Analiza in splošne značilnosti krvne slike veslačev – kandidatov za reprezentanco

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IMŠ
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NAMEN

1. OCENA OKSIFORMNE KAPACITETE KRVI
2. OCENA REGENERACIJE PO NAPORIH

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Biokemične preiskave (serum)

X	AST
X	ALT
	GGT
	ALP
X	CK
	LDH
	AMILAZA
	KISLA FOSF.
	LIPAZA
	BILIRUBIN CEL.
	BILIRUBIN DIR.
X	SEČNINA
X	KREATININ
	URAT
	GLUKOZA
	HOLESTEROL
	TRIGLICERIDI
	HDL HOLESTEROL
	LDL HOLESTEROL
	ŽELEZO
	TIBC
	TRANSFERIN
	KALIJ
X	NATRIJ
	KLORIDI
	KALCIJ
	FOSFAT
	MAGNEZIJ
	PROTEINI
	ALBUMIN
	RF
	CRP

Hematološke preiskave (EDTA)

X	HEMOGRAM (EDTA)
	DKS ROČNO
	RETIKULOCITI
	SEDIMENTACIJA
	HbA1C

Koagulacijske preiskave

	PČ, INR
	PTČ

Urinske preiskave

	TRAK
	SEDIMENT
	URICULT
	TEST NA NOSEČNOST

Blato

	BLATO NA PREB.
	PARAZITI
	KRI

Drugo

X	FERITIN
	IgE
	proBNP

Ščitnica (serum)

	TSH
	FT3
	FT4

Tumorski označevalci (serum)

	T-PSA
	F-PSA
	Ca 125
	CEA
	Ca 19-9
	Ca 15-3
	S-ALFA FETOPROTEIN
	NSE
	βHCG-TM

Hormoni (serum)

	βHCG
	FSH
	LH
	PROLAKTIN
	ESTRADIOL
	PROGESTERON
	TESTOSTERON
X	KORTIZOL
	DHEAs

	VITAMIN B 12
	FOLNA KISLINA
	PTH (EDTA)
	VITAMIN D total
	MIOGLOBIN

Levkociti:

i. Povišani so pri vnetju ali okužbi; pri nezadostni regeneraciji po treningu

ii. Znižani so pri malnutriciji ali pri stanjih, ko je oslabljen imunski sistem, pri boleznih kostnega mozga, povečani vranici , pri hrunnen infekt

iii. Dobro trenirani vzdržljivostni športniki imajo lahko nizke vrednosti, kar lahko smatramo kot normalno za njih (vzdržljivostni trening (kot oblika stresa za telo) vpliva na povečano izločanje hormonov (kortizol), kar zmanja št. število in funkcijo levkocitov).

Nevtrofilci: so prva obrambna linija pred patogeni; med telesno vadbo se jih iz kosti v kri sprosti večje število zato, da »očistijo« uničena mišična vlakna. Zato vzdržljivostni športniki hitreje porabljajo rezerve v kosteh in je zato število pri njih nizko – to vpliva na večjo dovzetnost za prehlade in infekte.

HEMOGLOBIN (Hb)

Vezan na hemoglobin (Hb) v eritrocitih (98%) in raztopljen v plazmi (2%)

Oksiformna kapaciteta krvi

= največja količina kisika, ki jo lahko sprejme volumska enota krvi.

Odvisna je od koncentracije Hb v krvi.

- 1g Hb veže 1.34 ml kisika
- Koncentracija Hb: moški 140-180 g / l krvi

Ženske 120 – 160 g / l krvi

- Oksiformna kapaciteta je torej:

150 g / l x 1.34 ml = 201 ml kisika / l krvi

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Padec Hb za 0.1% povzroči padec VO_2max za 1%

Hematokrit: odvisen od števila in velikosti eritrocitov in od hidracije

i. Povišan je lahko pri dehidraciji

ii. Znižan je pri dobro treniranih vzdržljivostnih športnikih zaradi povečanega volumna plazme (»športna anemija«). Nenaden padec v Ht in številu E pogosto vidimo v dneh po uvedbi intenzivnega treninga ali po težki vzdržljivostni tekmi (npr. maraton). Hb je ob tem v referenčnem območju.

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Feritin: je dober kazalec zalog železa v telesu

Znižan pri pomanjkanju železa, kar bo verjetno vodilo v anemijo, in pri anemijah zaradi pomanjkanja železa

ŽELEZO IN ŠPORT - DIAGNOSTIKA

1. FERITIN:
    1. Zaloge Fe v telesu (jetra, vranica, kostni mozeg)
    2. Konc v krvi majhna, vendar sorazmerna konc v organih
2. SERUMSKO Fe
    1. Celotna koncentracija Fe v serumu
3. TIBC
    1. Količina Fe, ki bi jo enota krvi lahko nosila, če bi bil transferin popolnoma zasičen z Fe
4. TRANSFERIN
    1. Ima kratko življenjsko dobo
    2. ZNIŽAN: Je direkten pokazatelj slabe kalorične ali proteinskega vnosa ali pokazatelj povečane izgube (proteinuria)
    3. POVIŠAN: pokazatelj pomanjkanja Fe

Natrij:

i. Znižan pri športnikih, ki zauživajo preveč tekočin

ii. Povišan pri dehidraciji, jemanju diuretikov

Sečnina:

Povišana pri odpovedi ledvic, razgradnji mišic (težki fizični napori) ali dehidraciji in povečanem vnosu beljakovin

Kreatinin:

Povišan pri odpovedi ledvic in mišični razgradnji

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Standardi Avstralskega Inštituta za šport za moške vzdržljivostne športnike

a. E 5,21±0,46 mill/µl

b. Hb 16,1±1,4 g/dl

c. Ht 0,47±0,04

d. MCV 88,6±3,0 fl

e. MCH 1,81±0,1 fmol

f. MCHC 21,1±1,3 mmol/l

g. Fe 18,1±7,1 µmol

h. Feritin 66,2±31,2 ng/ml

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DECEMBER 2014

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Hb	152	147		145	144	165	155			147	152	142	168		**161**
Ht	0.45	0,43		0,44	0,45	0,48	0,47			0,43	0,45	0,43	0,49		**0,47**
ERITROCITI	5,40	4,8		4,90	5,00	5,50	5,20			4,80	5,40	4,80	5,50		**5,21**
LEVKOCITI	6,60	3,8		5,9	3,5	5,1	9,1			4,3	4,3	5,6	4,3		**4,0**
NEVTROFILCI (število)	2,66	1,56		1,95	1,12	2,64	4,20			1,92	2,07	2,83	1,92		**1,6**
FERITIN	61,6			65,68		178,6	102,9			103,8	169,4	103,7	103,1		**66**
SEČNINA	6,2	6,4		8,5	5,00	7,90	6,90			6,20	4,10	7,20	4,00		**8,1**
KREATININ	81	83		88	77	83	82			79	64	77	80		**106**
AST	0,41	0,50		0,61	0,43	0,56	0,54			0,54	0,48	0,38	0,71		**0,58**
ALT	0,37	0,43		0,32	0,39	0,46	0,52			0,45	0,47	0,5	0,58		**0,74**

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JANUAR 2015

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Hb	161	151	152	149	151	158	167			145	162	156	168		**161**
Ht	0,47	0,45	0,46	0,43	0,47	0,46	0,49			0,42	0,48	0,5	0,49		**0,47**
ERITROCITI	5,6	5,00	5,30	4,9	5,1	5,4	5,5			4,7	5,7	5,2	5,6		**5,21**
LEVKOCITI	4,1	6,2	8,3	6,8	5,3	3,9	7,4			4,5	4,4	4,5	5,6		**4,0**
NEVTROFILCI (število)	1,67	4,03	5,44	1,51	3,09	2,15	3,1			2,08	2,01	2,6	3,51		**1,6**
Na	141	142	140	141	140	140	140			140	141	142	141		**135-145**
FERITIN		119,2	66,54	61,81		201,2	113,9			102,3	122	102	72,37		**66**
SEČNINA	5,9	6,4	6,4	8,8	5,6	6,5	8,1			5,4	5,9	4,5	5		**8,1**
KREATININ	89	96	81	92	80	78	87			71	72	83	75		**106**
AST	0,49	0,46	0,71	0,53	0,51	0,48	0,56			0,63	0,48	0,36	0,89		**0,58**
ALT	0,44	0,53	0,52	0,26		0,38	0,61			0,63	0,47	0,4	0,63		**0,74**
CK	4,46	4,26	10,70	4,94	2,71	3,33	3,53			5,54	2,67	3,2	17,51		**5,0**

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MAREC 2015

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Hb	150	155	137		146	159	165			153	163	149	173		**161**
Ht	0,43	0,45	0,41		0,44	0,46	0,48			0,45	0,47	0,44	0,51		**0,47**
ERITROCITI	5,1	5,1	4,7		4,90	5,20	5,30			4,90	5,60	4,90	5,60		**5,21**
LEVKOCITI	4,1	4,6	5,1		4,9	5,00	8,10			4,30	4,90	5,00	4,20		**4,0**
NEVTROFILCI (število)	1,85	2,64	2,67		2,39	3,05	3,29			1,69	2,54	2,63	2,28		**1,6**
Na	141	139	142		140	142	143			142	140	142	141		**135-145**
FERITIN	68,89	149,3	45,95		55,71	188,8	99,29			133,9	145,9	101,8	54,61		**66**
SEČNINA	6,5	7,3	6,9		5,00	8,30	8,40			5,80	5,90	6,60	5,50		**8,1**
KREATININ	91	95	77		77	76	83			85	70	82	81		**106**
AST	0,65	0,48	0,70		0,50	0,48	0,58			1,08	0,41	0,40	0,64		**0,58**
ALT	0,5	0,42	0,52		0,49	0,39	0,52			1,26	0,34	0,39	0,64		**0,74**
CK	7,42		6,9		3,40		4,11			12,77		4,30	6,71		**5,0**
KORTIZOL	510,3	205,4	472,3		581,4	602,2	648,6			441,1	296	592,2	441,6		**536**

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JUNIJ 2015

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Hb	151	156	143	147	149	156	159			159		150		151	**161**
Ht	0,46	0,49	0,42	0,44	0,46	0,49	0,49			0,49		0,44		0,44	**0,47**
ERITROCITI	5,3	5,2	4,80	4,80	4,9	5,3	5,2			5,2		5,1		5,10	**5,21**
LEVKOCITI	4,5	4,2	6,1	5,8	4,7	4,8	7,7			7,7		6,3		4,1	**4,0**
NEVTROFILCI (število)	1,77		3,8	1,77	2,25	2,68	3,57			3,57		4,11		2,23	**1,6**
Na	140			142	140		141			141				140	**135-145**
FERITIN	55,43	95,70	144,6		61,94	156	114			114		111,1		210,2	**66**
SEČNINA	6,5			8,4	7,00	7,70	8,80			8,80		6,60		5,80	**8,1**
KREATININ	88	108		92	86	75	97			97		75		79	**106**
AST	0,66	0,49	0,7	0,50	0,50	0,42	0,74			0,74		0,31		0,55	**0,58**
ALT	0,48	0,49	0,53	0,19	0,38	0,37	0,63			0,63		0,32		0,34	**0,74**
CK	9,3	4,45	4,26	5,83	5,34	2,01	7,24			7,24		4,1		5,73	**5,0**
KORTIZOL	472,3	456,9		564,7	425,1	332,5	394,6			394,6		485		412,9	**536**
TESTOSTERON	5,27				6,04		8,39			8,39				4,75	
VITAMIN D		50,1				42,2						35,1			**30**
FOLNA KISLINA	10,22			16,45	17,41		18,75			18,75		23,49		26,2	**10,4**
B12	454,1			330,5	217,9		661,1			661,1		267,4		349,6	**141**

AVGUST 2015

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Hb	155	150	139			151	158			134					**161**
Ht	0,45	0,46	0,43			0,46	0,47			0,41					**0,47**
ERITROCITI	5,3	4,9	4,8			5,1	5,2			4,4					**5,21**
LEVKOCITI	4,6	5,7	6,4			4,4	8			3,9					**4,0**
NEVTROFILCI (število)	2,01	3,41	3,09			2,22	3,65			1,57					**1,6**
Na	141	148				146				147					**135-145**
FERITIN	56	128	149			164				202					**66**
SEČNINA	5,8		6,6				6,4								**8,1**
KREATININ	85		81				84								**106**
AST	0,6	0,48	0,79			0,40	0,55			0,55					**0,58**
ALT	0,48	0,48	0,56			0,34	0,45			0,44					**0,74**
CK	8,68	5,45	16,14			2,48	3,35			5,8					**5,0**
KORTIZOL	234					309				391					**536**
FOLNA KISLINA		16,4				14				28,4					**10,4**
B12		327				384				342					**141**

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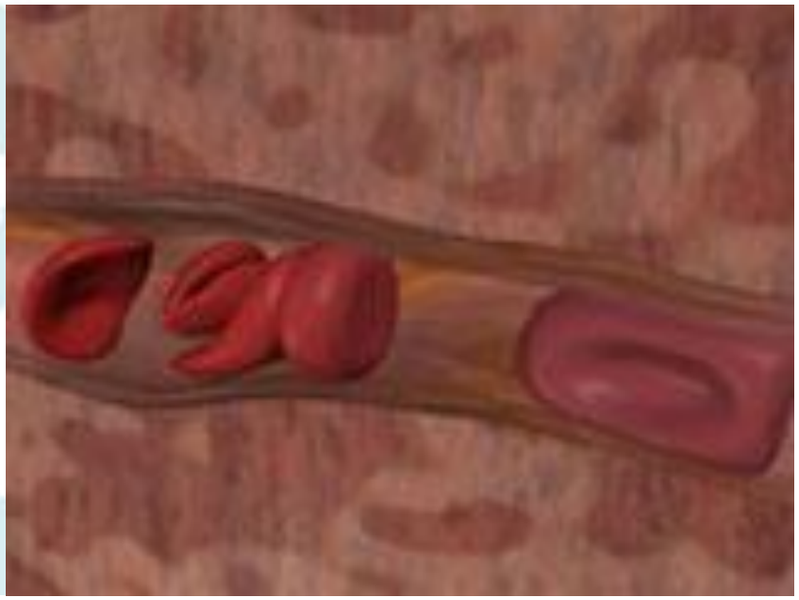
NOVEMBER 2015

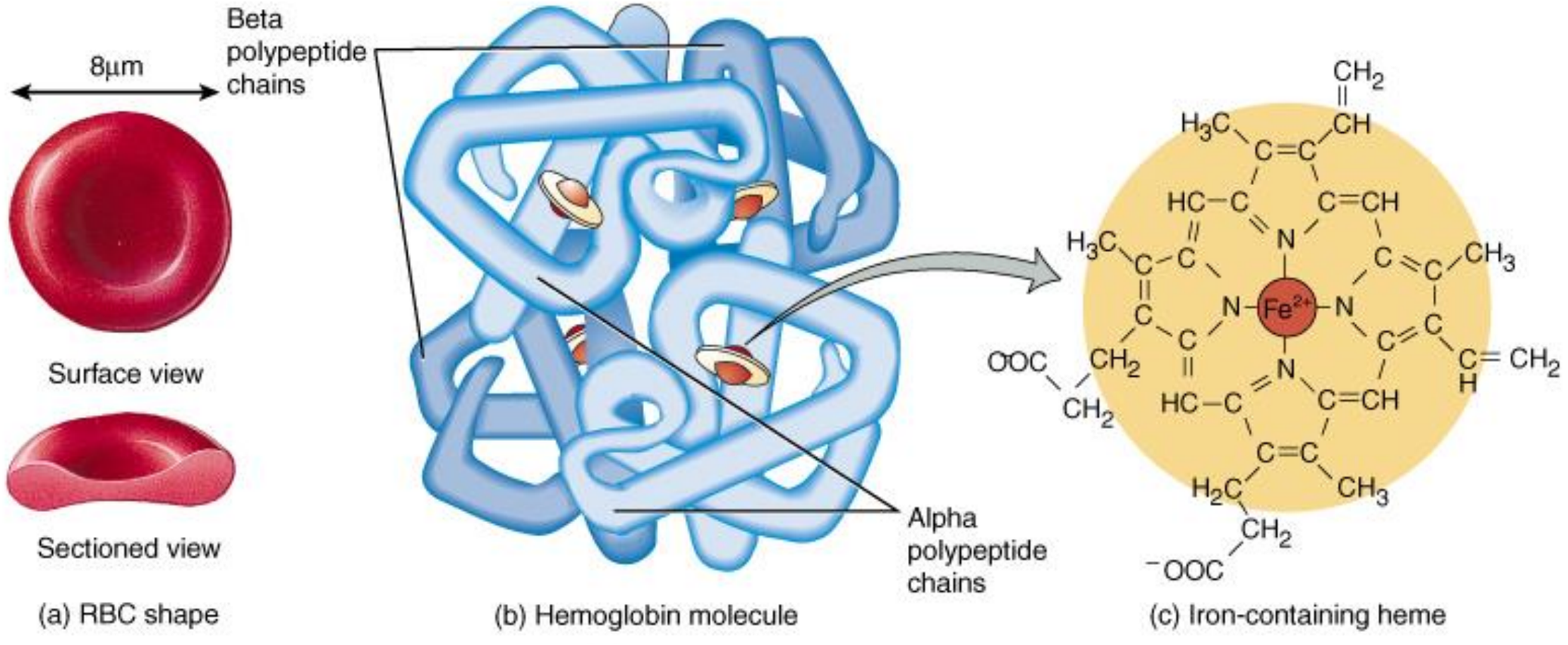
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Hb	158	152	144	157	150	161	152	147	161	139	163	141	175	152	**161**
Ht	0,47	0,47	0,44	0,47	0,46	0,48	0,47	0,44	0,46	0,4	0,48	0,43	0,51	0,45	**0,47**
ERITROCITI	5,5	5,00	5,1	5,2	5,1	5,6	5,1	5,00	5,3	4,50	5,6	4,9	5,7	5,3	**5,21**
LEVKOCITI	4,8	8,8	6,2	5,9	4,7	5,2	8,4	5,3	5,1	3,7	5,4	4,7	4	7,2	**4,0**
NEVTROFILCI (število)	2,37	6,19	3,53	1,59	2,42	3,18	3,67	2,35	2,43	1,53	2,83	2,32	1,78	5,09	**1,6**
Na	137	139		137	137	136	137	139	137	138	137	139	136	138	**135-145**
FERITIN	72	73	129	55	77	154	89	81	46	200	78	82	138	134	**66**
SEČNINA		10,7	6,9	8,5	6,3	8,6		5,70	4,2	6,5		6,5	4,20	4,8	**8,1**
KREATININ		103	83	96		73		82	83	75		76	84	77	**106**
AST		0,62	0,79	0,62				0,62	1,19		0,61		0,69		**0,58**
ALT		0,44	0,76	0,32				0,42	0,45		0,54		0,56		**0,74**
CK	6,11	6,45	8,86	4,72	2,88			6,09	3,11	9,86	5,46	4,16	9,82		**5,0**

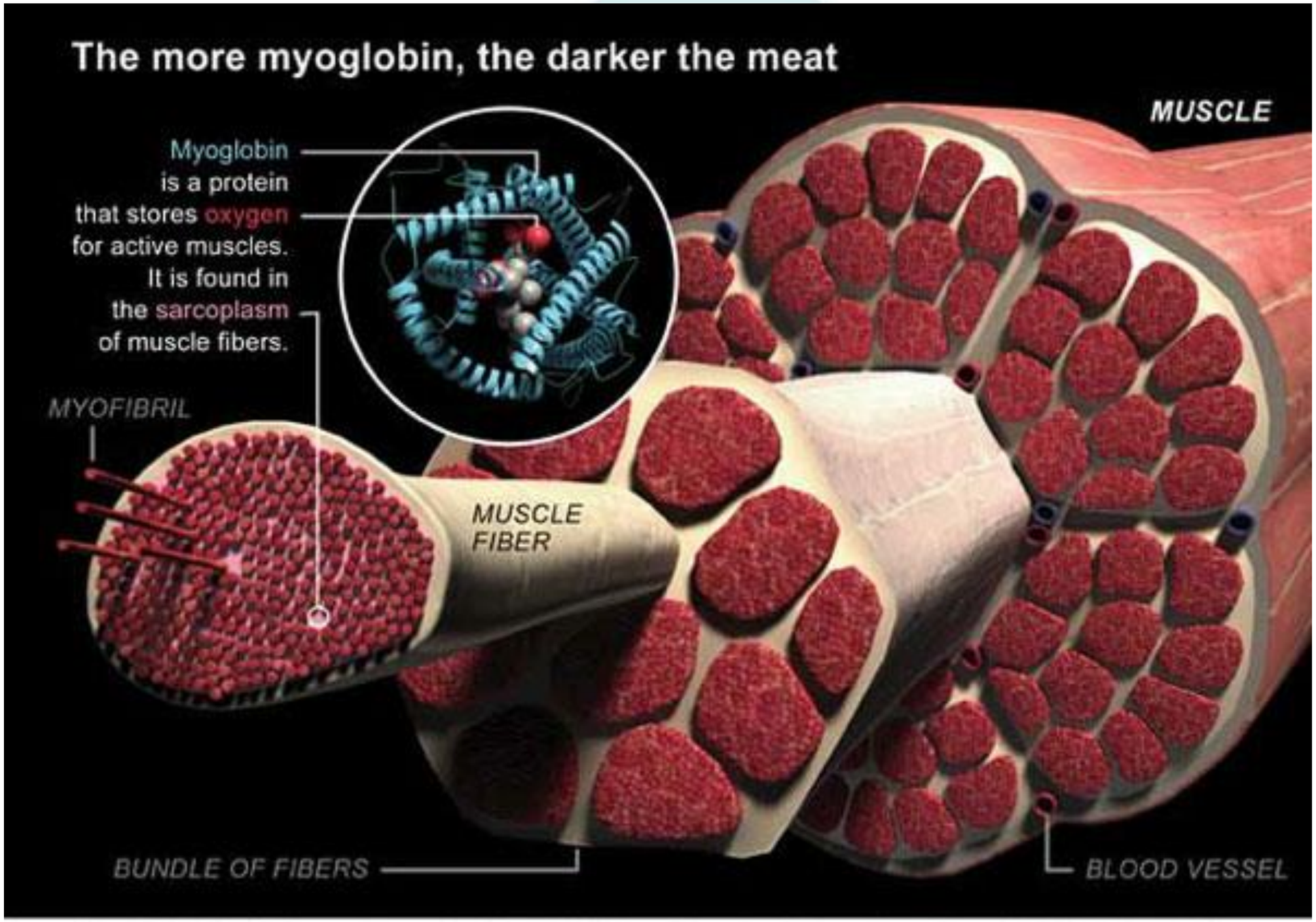
VLOGA IN PRESNOVA ŽELEZA V TELESU

1. **VLOGA Fe:**
    1. TVORBA Hb IN Mb
    2. TVORBA ENCIMOV OKSIDATIVNE FOSFORILACIJE

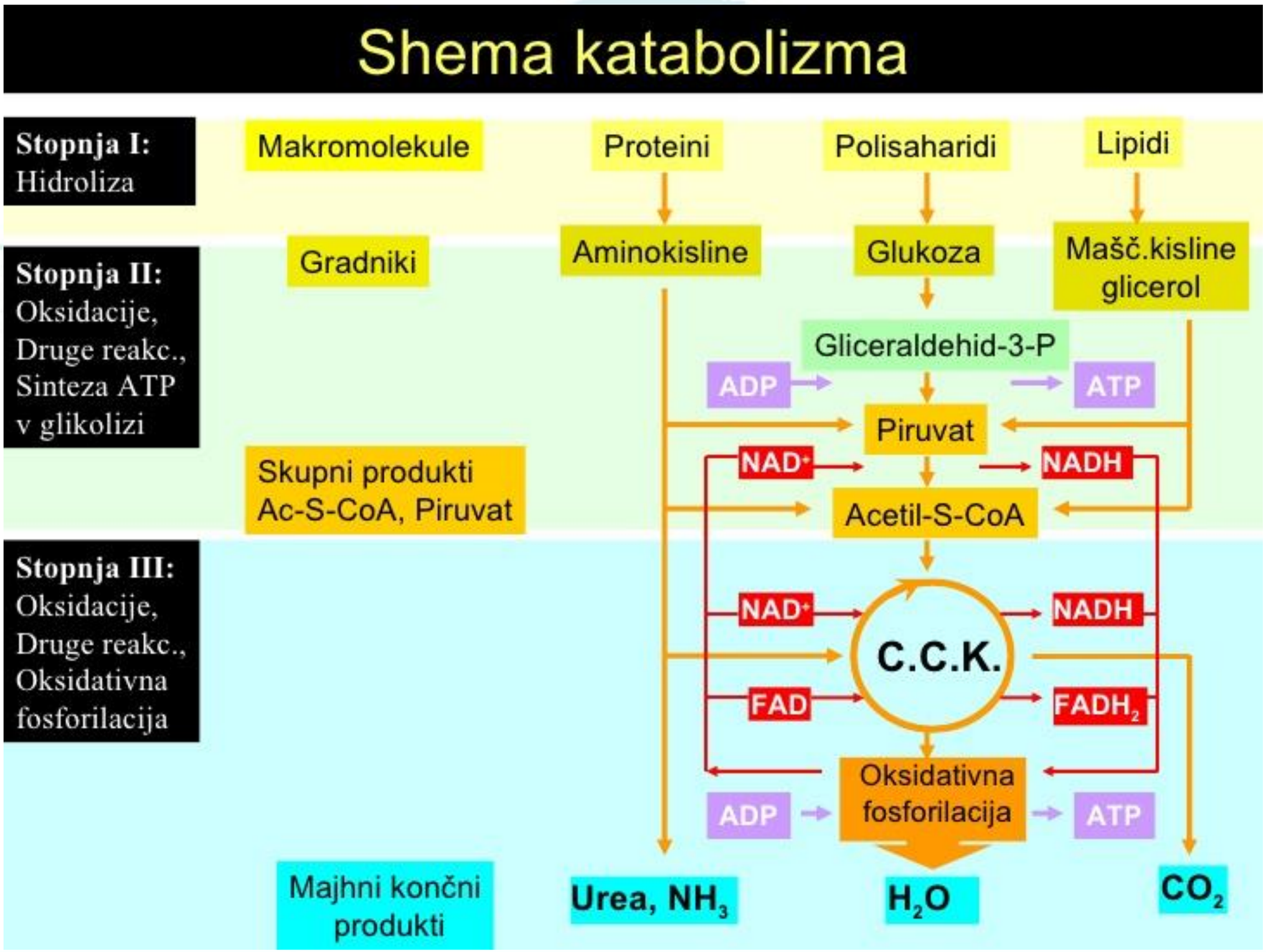
HEMOGLOBIN




8µm
Surface view
Sectioned view
(a) RBC shape
Beta polypeptide chains
Alpha polypeptide chains
(b) Hemoglobin molecule
(c) Iron-containing heme


The more myoglobin, the darker the meat
MUSCLE
Myoglobin is a protein that stores oxygen for active muscles. It is found in the sarcoplasm of muscle fibers.
MYOFIBRIL
MUSCLE FIBER
BUNDLE OF FIBERS
BLOOD VESSEL
George Frederick for LiveScience
Sources: Dr. Daniel L. Fletcher, University of Connecticut; University of Montana-Missoula; Indiana State University

Shema katabolizma



VLOGA IN PRESNOVA ŽELEZA V TELESU

2. **KOLIČINA Fe** V TELESU: celokupno **4 – 5 g**
   1. 65 % v Hb
   2. 4 % Mb
   3. 1 % različne hem substance (znotrajcelična oksidacija)
   4. 0,1 % vezan na transferin v plazmi
   5. 15 – 30 % shranjen v retikulo - endotelijskem sistemu in jetrih v obliki feritina

VLOGA IN PRESNOVA ŽELEZA V TELESU

BILIRUBIN

MAKROFAGI
RAZGRADNJA Hb → PROSTO Fe

CERULOPLAZMIN (Cu)

TKIVA (JETRA, RE SISTEM)

FERITIN

HEMOSIDERIN

ENCIMI

PROSTO Fe

Hb (ERITORCITI)

CERULOPLAZMIN (Cu)

TRANSFERIN – Fe PLAZMA

IZGUBA KRVI (0,7 mg Fe NA DAN Z MENSTRUACIJO)

Fe 2+ ABSORPCIJA (TANKO ČREVO)

Fe IZLOČANJE (0,6 mg NA DAN)

OBLIKE ŽELEZA

ŽELEZO SE V HRANI NAHAJA V DVEH OBLIKAH:

1. HEM-Fe (**hrana živalskega izvora**): Hrana, ki vsebuje hem obliko Fe, vsebuje več Fe; hem oblika Fe se lažje absorbira kot ne-hem oblika

2. NE-HEM Fe (**hrana rastlinskega izvora**): Hrana, ki vsebuje ne-hem obliko Fe se slabše absorbira, dodatno pa absorpcijo zavirajo faktorji kot so tanin (v čajih), fitati (pšenični otrobi)

TOKOKROG Fe V TELESU

- ABSORPCIJA Fe JE OMEJENA KER TELO NIMA UČINKOVITEGA MEHANIZMA, DA BI IZLOČILO VIŠEK
- ABSORPCIJA V ČREVESJU JE ODVISNA OD STANJA ZALOG (feritin, hemosiderin)
- ABSORBIRA SE 10 – 15 % ZAUŽITEGA Fe

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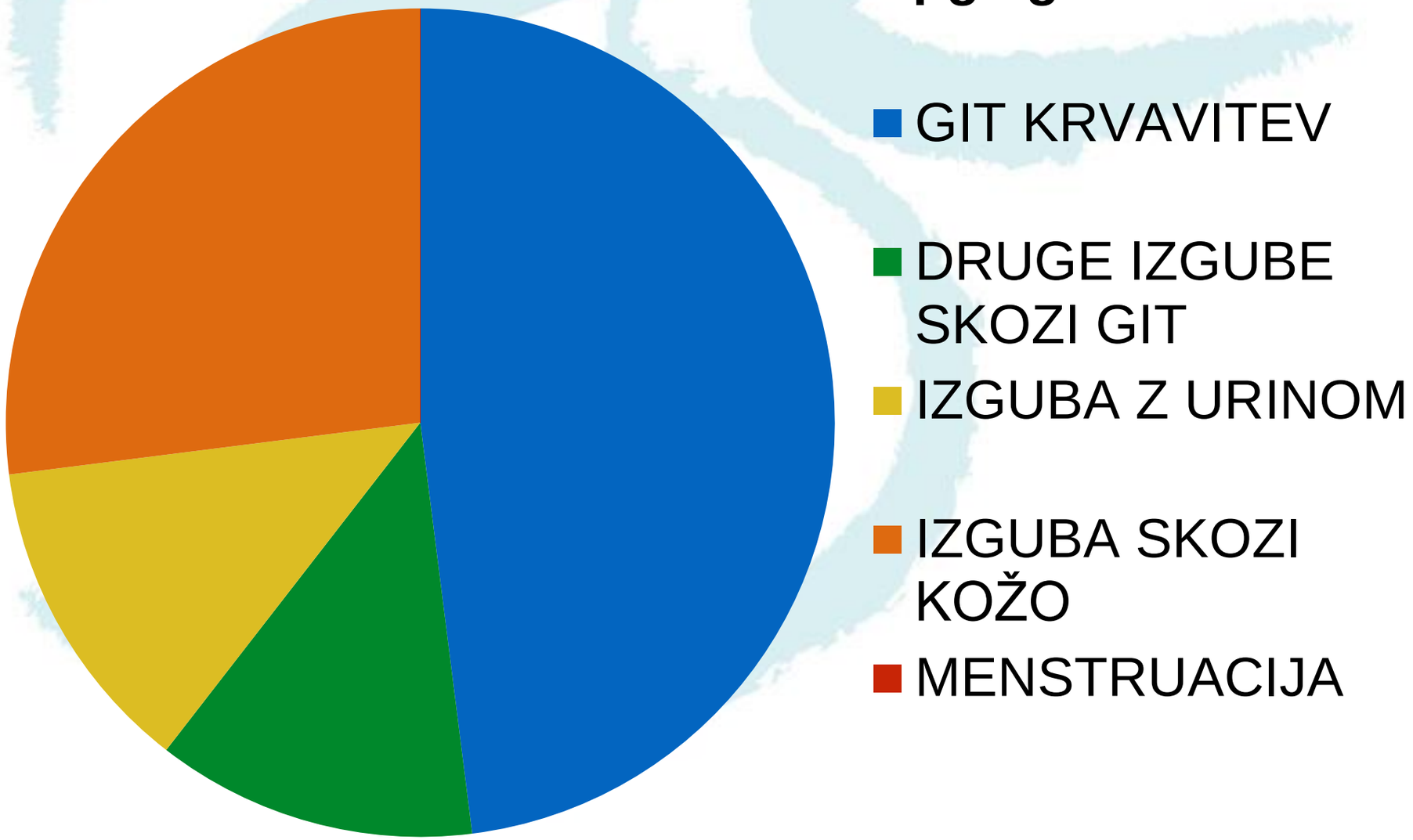
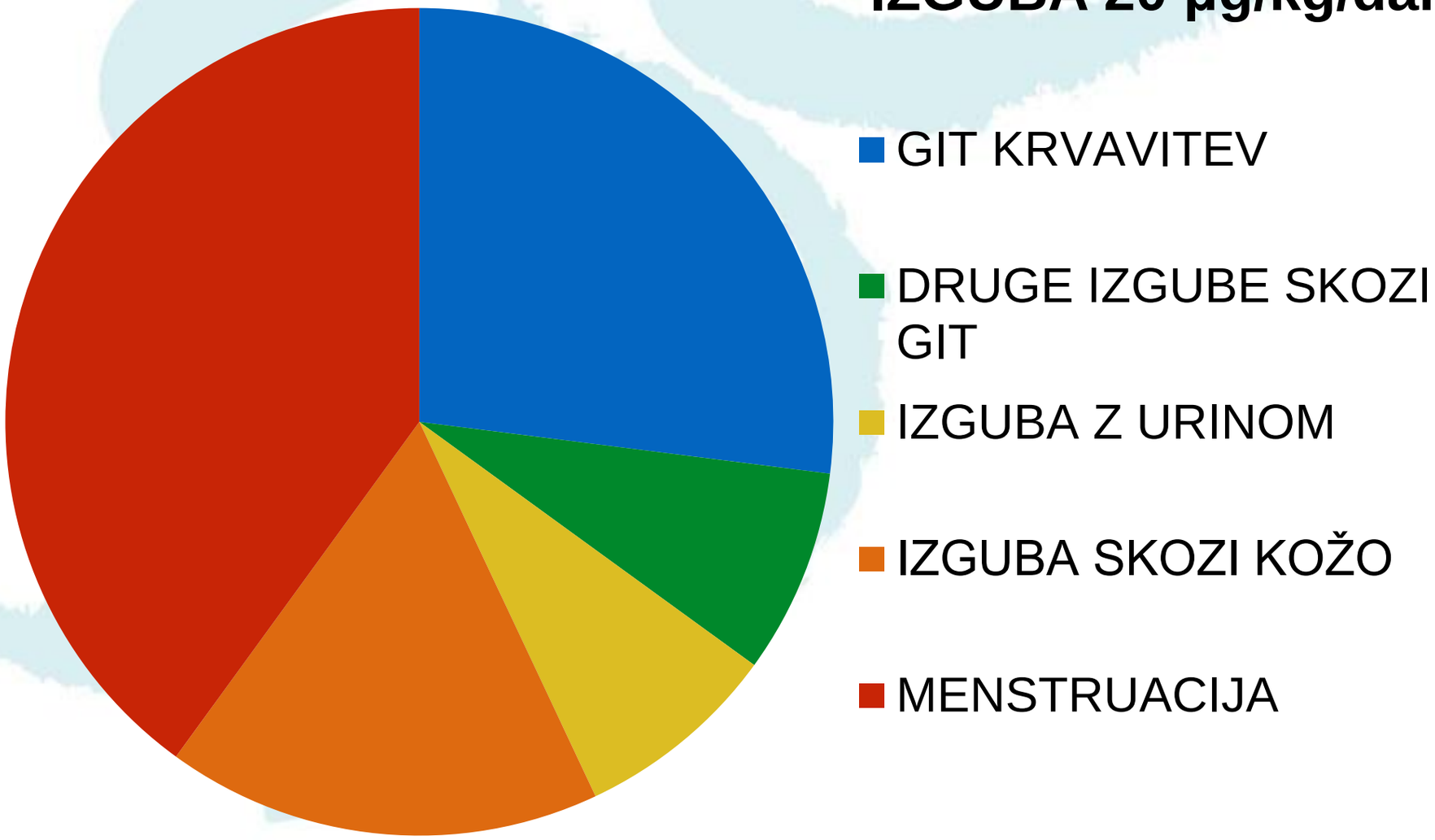
IZGUBA FE PRI ŠPORTNIKIH

MOŠKI IN POSTMENOPAVZALNE ŽENSKE
IZGUBA 12 µg/kg/dan



IZGUBE Fe PRI ŠPORTNIKIH

ŽENSKE
IZGUBA 20 µg/kg/dan



VZROKI POMANJKANJA ŽELEZA PRI ŠPORTNIKIH

NEZADOSTEN VNOS S HRANO	**Hrana z nizko vsebnostjo Fe**
HRANA S SLABO SPOSOBNOSTJO ABSORPCIJE Fe	**Hrana rastlinskega izvora ima manjšo vsebnost Fe, ki se slabo absorbira**
POVEČANA IZGUBA Fe (hematuria)	**Povečana razgradnja eritrocitov zaradi povečane intravaskularne kompresije (hemoliza) – izločanje z urinom**
IZGUBA Fe Z ZNOJEM	**Izgube z znojem so majhne vendar pomembne ob mejnem pomanjkanju**
IZGUBA Fe S KRVAVITVIJO	**GIT, menstruacije**
DILUCIJSKA PSEVDOANEMIJA (ŠPORTNA ANEMIJA)	**Povečanje volumna krvi (prehodno)**

Rowland T. Am J Lifestyle Med. 2012.

POVEČANA RAZGRADNJA ERITROCITOV PRI ŠPORTNIKIH

- Življenjska doba eritrocitov je 80 dni
- Največje tveganje pri tekačih in kontaktnih športih
- Najdena tudi pri plavalcih in plesalcih
- Tekači: trša podlaga, večja hemoliza

Shaskey DJ, Green GA. Sports Med, 2000.

Telford R, et al. J Appl Physiol. 2003. Selby GB, Eichner ER. AJM, 1986.

IZGUBA Fe Z ZNOJEM

- KONCENTRACIJA Fe V ZNOJU JE NIZKA (2mg/l znoja)

- VELIKA IZGUBA ZNOJA PRI INTENZIVNIH IN DOLGOTRAJNIH NAPORIH

DNEVNE POTREBE ŠPORTNIKOV PO VNOSU ŽELEZA

POPULACIJA	DNEVNI PRIPOROČEN VNOS
Mladostniki	11 mg/dan
Mladostnice - premenstrualno	8 mg/dan
Mladostnice – rast + menstruacija	15 mg/dan
Odrasli moški	8 mg/dan
Vzdržljivostni športniki – intenzivni treningi	8 – 17,5 mg/dan
Odrasle ženske - v reproduktivni dobi	18 mg/dan
Vzdržljivostne športnice - brez menstruacije	8 – 17 mg/dan
Vzdržljivostne športnice - v reproduktivni dobi	18 – 23 mg/dan
Odrasle ženske - postmenopavzalno	8 mg/dan
Noseče ženske	27 mg/dan

POSEBNOSTI PRI ŽENSKAH

- ŽENSKE IMAJO ZARADI IZGUBE Fe Z MENSTRUACIJO POTREBE PO VEČJEM VNOSU S HRANO

- ŽENSKE IMAJO MANJŠO POTREBO PO VNOSU KALORIJ, ZATO MORAJO UŽIVATI HRANO Z VEČ ŽELEZA

Inštitut za medicino in šport

HRANA, KI VSEBUJE HEM - Fe

HRANA	KOLIČINA	VSEBNOST Fe (mg)
JETRA	100 g	9,3
JETRNA PAŠTETA	40 g	4,0
PUSTO RDEČE ZREZEK	100 g	3,0
PERUTNINA (temno meso)	100 g	1,1
RIBE	100 g	0,3 – 1,9
OSTRIGE	100 g (surove)	3,9
LOSOS	100 g	0,9

HRANA, KI VSEBUJE NE – HEM Fe

HRANA	KOLIČINA	VSEBNOST Fe (mg)
JAJCA	100 g (2)	1,6
KOSMIČI, OBOGATENI Z Fe	30 g	2,5 – 5,0
POLNOZRNATI KRUH	60 g	1,4
ŠPINAČA (kuhana)	145 g	4,4
LEČA	220 g	3,1
FIŽOL V ZRNJU (konzerviran)	190 g	4,0
TOFU	100 g	1,2
SUHE MARELICE	50 g	1,6
MANDLJI	50 g	1,8

STOPNJE POMANJKANJA ZALOG ŽELEZA

	FERITIN	Fe	SATURACIJA TRANSFERINA (%)	TIBC	Hb
NORMALNO	**> 35**	**norm**	**> 16**	**norm**	**norm**
1. STOPNJA	**< 35**	**norm**	**> 16**	**norm**	**norm**
2. STOPNJA	**< 15**	**↓**	**< 16**	**↑**	**norm**
3. STOPNJA	**< 15**	**↓**	**< 16**	**↑**	**↓**

Chatard JC. et al. Sports Med. 1999. , Peeling et al. Int J Sport Nutr Ex Metab. 2007

POSLEDICE POMANJKANJE Fe

KLINIČNA SLIKA:

- UTRUJENOST,
- PADEC IMUNSKE ODPORNOSTI,
- MOTNJE POZORNOSTI,
- RAZDRAŽLJIVOST,
- SLABŠA SPOSOBNOST UČENJA

PRAKTIČNI NASVETI

1. VKLJUČUJ DOBRE VIRE HEM - Fe REDNO V OBROKE
   - Poveča absorpcijo ne - hem Fe
   - Frekvenca vnosa hem-Fe je pomembnejša od količine
   - Vključi pusto rdeče meso 3 – 4 x tedensko
   - Vključi tudi školjke in jetra kot alternativo mesu
   - Dodatno vključi piščanca, svinjino in temno ribo

2. SINHRONIZIRAJ VNOS Fe Z DRUGIMI PREHRAMBENIMI CILJI
   - Primer: sendvič s pljučno pečenko, testenine z mesno omako

PRAKTIČNI NASVETI

3. VKLJUČI HRANO, KI JE BOGATA Z NE-HEM OBLIKO Fe V VEČINO OBROKOV
   - Polnozrnati žitni izdelki, suho sadje, stročnice, jajca, oreščki in semena, listnata zelena zelenjava
4. HRANA NAJ BO MEŠANA, DA BODO FAKTORJI IZ HRANE POSPEŠILI ABSORPCIJO NE-HEM OBLIKE Fe
   - Vitamin C
   - Faktor iz mesa

5. ZMANJŠAJ VPLIV FAKTORJEV, KI ZMANJŠUJEJO ABSORPCIJO Fe
   - Fitati: npr ne dodaj pšeničnih otrobov k obro
   - Tanin: kavo in čaj pij med obroki
   - Sojini proteini
   - Kalcij

PRAKTIČNI NASVETI - VEGETARIJANCI

TIP HRANE	NORMALNA ABSORPCIJA	IZBOLJŠANJE ABSORPCIJE
ZELENJAVA (VSEH VRST)	Vsebuje Fe v ne-hem obliki, ki ima slabšo absorpcijo kot Fe iz mesa	Dodaj vit C (stisnjen sok limone ali pomaranče pred jedjo)
TEMNA ZELENA ZELENJAVA	Vsebuje Fe in oksalno ksl, ki zavira absorpcjo Fe	Za odstranitev oksalne ksl blanširaj zelenjavo v vreli vodi 5 – 10 s
ŽITA Z VISOKO VSEBNOSTJO VLAKNIN (velika vsebnost otrobov)	Vsebujejo veliko fitatov, ki se vežejo s Fe in upočasnijo resorpcijo	Nadomesti otrobe s polnozrnatimi jedmi

ŽELEZO IN ŠPORT

- Fe JE EDEN OD POMEMBNIH DEJAVNIKOV V ZMOGLJIVOSTI ŠPORTNIKA (SPOSOBNOST KRVI ZA PRENOS KISIKA, FUNKCIJA OKSIDATIVNIH ENCIMOV)

- VZDRŽLJIVOSTNI ŠPORTI (HRANA Z VISOKO VSEBNOSTJO OH)

- POMEN ZGODNJE DIAGNOSTIKE POMANJKANJA ZALOG Fe

HITRI VODNIK O ŽELEZU

SIMBOL	**Fe**
DNEVNI PRIPOROČENI VNOS	**Odrasli moški: 8 mg/dan Odrasle ženske: 18 mg/dan**
PRIPOROČENI VNOS ZA ŠPORTNIKE	**15 – 18 mg/dan**
FUNKCIJA	**Prenos kisika (Hb, Mb), del oksidativnih encimov**
DOBRI VIRI V HRANI	**Meso, ribe, perutnina, školjke; Manj v stročnicah, temni listnati zeleni zelenjavi, suhem sadju**
POMANJKANJE	**Utrujenost, manjša odpornost za infekcije, upočasnjen metabolizem**
TOKSIČNOST	**Hemokromatoza, poškodba jeter**

ZAKAJ NE V LAB PO TEŽKEM TRENINGU?

- **MOŽNE SPREMEMBE 12-24 UR PO TRENINGU:**
- Padec Hb za 5%
- Padec Ht za 5%
- Porast sečnine za 15%
- Porast sečne kisline za 25%
- Porast CK za 175%
- Porast AST za 40%
- Porast bilirubina za 50%

Table I. Characteristics of study groups included in the meta-analysis sorted by protocol and first author

Study	Subjects	Sample size[a]	Design	Competitive level	Training phase	Hypoxic (h/d)[b]	Exposure/ intervention days[c]	Altitude level (m)[d]	Hypoxia device
Live-high train-high									
Bailey et al.[29]	Runners	8M, 2F; 14M, 5F	C	Elite	?	24	28	1640	
	Runners	9M, 5F; 6M, 3F	C	Elite	?	24	28	1750	
Burtscher et al.[30]	Runners	10M; 12M	C	Subelite	?	24	12	2315	
Friedmann et al.[31]	Boxers +Fe[e]	9M	U	Subelite	Off-season	24	18	1800	
	Boxers –Fe[e]	7M	U	Subelite	Off-season	24	18	1800	
Gore et al.[32]	Cyclists	8M	U	Elite	?	24	31	2690	
Ingjer and Myhre[33]	Skiers	7M; 7M	U	Elite	Competitive	24	21	1900	
Jensen et al.[34]	Rowers	9M; 9M	C	Elite	Competitive	24	21	1822	
Levine and Stray-Gundersen[35]	Runners	10?	U	Subelite	?	24	28	1200	
	Runners	9?	U	Subelite	?	24	28	2500	
Levine and Stray-Gundersen[2]	Runners	9M, 4F; 9M, 4F	C	Subelite	Competitive	24	28	2500	
Miyashita et al.[36]	Swimmers	12M, 8F	U	Elite	Competitive	24	21	2300	
Pyne[37]	Swimmers	14M, 8F	U	Elite	Competitive	24	21	2102	
Rusko et al.[38]	Skiers	14M; 7M	C	Elite	?	24	22	1700	
Saunders et al.[39]	Runners	10M; 13M	C	Elite	?	24	20	1750	
Svedenhag and Saltinj[40]	Runners	5M; 4M, 2F	C	Elite	?	24	14	2000	
Svedenhag et al.[41]	Skiers	5M, 2F	U	Elite	?	24	30	1900	
Live-high train-low									
Dehnert et al.[42]	Triathletes	6?; 10?	C	Subelite	?	~18–24	13	1956/800	
Levine and Stray-Gundersen[2]	Runners	9M, 4F; 9M, 4F	C	Subelite	Competitive	~18–24	28	2500/1200	
Stray-Gundersen and Levine[43]	Runners	6?	U	Subelite	?	~18–24	28	2500/1200	
Stray-Gundersen et al.[8]	Runners	8F, 14M	U	Elite	Competitive	~18–24	27	2500/1200	
Wehrlin et al.[44]	Orienteers	5M, 5F	U	Elite	Pre-season	~18–24	24	2456/1000	
Witkowski et al.[45]	Runners	8M, 4F	U	Subelite	?	~18–24	28	1780/1250	
	Runners	8M, 4F	U	Subelite	?	~18–24	28	2085/1250	
	Runners	8M, 4F	U	Subelite	?	~18–24	28	2454/1250	
	Runners	8M, 4F	U	Subelite	?	~18–24	28	2805/1250	
Artificial long continuous live-high train-low									
Clark et al.[46]	Cyclists, triathletes	9M; 10M	C	Subelite	?	9–10	20	2650	N_2 house
	Cyclists, triathletes	10M; 10M	C	Subelite	?	9–10	20/24	2650	N_2 house

Continued next page

Table I. Contd

Study	Subjects	Sample size[a]	Design	Competitive level	Training phase	Hypoxic (h/d)[b]	Exposure/ intervention days[c]	Altitude level (m)[d]	Hypoxia device
Gore et al.;[47] Hahn et al.[48]	Triathletes	6M; 6M	C	Elite	?	8–10	23	3000	N_2 house
Hahn et al.[48]	Cyclists	5F; 6F	C	Elite	?	8–10	12	2650	N_2 house
Hinckson and Hopkins[49]	Runners, triathletes	11M; 11M	X	Subelite	?	8	25	2500–3500	N_2 tent
Hinckson et al.[50]	Runners	8M, 2F	U	Subelite	?	10	24–30/30	2500–3500	N_2 tent
Martin et al.[51]	Cyclists	5F; 6F	C	Elite	?	8–10	12	2650	N_2 house
Mattila and Rusko[52]	Cyclists	5M	U	Elite	Competitive	18	11	3000	N_2 house
Nummela[26]	Runners	6M, 2F; 10M	C	Elite	?	16–17	17	2200	N_2 house
Roberts et al.[53]	Cyclists	14M, 5F; 14M, 5F	X	Subelite	?	8–10	5–15	2650	N_2 house
Rusko et al.[38]	Skiers	9M, 3F; 8M, 2F	B?	?	?	12–16	25	2500	N_2 house
Saunders et al.[39]	Runners	10M; 13M	C	Elite	?	9–12	19/25	2000–3100	N_2 house
Artificial short continuous live-high train-low									
Basset et al.[54]	Skiers, skaters	7M, 5F; 7M, 5F	X, B	Subelite	Off-season	3	6/19	3650	N_2 tent
Katayama et al.[55]	Runners	6M; 6M	C	Subelite	?	1.5	9/19	4000	Chamber
Katayama et al.[56]	Runners	8M; 7M	C	Subelite	Competitive	3	14	4000	N_2 tent
Gore (2006); Rodriguez (2007)[57,58]	Swimmers	3M, 3F; 4M, 3F	C	Subelite	?	3–5	9	4000–5500	Chamber
Gore et al.;[57] Rodriguez et al.[58]	Runners	2M, 3F; 3M, 2F	C	Subelite	?	3–5	9	4000–5500	Chamber
Artificial brief intermittent live-high train-low									
Bonetti et al.[59]	Kayakers	10M; 10M	X	Subelite	Competitive	0.5/1	15/19	3600–6000	Inhaler
Bonetti et al.[60]	Cyclists	18M; 9M	C	Subelite	Competitive	0.5/1	15/19	3600–6000	Inhaler
Hamlin and Hellmans[61]	Multisport athletes	5M, 7F; 8M, 2F	C, B	Subelite	?	0.75/1.5	15/19	3400–5000	Inhaler
Hinckson et al.[62]	Rowers	2M, 5F; 1M, 4F	C, B	Elite	?	0.9/1.5	15/19	3600–6000	Inhaler
Julian et al.[63]	Runners	7M; 7M	C, B	Elite	Competitive	0.75/1.5	20/26	3600–5000	Inhaler
Wood et al.[9]	Hockey players	15M; 14M	C, B	Subelite	Competitive	0.6/1	15/19	3600–6000	Inhaler
Live-low train-high									
Dufour et al.[64]	Runners	9M; 9M	C	Subelite	Pre-season	0.2–0.33/0.33	12/40	3000	Inhaler
Hendriksen and Meeuwsen[65]	Triathletes	12M; 12M	X, B?	Subelite	Pre-season	2	10	2500	Chamber
Katayama et al.[66]	Non-athletes	7M; 7M	C	Trained	?	0.5	10/12	4500	Chamber
Morton and Cable[67]	Team sports	8M; 8M	C	Trained	?	0.17/0.5	9/19	2750	N_2 house

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Table II. Meta-analysis of effects on sea-level mean power output following adaptation to hypoxia experienced in studies with various protocols of natural and artificial altitude. Effects of mean and enhanced protocols are those predicted for controlled trials and maximal tests. Effects in parentheses are unclear (>5% chance of enhancement and >5% chance of impairment); otherwise **bold** indicates ≥50% chance of enhancement, *italic* indicates ≥50% chance of impairment, and plain font indicates ≥50% chance of trivial effect. These probabilistic outcomes are computed with reference to a smallest important change of 1%

Effect	Natural altitude protocols		Artificial altitude protocols			
	live-high train-high	live-high train-low	live-high 8–18 h/d, continuous, train-low	live-high 1.5–5 h/d, continuous, train-low	live-high <1.5 h/d, intermittent, train-low	live-low train-high 0.5–2 h/d
Effect of mean protocol[a] (%); ±90% CL[b]						
Elite	(1.6; ±2.7)	**4.0; ±3.7**	(0.6; ±2.0)		(0.2; ±1.8)	
Subelite	(0.9; ±3.4)	**4.2; ±2.9**	**1.4; ±2.0**	(0.7; ±2.5)	**2.6; ±1.2**	(0.9; ±2.4)
Effect of enhanced protocol[c] (%); ±90% CL						
Elite	**5.2; ±4.1**	**4.3; ±4.1**	(4.0; ±5.5)		(1.2; ±2.5)	
Subelite	**4.5; ±4.1**	**4.6; ±3.3**	**4.8; ±5.3**	**3.5; ±3.5**	**3.6; ±2.1**	**6.8; ±4.9**
Study characteristics changed by +1 SD or −1 SD for enhanced protocol	+ Altitude − Days exposure + Test day	− Altitude − Test day	+ Altitude + Hours hypoxia − Days exposure	− Altitude − Test day	+ Exposure ratio − Test day	− Altitude − Train intensity + Days exposure + Test day
Study characteristics (mean ± SD)						
References	10	5	9	4	6	7
Study groups	13	9	10	5	5	7
Study estimates	33	13	17	11	33	19
Subjects/estimate	16±7	12±6	17±9	15±5	20±6	17±5
Effective subjects/estimate	36±22	41±11	20±9	15±5	20±6	17±5
Elite athletes (%)	54	33	50	0	33	0
Controlled trials (%)	46	11	85	100	100	100
Blind trials (%)	0	0	0	20	67	14
Males (%)	84	61	80	72	81	90
Competitive phase (%)	31	33	10	20	67	14
Phase unknown (%)	54	56	90	60	0	43
Maximal tests (%)	78	100	85	100	71	92
Altitude level (m)	2030±410	2400±290	2890±420	4530±840	6000	2750±310
Hours of hypoxia per day	24	~18–24	11±3			
Minutes of hypoxia per day				210±84	40±9	47±48
Days of exposure	23±6	27±1	18±7	9±3	16±2	14±4

Continued next page

Table II. Contd

Effect	Natural altitude protocols		Artificial altitude protocols			
	live-high train-high	live-high train-low	live-high 8–18 h/d, continuous, train-low	live-high 1.5–5 h/d, continuous, train-low	live-high <1.5 h/d, intermittent, train-low	live-low train-high 0.5–2 h/d
Total period of treatment (d)	23 ± 6	27 ± 1	19 ± 7	14 ± 5	20 ± 3	30 ± 13
Exposure/treatment ratio (%)	100	100	96 ± 7	76 ± 32	82 ± 8	55 ± 27
Training intensity (1–4)						2.3 ± 1.1
Post-exposure test day[d]	9.1 ×/+1.9	5.4 ×/+ 2.2	2.2 ×/+ 2.7	4.4 ×/+ 1.9	6.4 ×/+ 2.3	2.8 ×/+ 1.9
Duration of maximal tests[d] (min)	6.9 ×/+2.4	*11 ×/+ 1.3*	5.6 ×/+ 2.3	5.2 ×/+ 3.0	6.1 ×/+ 2.5	3.9 ×/+ 4.9
Effects of study characteristics (%); ±90% CL						
Subelite-elite	(0.7; ±3.8)	(0.3; ±2.2)	(0.8; ±3.2)		**2.4; ±2.8**	
Uncontrolled-controlled	3.3; ±3.6	*–2.6; ±3.0*	(–1.6; ±3.4)			
Blind-not blind					(–1.4; ±4.5)	
Female-male		(–0.3; ±3.9)				
Competitive-unknown phase	(0.5; ±3.8)					
Submaximal-maximal test	(0.0; ±1.6)		*–3.3; ±2.4*		(–0.3; ±1.8)	(1.4; ±3.2)
1 SD altitude level	**1.2; ±1.6**	–0.1; ±1.0	**1.5; ±2.5**	**–2.3; ±2.5**		(–0.9 ±2.5)
1 SD hours hypoxia			0.8; ±1.8			
1 SD minutes hypoxia					(0.4; ±2.3)	
1 SD days exposure	*–1.8; ±1.7*		*–1.0; ±1.7*			**2.4; ±2.5**
1 SD exposure/treatment ratio					0.6; ±1.2	
1 SD training intensity						(–1.2; ±2.5)
1 SD post-exposure test day	0.5; ±0.7	–0.2; ±0.3	(0.1; ±2.1)	–0.5; ±0.8	–0.4; ±0.6	**1.2; ±1.5**
1 SD duration of max. test	**3.0; ±2.5**		–0.9; ±1.2	–0.3; ±0.6	0.6; ±1.3	–0.2; ±1.1
Random variation (%); ±90% CL or ×/+90% CL factor						
Between-study SD	2.7; ±2.3	1.3; ±1.3	1.0; ±1.9	2.2; ±3.5	–0.6; ±0.9	2.4; ±3.1
Standard error of measurement	2.4; ×/+1.7	0.7; ×/+2.2	2.2; ×/+1.9	1.2; ×/+ 1.9	3.2; ×/+1.3	2.8; ×/+1.5

a Effects are the means predicted for controlled trials and maximal tests, but are otherwise evaluated at the mean values of the study characteristics for which effects are shown.

b 90% CL: subtract and add this number to the observed effect to obtain the 90% CL for the true (large-sample) effect.

c Effects are the predicted means in maximal tests adjusted to ±1 SD away from the mean for selected study characteristics shown.

d SD shown as ×/+ factor derived from log-transformed times.

CL = confidence limits.

Table III. Meta-analysis of effects on sea-level maximal oxygen uptake following adaptation to hypoxia experienced in studies with various protocols of natural and artificial altitude. Effects of mean protocol are those predicted for controlled trials. Effects in parentheses are unclear (>5% chance of increase and >5% chance of decrease); otherwise **bold** indicates ≥50% chance of increase, *italic* indicates ≥50% chance of decrease, and plain font indicates ≥50% chance of a trivial effect. These probabilistic outcomes are computed with reference to a smallest important change of 1%

Effect	Natural altitude		Artificial altitude			
	live-high train-high	live-high train-low	continuous long hypoxia (8–18 h/d), train-low	continuous brief hypoxia (1.5–5 h/d), train-low	intermittent brief hypoxia (<1.5 h/d), train-low	live-low, train-high (0.5–2 h/d)
Effect of mean protocol[a] (%); ±90% CL[b]						
Elite	*–1.5; ±2.0*	(6.4; ±11.2)	–0.5; ±1.4		(0.1; ±2.8)	
Subelite	**4.3; ±2.6**	(6.4; ±9.4)		(–1.1; ±3.5)		**1.1; ±2.0[e]**
Study characteristics (mean ± SD)[c]						
References	12	5	5	4	3	8
Study groups	15	9	6	5	3	8
Study estimates	20	10	7	6	5	10
Subjects per estimate	15 ± 7	12 ± 6	20 ± 10	15 ± 5	19 ± 5	16 ± 5
Effective subjects per estimate[d]	33 ± 19	41 ± 11	20 ± 10	15 ± 5	19 ± 5	16 ± 5
Elite athletes (%)	57	33	33	0	33	0
Controlled trials (%)	43	11	100	100	100	100
Blind trials (%)	0	0	0	20	33	13
Males (%)	87	61	75	72	100	91
Competitive phase (%)	29	33	0	20	100	13
Phase unknown (%)	57	56	100	60	0	50
Altitude level (m)	1990 ± 400	2400 ± 290	2680 ± 160	4530 ± 880	6000	2970 ± 680
Hours of hypoxia per day			10 ± 2			
Minutes of hypoxia per day				210 ± 90	35 ± 8	45 ± 46
Days of exposure	23 ± 6	27 ± 1	18 ± 6	9 ± 3	17 ± 3	14 ± 4
Total period of treatment (d)	23 ± 6	27 ± 1	19 ± 7	14 ± 5	21 ± 4	28 ± 14
Exposure/treatment ratio (%)	100	100	96 ± 9	76 ± 33	78 ± 1	59 ± 27
Training intensity (1–4)						2.1 ± 1.1
Post-exposure test day[c]	8.0 ×/+ 1.8	4.8 ×/+ 2.1	1.2 ×/+ 2.3	4.4 ×/+ 2.0	4.7 ×/+ 2.5	2.9 ×/+ 2.2
Effects of study characteristics (%); ±90% CL						
Uncontrolled-controlled	0.3; ±2.4	(–2.7; ±9.3)				
Competitive-unknown phase	(1.3; ±2.7)					
Subelite-elite	**5.5; ±2.4**	(–0.0; ±5.2)				
1 SD altitude level	0.3; ±1.2					(0.0; ±2.3)

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Table III. Contd

Effect	Natural altitude		Artificial altitude			
	live-high train-high	live-high train-low	continuous long hypoxia (8–18 h/d), train-low	continuous brief hypoxia (1.5–5 h/d), train-low	intermittent brief hypoxia (<1.5 h/d), train-low	live-low, train-high (0.5–2 h/d)
1 SD hours exposure			2.5; ±1.9			
1 SD days exposure	0.5; ±1.3		–0.9; ±1.7	(1.1; ±4.3)		(1.0; ±2.2)
1 SD training intensity						*–1.2; ±2.1*
1 SD post-exposure test day	1.0; ±1.0	(1.1; ±2.8)			(–0.5; ±3.3)	
Random variation (%); ±90% CL or ×/+90% CL factor						
Between-study SD	1.8; ±2.4	3.8; ×/+1.7[e]	1.7; ×/+1.9[e]	3.3; ×/+2.5[e]	2.6; ×/+2.2[e]	2.1; ±2.8
Standard error of measurement	2.9; ×/+1.8					2.5; ×/+2.6

a Effects are the means predicted for controlled trials, but otherwise evaluated at the mean values of the study characteristics for which effects are shown.

b 90% CL: subtract and add this number to the observed effect to obtain the 90% CL for the true (large-sample) effect.

c SD shown as ×/+ factor derived from log-transformed times.

d Derived by adjusting all sample sizes to those of controlled trials with equal numbers in control and experimental groups.

e Insufficient within-study clusters to estimate error of measurement; between-study SD includes within-study sampling variation.

CL = confidence limits.

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Table IV. Meta-analysis of effects on sea-level haemoglobin (Hb) or red-cell mass (Hb mass), exercise economy, Hb concentration, and peak lactate in an exercise test following adaptation to hypoxia experienced in studies with various protocols of natural and artificial altitude. Effects in parentheses are unclear (>5% chance of increase and >5% chance of decrease); otherwise **bold** indicates ≥50% chance of increase, *italic* indicates ≥50% chance of decrease, and plain font indicates ≥50% chance of a trivial effect. These probabilistic outcomes are computed with reference to a smallest important change of 1% for Hb mass, 1% for economy, and 0.20 of baseline between-subject SD for Hb concentration and peak lactate

Effect	Hb mass, where measured[a]	Economy, where measured[b]	Hb concentration		Peak lactate	
			LHTH	intermittent brief hypoxia, *train low*	LHTH	intermittent brief hypoxia, *train low*
Effect of mean protocol[c](%); ±90%CL[d]	(1.3; ±2.4)	0.4; ±1.3	**4.8; ±2.7**	**2.3; ±1.2**	(0.7; ±5.7)	–3.5; ±4.7
Study characteristics (mean ± SD)						
References	12	14	5	4	5	5
Study groups	14	15	7	4	7	7
Study estimates	18	19	8	8	9	14
Subjects/estimate	15±7	19±5	16±9	22±5	19±8	24±3
Effective subjects/estimate	25±9	31±27	32±11	22±5	35±23	24±3
Elite athletes (%)	46	33	57	20	43	0
Controlled trials (%)	62	80	43	100	57	100
Blind trials (%)	0	7	0	60	0	50
Males (%)	74	91	83	92	82	90
Competitive phase (%)	15	53	29	80	29	75
Phase unknown (%)	62	40	43	0	43	0
Altitude level (m)	2540±970	3410±1460	1900±280	6000	1990±320	6000
Minutes of hypoxia per day				37±7		35±6
Days of exposure	21±7	20±6	24±5	16±2	22±6	15
Total period of treatment (d)	21±7	24±6	24±5	20±4	22±6	18±2
Exposure/treatment ratio (%)	100	86±22	100	83±9	100	84±9
Post-exposure test day[e]	3.9 ×/+ 2.6	3.3 ×/+ 2.8	9.1 ×/+ 2.1	4.3 ×/+ 2.3	8.3 ×/+ 2.2	5.9 ×/+ 2.3
Effects of study characteristics (%); ±90% CL						
1 SD *altitude level*	*(1.5; ±2.6)*	*0.6; ±1.6*	*(–1.8; ±4.0[e])*		*–12.4; ±7.0*	
1 SD exposure days	**2.7; ±2.7**	–0.8 ±1.6			(1.4; ±7.7)	
1 SD post-exposure test day	–0.9; ±1.0	(0.1; ±1.4)	*–3.3; ±3.9*	0.6; ±1.3	*–10.5; ±7.7*	–0.6; ±2.1
Random variation (%); ±90% CL or ×/+90% CL factor						
Between-study SD	4.6; ±2.2	–1.0; ±2.5	3.6; ×/+1.8[f]	1.7; ×/+1.7[f]	8.7; ×/+1.7[f]	3.6; ±4.8
Standard error of measurement	2.1; ×/+1.9	6.0; ×/+1.7				7.3; ×/+1.5

a Number of estimates: LHTH, 10; LHTL, 3; artificial long continuous LHTL, 3; artificial brief continuous LHTL, 2.

b Number of estimates: LHTH, 4; LHTL, 3; artificial long continuous LHTL, 3; artificial brief continuous LHTL, 3 artificial brief intermittent LHTL, 5; LLTH, 1.

c Effects are the predicted means evaluated at the mean values of the study characteristics for which effects are shown.

d 90% CL: subtract and add this number to the observed effect to obtain the 90% CL for the true (large-sample) effect.

e *SD shown as ×/+ factor derived from log-transformed times.*

f Insufficient within-study clusters to estimate error of measurement; between-study SD includes within-study sampling variation.

CL = confidence limits; **LHTH** = live-high train-high; **LHTL** = live-high train-low; **LLTH** = live-low train-high.

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