipemia may interfere with automated coagulometers that depend on optical density for clot determination.

Developmental haemostasis refers to age related changes in the haemostatic system. These changes:

- Must be viewed as physiological.
- Probably protect children from thrombosis.
- Are important for accurately defining normal from abnormal.

Stago Reagents			
PT (sec/INR)	Day 1	Day 3	1 Month - 1 Year
STA®-Neoplastine® Cl plus (sec)	15.6* (14.4-16.4) n=21 (10F / 11M)	14.9* (13.5-16.4) n=25 (13F / 12M)	13.1 (11.5-15.3) n=35 (8F / 27M)
STA®-Neoplastine® Cl plus (INR)	1.26* (1.15-1.35) n=21 (10F / 11M)	1.20* (1.05-1.35) n=25 (13F / 12M)	1.00 (0.86-1.22) n=35 (8F / 27M)
STA®-Neoplastine R® (sec)	14.5 (12.3-16.6) n=10 (5F / 5M)	13.9 (12.5-14.7) n=10 (5F / 5M)	13.4 (12.3-14.9) n=20 (3F / 17M)
APTT (sec)			
STA®-PTT Automate	38.7* (34.3-44.8) n=21 (10F / 11M)	36.3* (29.5-42.2) n=25 (13F / 12M)	39.3* (35.1-46.3) n=33 (3F / 30M)
STA®-C.K. Prest®	N/A	N/A	34.4* (31.1-36.6) n=20 (3F / 17M)
STA®-Cephascreen®	39.7* (34.9-47.4) n=10 (4F / 6M)	38.0 (31.2-44.0) n=10 (4F / 6M)	32.2 (29.1-35.5) n=28 (3F / 25M)
FIBRINOGEN (g/L)			
STA®- Fibrinogen	2.80 (1.92-3.74) n=22 (10F / 12M)	3.30 (2.83-4.01) n=21 (10F / 11M)	2.42* (0.82-3.83) n=34 (7F / 27M)
COAGULATION FACTORS (%)			
STA®- Deficient II	54* (41-69) n=23 (13F / 10M)	62* (50-73) n=22 (11F / 11M)	90* (62-103) n=22 (7F / 15M)
STA®- Deficient V	81* (64-103) n=22 (13F / 9M)	122 (92-154) n=22 (11F / 11M)	113 (94-141) n=20 (6F / 14M)
STA®- Deficient VII	70* (52-88) n=22 (12F / 10M)	86* (67-107) n=22 (11F / 11M)	128 (83-160) n=20 (6F / 14M)
STA®- Deficient VIII	182 (105-329) n=20 (9F / 11M)	159 (83-274) n=25 (12F / 13M)	94* (54-145) n=21 (6F / 15M)
STA®- Deficient IX	48* (35-56) n=24 (11F / 13M)	72* (44-97) n=23 (11F / 12M)	71* (43-121) n=21 (5F / 16M)
STA®- Deficient X	55* (46-67) n=22 (12F / 10M)	60* (46-75) n=22 (11F / 11M)	95* (77-122) n=21 (6F / 15M)
STA®- Deficient XI	30* (7-41) n=20 (10F / 10M)	57* (24-79) n=22 (11F / 11M)	89* (62-125) n=22 (6F / 16M)
STA®- Deficient XII	58* (43-80) n=20 (9F / 11M)	53* (13-97) n=21 (11F / 10M)	79* (20-135) n=21 (7F / 14M)
COAGULATION INHIBITORS			
STA®-Stachrom® AT III (%)	76* (58-90) n=21 (9F / 12M)	74* (60-89) n=22 (10F / 12M)	109* (72-134) n=41 (8F / 33M)
STA®-Staclot® Protein C (%)	36* (24-44) n=22 (9F / 13M)	44* (28-54) n=21 (10F / 11M)	71* (31-112) n=25 (5F / 20M)
STA®-Stachrom® Protein C (%)	32* (24-40) n=20 (9F / 11M)	33* (24-51) n=22 (11F / 11M)	77* (28-124) n=24 (4F / 20M)
STA®-Staclot® Protein S (%)	36* (28-47) n=22 (13F / 9M)	49* (33-67) n=24 (11F / 13M)	102* (29-162) n=41 (8F / 33M)
STA®-Liatest® Free Protein S (%)	40* (37-42) n=10 (5F / 5M)	47* (40-57) n=11 (5F / 6M)	98 (80-116) n=20 (10F / 10M)
Asserachrom® Free TFPI (µg/mL)	N/A	N/A	7.13* (5.63-8.44) n=13 (0F / 13M)
Asserachrom® Total TFPI (µg/mL)	N/A	N/A	77.49 (69.42-85.58) n=13 (0F / 13M)
FIBRIN RELATED MARKERS (µg/mL)			
STA®- Liatest® D-Di	1.47* (0.41-2.47) n=20 (10F / 10M)	1.34* (0.58-2.74) n=23 (12F / 11M)	0.22 (0.11-0.42) n=20 (7F / 13M)
STA®- Liatest® FM	N/A	N/A	5.78 (2.46-11.96) n=19 (9F / 10M)
PROCOAGULANT PHOSPHOLIPIDS (sec)			
STA®- Procoag® PPL	41.4* (32.8-48.2) (5F / 5M)	40.8 (34.4-46.3) (5F / 5M)	31.6 (20.6-40.7) (10F / 10M)
TAFI (%)			
STA®- Stachrom® TAFI	30* (22-39) n=10 (5F / 5M)	30* (25-39) n=7 (3F / 4M)	68* (55-83) n=18 (3F / 15M)

Stago Reagents		
PT (sec/INR)	1 - 5 Years	6 - 10 Years
STA®-Néoplastine® CI plus (sec)	13.3* (12.1-14.5) n=43 (23F / 20M)	13.4* (11.7-15.1) n=53 (22F / 31M)
STA®-Néoplastine® CI plus (INR)	1.03* (0.92-1.14) n=43 (23F / 20M)	1.04* (0.87-1.20) n=53 (22F / 31M)
STA®-Néoplastine R® (sec)	13.9 (13.0-14.8) n=20 (10F / 10M)	14.6 (14.0-15.4) n=20 (10F / 10M)
APTT (sec)		
STA®-PTT Automate	37.7* (33.6-43.8) n=56 (26F / 30M)	37.3* (31.8-43.7) n=71 (27F / 44M)
STA®-C.K. Prest®	32.3* (29.8-35.0) n=22 (11F / 11M)	32.9* (30.8-34.8) n=22 (12F / 10M)
STA®-Cephascree®	31.6 (28.6-35.8) n=30 (15F / 15M)	33.1 (29.8-35.3) n=31 (16F / 15M)
FIBRINOGEN (g/L)		
STA®- Fibrinogen	2.82* (1.62-4.01) n=43 (23F / 20M)	3.04 (1.99-4.09) n=52 (22F / 30M)
COAGULATION FACTORS (%)		
STA®- Deficient II	89* (70-109) n=67 (26F / 41M)	89* (67-110) n=64 (23F / 41M)
STA®- Deficient V	97* (67-127) n=67 (26F / 41M)	99* (56-141) n=64 (23F / 41M)
STA®- Deficient VII	111* (72-150) n=66 (25F / 41M)	113* (70-156) n=64 (23F / 41M)
STA®- Deficient VIII	110* (36-185) n=45 (26F / 19M)	117* (52-182) n=52 (20F / 32M)
STA®- Deficient IX	85* (44-127) n=44 (25F / 19M)	96* (48-145) n=51 (19F / 32M)
STA®- Deficient X	98* (72-125) n=66 (25F / 41M)	97* (68-125) n=49 (20F / 29M)
STA®- Deficient XI	113 (65-162) n=41 (24F / 17M)	113 (65-162) n=50 (18F / 32M)
STA®- Deficient XII	85* (36-135) n=39 (20F / 19M)	81* (26-137) n=45 (17F / 28M)
COAGULATION INHIBITORS		
STA®-Stachrom® AT III (%)	116* (101-131) n=49 (26F / 23M)	114* (95-134) n=59 (25F / 34M)
STA®-Staclot® Protein C (%)	96* (65-127) n=42 (21F / 21M)	100 (71-129) n=53 (21F / 32M)
STA®-Stachrom® Protein C (%)	94* (50-134) n=39 (16F / 23M)	94* (64-125) n=50 (17F / 33M)
STA®-Staclot® Protein S (%)	101* (67-136) n=49 (26F / 23M)	109* (64-154) n=59 (25F / 34M)
STA®-Liatest® Free Protein S (%)	93 (63-120) n=20 (10F / 10M)	98 (83-123) n=20 (10F / 10M)
Asserachrom® Free TFPI (µg/mL)	6.75 (5.06-9.05) n=21 (11F / 10M)	6.69* (4.29-9.31) n=20 (9F / 11M)
Asserachrom® Total TFPI (µg/mL)	76.33 (61.27-89.80) n=21 (11F / 10M)	73.99* (59.13-88.02) n=20 (9F / 11M)
FIBRIN RELATED MARKERS (µg/mL)		
STA®- Liatest® D-Di	0.25* (0.09-0.53) n=40 (19F / 21M)	0.26* (0.10-0.56) n=39 (12F / 27M)
STA®- Liatest® FM	3.87* (1.65-5.08) n=18 (9F / 9M)	3.64* (2.36-5.02) n=20 (10F / 10M)
PROCOAGULANT PHOSPHOLIPIDS (sec)		
STA®- Procoag® PPL	27.7* (22.8-35.4) (10F / 10M)	26.1* (20.0-33.2) (10F / 10M)
TAFI (%)		
STA®- Stachrom® TAFI	77* (67-90) n=19 (10F / 9M)	77* (66-93) n=20 (10F / 10M)

Stago Reagents		11 - 16 Years	Adults
PT (sec/INR)			
STA®-Néoplastine® CI plus (sec)		13.8* (12.7-16.1) n=23 (7F / 16M)	13.0 (11.5-14.5) n=51
STA®-Néoplastine® CI plus (INR)		1.08* (0.97-1.30) n=23 (7F / 16M)	1.00 (0.80-1.20) n=51 (43F / 8M)
STA®-Néoplastine R® (sec)		15.0 (14.0-16.0) n=20 (10F / 10M)	14.7 (12.8-17.4) n=20 (17F / 3M)
APTT (sec)			
STA®-PTT Automate		39.5* (33.9-46.1) n=54 (12F / 42M)	33.2 (28.6-38.2) n=42
STA®-C.K. Prest®		34.1* (29.4-40.4) n=39 (8F / 31M)	29.1 (25.7-31.5) n=40
STA®-Cephascreen®		33.8 (28.0-37.9) n=31 (14F / 17M)	33.6 (26.3-40.3) n=26 (20F / 6M)
FIBRINOGEN (g/L)			
STA®- Fibrinogen		3.15 (2.12-4.33) n=21 (7F / 14M)	3.1 (1.9-4.3) n=55 (47F / 8M)
COAGULATION FACTORS (%)			
STA®- Deficient II		90* (61-107) n=23 (6F / 17M)	110 (78-138) n=44
STA®- Deficient V		89* (67-141) n=20 (5F / 15M)	118 (78-152) n=44
STA®- Deficient VII		118 (69-200) n=22 (6F / 16M)	129 (61-199) n=44
STA®- Deficient VIII		120* (59-200) n=24 (6F / 18M)	160 (52-290) n=44
STA®- Deficient IX		111* (64-216) n=25 (6F / 19M)	130 (59-254) n=44
STA®- Deficient X		91* (53-122) n=24 (7F / 17M)	124 (96-171) n=44
STA®- Deficient XI		111 (65-139) n=24 (5F / 19M)	112 (67-196) n=44
STA®- Deficient XII		75* (14-117) n=22 (7F / 15M)	115 (35-207) n=44
COAGULATION INHIBITORS			
STA®-Stachrom® AT III (%)		111* (96-126) n=26 (8F / 18M)	96 (66-124) n=43
STA®-Staclot® Protein C (%)		94* (66-118) n=25 (8F / 17M)	104 (74-164) n=42
STA®-Stachrom® Protein C (%)		88* (59-112) n=20 (6F / 14M)	103 (54-166) n=44
STA®-Staclot® Protein S (%)		103* (65-140) n=27 (9F / 18M)	75 (54-103) n=44
STA®-Liatest® Free Protein S (%)		97 (76-127) n=20 (10F / 10M)	97 (74-120) n=20 (10F / 10M)
Asserachrom® Free TFPI (µg/mL)		7.66* (5.15-8.74) n=15 (6F / 9M)	10.70 (6.12-12.34) n=20
Asserachrom® Total TFPI (µg/mL)		74.09 (61.63-87.36) n=15 (6F / 9M)	87.49 (63.64-104.38) n=20
FIBRIN RELATED MARKERS (µg/mL)			
STA®- Liatest® D-Di		0.27* (0.16-0.39) n=21 (6F / 15M)	0.18 (0.05-0.42) n=32 (19F / 13M)
STA®- Liatest® FM		3.18* (1.06-5.65) n=20 (10F / 10M)	10.24 (2.43-25.71) n=20 (17F / 3M)
PROCOAGULANT PHOSPHOLIPIDS (sec)			
STA®- Procoag® PPL		27.6* (20.7-36.2) n=20 (10F / 10M)	36.4 (29.6-43.2) n=20
TAFI (%)			
STA®- Stachrom® TAFI		86* (65-106) n=20 (10F / 10M)	110 (72-143) n=15 (13F / 2M)

Results of coagulation assays are system and reagent dependent. Age-related reference ranges must therefore be developed for each reagent/ coagulometer combination to facilitate accurate diagnosis of paediatric samples. Published data confirms that reference ranges generated using a specific reagent/ coagulometer combination cannot be applied to any other reagent/ coagulometer system.

The reference ranges were generated at Royal Children's Hospital, Melbourne Australia, (Prof Paul Monagle) from samples collected in 3.2% citrate and analysed using STA® analysers line and reagents as indicated.

This second edition includes new parameters recently discovered in the field of haemostasis. For each test/reagent the first row shows the mean and boundaries including 95% of the population.

The second row shows the number of individual samples and the ratio of males to females for each group.

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Data extracted from: Monagle P. et al. *Thromb Haemost* 2006; 95: 362-372.

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Summerhayes R. & al. *J of Thromb and Haemost*, 2007; 5, Supp 2: P-M-105.

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* Denotes values that are significantly different from adult values ($p < 0.05$).