

Table 3.

95% reference ranges for blood parameters of athletes measured on an ADVIA. Modal group is Caucasian non-endurance athletes of age 19-24 y, measured <610 m above sea level on their first laboratory visit between 07:30 and 16:00 at least 12 h after exercise. Reference ranges for other groups are shown only when they are substantially different from those of the modal group.

	Haemoglobin concentration (g.L ⁻¹)	Red cell count (10 ¹² .L ⁻¹)	Mean cell volume (fL)	Reticulocyte count (10 ⁹ .L ⁻¹)	Reticulocyte percentage (%)	Mean cell volume of reticulocytes (fL)
FEMALES						
Modal group	114-151	3.85-5.19	78.0-96.7	29-105	0.65-2.27	94-114
Ethnicity						
Asian						
African	107-146		76.0-95.4	35-118	0.76-2.52	
Oceanian			75.6-95.3			91-112
Age						
<19 y		3.92-5.26	76.7-95.5			
≥25 y						
Sport						
Endurance	118-155		79.4-98.1			96-116
Altitude						
1730 to 2220 m	126-163	4.25-5.60	74.6-93.5	35-117		
Visit						
Second						
Third	112-149	3.79-5.12			0.72-2.38	95-115
Time since exercise						
≥4 to 12 h						
≥1.5 to 4 h						
<1.5 h						
Time of day						
<07:30						
≥16:00						
MALES						
Modal group	131-167	4.41-5.85	78.3-94.0	30-108	0.62-2.08	94-113
Ethnicity						
Asian		4.49-5.93				
African	126-163					
Oceanian	133-170			34-118		
Age						
<19 y	129-166			28-104	0.57-2.00	
≥25 y						
Sport						
Endurance	133-169					
Altitude						
1730 to 2220 m	146-183	4.83-6.27	76.1-92.0	42-130	0.75-2.33	
Visit						
Second	129-166	4.35-5.78				
Third		4.36-5.79		33-114	0.69-2.21	
Time since exercise						
≥4 to 12 h						
≥1.5 to 4 h						
<1.5 h						
Time of day						
<07:30						
≥16:00						

Table 4.

Statistics for the five component haematological and serum parameters, as well as ON- and OFF-model scores: means and standard deviations for the modal group, and substantial mean values (with 95% confidence limits) of a given level of an effect minus the modal group level. Modal group is Caucasian non-endurance athletes of age 19-24 y, measured <610 m above sea level on their first laboratory visit between 07:30 and 16:00 at least 12 h after exercise.

		Haematocrit (%)	Reticulocyte haematocrit ^a (1%)	Macrocytes ^b (%)	EPO ^a (mU.mL ⁻¹)	sTfr ^a (mg.L ⁻¹)	ON-model score	OFF-model score
Modal group	F	39.6 ± 2.6	0.79 ± 0.12	0.29 x/± 2.24	10.1 x/± 1.53	1.24 x/± 1.28	2.03 ± 0.19	1.51 ± 0.25
	M	44.2 ± 2.7	0.81 ± 0.12	0.21 x/± 1.97	9.2 x/± 1.43	1.23 x/± 1.24	2.14 ± 0.18	1.74 ± 0.25
Ethnicity (vs Caucasians)								
Asian	F					x1.09 (x/±1.07)		
	M	0.7 (±0.8)				x1.04 (x/±1.05)		
African	F	-0.7 (±1.4)	0.05 (±0.06)			x1.23 (x/±1.12)	0.05 (±0.06)	-0.14 (±0.12)
	M					x1.08 (x/±1.06)		
Oceanian	F			x0.52 (x/±1.79)	0.86 (x/±1.33)	x0.88 (x/±1.21)		
	M		0.04 (±0.05)			x1.11 (x/±1.10)	-0.14 (±0.13)	
Age (vs 19 to <25 y)								
<19 y	F			x0.83 (x/±1.21)	x0.91 (x/±1.10)		-0.04 (±0.04)	
	M		-0.02 (±0.02)	x0.89 (x/±1.14)				
≥25 y	F							
	M							
Sport (vs Non-endurance)								
Endurance	F	1.1 (±0.6)		x1.27 (x/±1.22)			0.05 (±0.05)	0.07 (±0.06)
	M			x1.19 (x/±1.15)	x1.12 (x/±1.06)	x1.04 (x/±1.04)	0.06 (±0.04)	
Altitude (vs <610 m)								
1730 to 2220 m	F	1.8 (±1.7)	0.05 (±0.05)	x0.59 (x/±1.52)		x1.06 (x/±1.08)		
	M	2.3 (±1.4)	0.10 (±0.07)	x0.73 (x/±1.41)	x1.07 (x/±1.09)	x1.10 (x/±1.06)	0.14 (±0.09)	
Visit (vs First)								
Second	F							
	M							-0.05 (±0.03)
Third	F	-0.7 (±0.4)						-0.08 (±0.04)
	M		0.03 (±0.02)					-0.07 (±0.03)
Time since exercise (vs ≥12 h)								
≥4 to 12 h	F							
	M							
≥1.5 to 4 h	F			x1.17 (x/±1.12)				
	M							
<1.5 h	F							
	M							
Time of day (vs ≥07:30 to 16:00)								
<07:30	F	0.5 (±0.5)						
	M							
≥16:00	F							
	M							

F, female; M, male.

^aData shown are for the square root of the value.

^bMean macrocyte percent shown is the back-transformed mean of the log-transformed value; standard deviation, effects, and confidence limits of the effects are multiplicative factors that are applied to this mean.

Table 5.

Statistics for blood parameters measured on ADVIA blood analysers: means and standard deviations for the modal group, and substantial mean values (with 95% confidence limits) of a given level of an effect minus the reference level. Modal group is Caucasian non-endurance athletes of age 19-24 y, measured <610 m above sea level on their first laboratory visit between 07:30 and 16:00 at least 12 h after exercise.

		Haemoglobin concentration (g.L ⁻¹)	Red cell count (10 ¹² .L ⁻¹)	Mean cell volume (fL)	Reticulocyte count* (√10 ⁹ .L ⁻¹)	Reticulocyte percentage (√%)	Mean cell volume of reticulocytes (fL)
Modal group	F	133 ± 9	4.52 ± 0.33	87.4 ± 4.6	7.8 ± 1.2	1.16 ± 0.17	103.9 ± 4.9
	M	149 ± 9	5.13 ± 0.36	86.2 ± 3.9	8.0 ± 1.2	1.11 ± 0.16	103.2 ± 4.8
Ethnicity (vs Caucasians)							
Asian							
	F						
	M		0.08 (±0.12)				
African							
	F	-6 (±5)		-1.7 (± 2.6)	0.6 (±0.6)	0.07 (±0.08)	
	M	-5 (±3)					
Oceanian							
	F			-2.0 (± 3.3)			-2.6 (±3.0)
	M	2 (±4)			0.4 (±0.5)		
Age (vs 19 to <25 y)							
<19 y							
	F		0.07 (±0.08)	-1.3 (± 1.1)			
	M	-2 (±2)			-0.2 (±0.2)	-0.03 (±0.03)	
≥25 y							
	F						
	M						
Sport (vs Non-endurance)							
Endurance							
	F	4 (±2)		1.3 (± 1.1)			2.0 (±1.1)
	M	2 (±2)					
Altitude (vs <610 m)							
1730 to 2220 m							
	F	12 (±5)	0.41 (±0.17)	-3.3 (±2.6)	0.6 (±0.5)		
	M	15 (±4)	0.42 (±0.17)	-2.1 (± 2.0)	1.0 (±0.6)	0.08 (±0.08)	
Visit (vs First)							
Second							
	F						
	M	-2 (±1)	-0.07 (±0.03)				
Third							
	F	-3 (±1)	-0.06 (±0.05)			0.04 (±0.03)	1.0 (±1.1)
	M		-0.06 (±0.04)		0.3 (±0.2)	0.04 (±0.02)	
Time since exercise (vs ≥12 h)							
≥4 to 12 h							
	F						
	M						
≥1.5 to 4 h							
	F						
	M						
<1.5 h							
	F						
	M						
Time of day (vs ≥07:30 to 16:00)							
<07:30							
	F						
	M						
≥16:00							
	F						
	M						

F, female; M, male.

*Data shown are for the square root of the value provided by the ADVIA.

Table 6.

Statistics (means, standard deviations) and 95% reference ranges for changes in ON- and OFF-model scores between pairs of visits. Modal group is Caucasian non-endurance athletes of age 19-24 y, measured <610 m above sea level on their first two laboratory visits (second - first) within 2 h of the same time of day, with an unknown change in time since exercise, and with 7-8 d between visits. Reference ranges for other groups and within-subject changes are shown only when they are substantially different from those of the modal group.

		ON-model change		OFF-model change	
		Mean±SD	95% Reference range	Mean±SD	95% Reference range
Modal group	F	0.02 ± 0.14	-0.26 – 0.29	-0.05 ± 0.22	-0.48 – 0.39
	M	0.00 ± 0.12	-0.25 – 0.24	-0.10 ± 0.18	-0.45 – 0.26
Ethnicity (vs Caucasians)					
Asian	F				
	M				
African	F				
	M				
Oceanian	F				
	M	0.04 (±0.04)	-0.21 – 0.29		
Age (vs 19 to <25 y)					
<19 y	F				
	M				
≥25 y	F				
	M				
Sport (vs Non-endurance)					
Endurance	F				
	M				
Altitude (vs <610 m)					
1730 to 2220 m	F				
	M			0.08 (±0.05)	-0.38 – 0.33
Visit difference (vs Second - First)					
Third - First	F	-0.06 (±0.08)	-0.33 – 0.24	-0.09 (±0.12)	-0.58 – 0.31
	M	-0.06 (±0.05)	-0.32 – 0.18	-0.04 (±0.07)	-0.49 – 0.22
Third - Second	F				
	M			0.04 (±0.04)	-0.41 – 0.30
Time between visits (vs 6 to 8 d)					
<6 d	F	-0.03 (±0.04)	-0.29 – 0.27		
	M	-0.03 (±0.03)	-0.28 – 0.20	0.05 (±0.04)	-0.40 – 0.30
≥9 d	F	0.04 (±0.07)	-0.24 – 0.35		
	M	0.08 (±0.05)	-0.20 – 0.34		
Change in time since exercise (vs unknown)					
>4 h earlier	F			-0.05 (±0.04)	-0.53 – 0.34
	M				
within ±4 h	F			-0.04 (±0.04)	-0.52 – 0.35
	M				
≥4 h later	F				
	M	0.03 (±0.03)	-0.22 – 0.27		
Change in time of day (vs within ±2 h)					
>2 h earlier	F			0.05 (±0.05)	-0.44 – 0.44
	M				
≥2 h later	F				
	M			-0.06 (±0.04)	-0.51 – 0.20

F, female; M, male.

Table 7.

Components of and total variation of the blood parameters as well as model scores. For reticulocyte haematocrit and both reticulocyte counts, the standard deviation is the square root of the variable. For macrocytes, EPO and sTfr the standard deviations are multiplicative (\times /-).

		Analytical error			Biological variation		Total
		Between ADVIAs	Within ADVIAs	Between assays	Within athletes	Between athletes	
Haematocrit	F	1.1	0.7	-	1.3	1.8	2.6
(%)	M	1.0	0.8	-	1.3	2.0	2.7
Haemoglobin concentration	F	2.8	2.5	-	4.3	7.0	9.0
(g.L ⁻¹)	M	2.1	2.1	-	4.0	7.5	9.0
Reticulocyte haematocrit	F	0.02	0.04	-	0.07	0.08	0.12
(%)	M	0.04	0.04	-	0.06	0.09	0.12
Reticulocyte percentage	F	0.02	0.06	-	0.10	0.12	0.17
(%)	M	0.05	0.04	-	0.08	0.12	0.16
Reticulocyte count	F	0.15	0.37	-	0.69	0.84	1.15
($\sqrt{10^9}$.L ⁻¹)	M	0.41	0.33	-	0.58	0.91	1.21
Macrocyte count	F	1.25	1.25	-	1.24	2.01	2.22
(%)	M	1.24	1.23	-	1.22	1.77	1.96
EPO	F			1.09	1.31	1.36	1.52
(mU.ml ⁻¹)	M			1.05	1.24	1.32	1.42
sTfr	F			1.03	1.08	1.26	1.28
(mg.L ⁻¹)	M			1.04	1.06	1.22	1.24
ON-model score	F	0.07	0.06	-	0.08	0.15	0.19
	M	0.06	0.05	-	0.08	0.14	0.18
Change in ON-model	F		0.09		0.11		0.14
	M		0.06		0.11		0.12
OFF-model score	F	0.04	0.08	-	0.13	0.19	0.25
	M	0.06	0.07	-	0.12	0.20	0.25
Change in OFF-model	F		0.12		0.18		0.22
	M		0.09		0.15		0.18