



ČLOVĚK A VYSOKÁ NADMOŘSKÁ VÝŠKA

Jiří Chvojka (Diploma in Mountain Medicine, UIAA)

**I STAND WITH
UKRAINE**





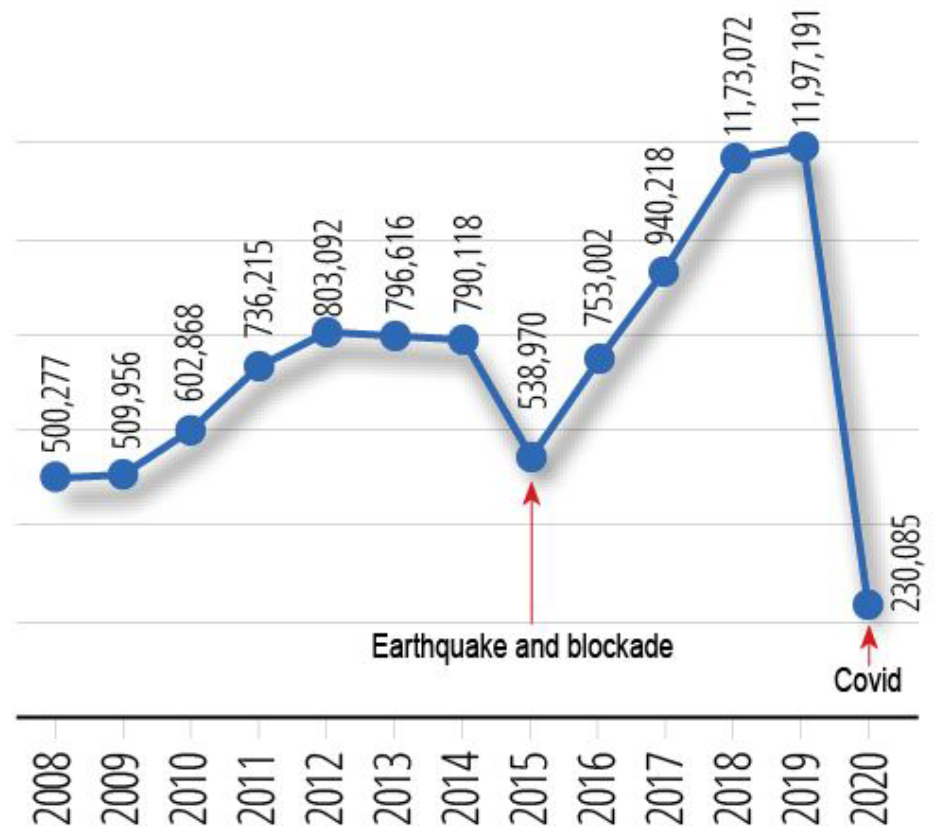
Pro některé nejsou hory a vysoká nadmořská výška problém...



- Hory zabírají 40 mil km² = 27% zemského povrchu
- 38 mil lidí žije trvale ve výškách nad 2440 m n.m.
- Každý rok navštíví hory nejméně **100 mil** turistů
- Od roku 1994 do roku 2000 narostl počet turistů v Nepálu o **450%**
- Od roku 1950 do roku 1990 se o nepálské osmitisícovky pokusilo **19 810** lezců
- Od roku 1990 do roku 2006 **30 141** lezců



Number of tourists in Nepal



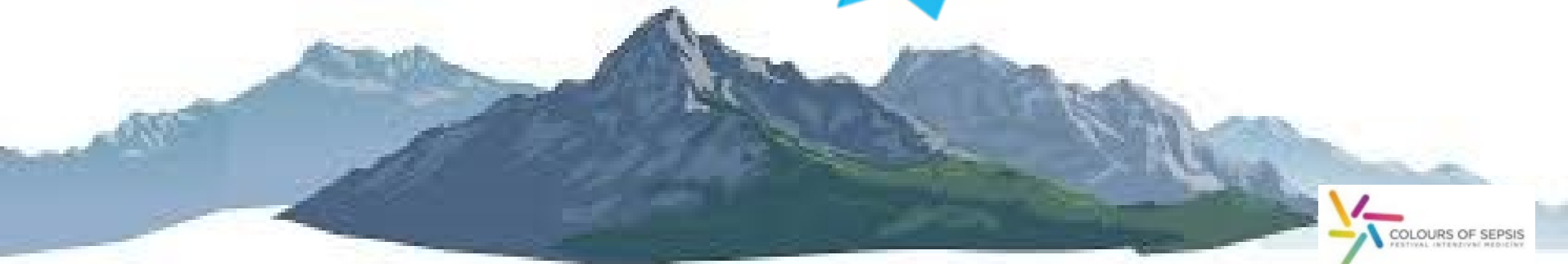
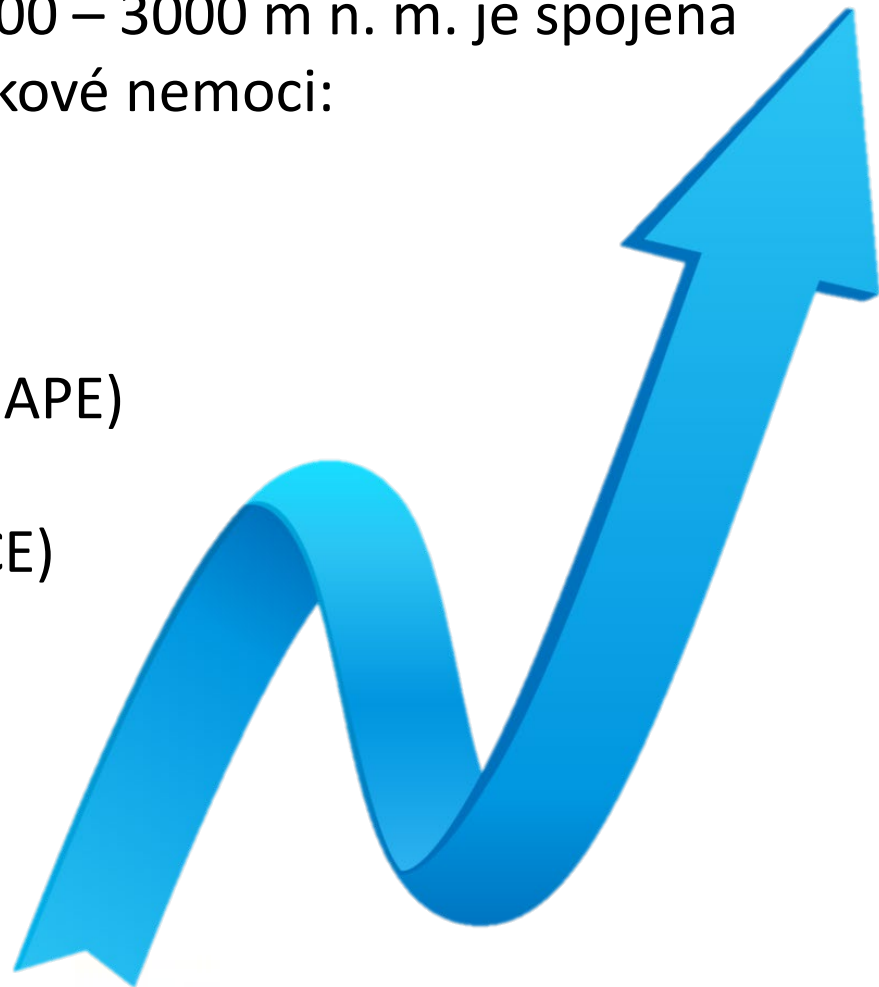
NEPAL TOURISM BOARD

>50 milionů turistů navštíví ročně vysokohorské prostředí



Každá cesta do nadmořské výšky >2500 – 3000 m n. m. je spojena s rizikem rozvoje některé z forem výškové nemoci:

- Acute mountain sickness (AMS)
- High-altitude pulmonary edema (HAPE)
- High-altitude cerebral edema (HACE)





the boundary. The Chinese Commission will in such circumstances be left to starve among the hills and valleys, begging food to sustain life, with no means of obtaining it. In some ten or twenty days men and animals will die in the desert, and be never more heard of. Again, on passing the Great Headache Mountain, the Little Headache Mountain, the Red Land, and the Fever Slope, men's bodies become feverish, they lose colour, and are attacked with headache and vomiting; the asses and cattle being all in like condition. Moreover there are three pools with rocky banks along which the pathway is only 16 or

賓所能越也其鄉慕不足
 附不能危城郭謂西諸
 獻者皆行賈賤人欲通貨
 送至縣度恐失實見欺
 害也起皮山南更不屬
 國稟食得以自贍讀曰尚時
 不能食或桀黠不肯給音古疆漢之節餒山谷之間餓
 人畜棄捐曠野而不反音能歷音古又歷大頭痛小
 頭痛之山赤土身熱之阪音能令人身熱無色頭痛嘔吐
 前漢書卷九十六上列傳十一中華書局聚

mountain sickness was certainly experienced by people before the dawn of documented history which was about 6000 years ago. Therefore, it is surprising to find only a few fragments in the written record about this sickness prior to the seventeenth century. We can speculate that perhaps some ancient reports and descriptions were destroyed in the fabulous library at Alexandria, or that perhaps there are some

MOUNTAIN SICKNESS: THE CHINA STORY

317

TABLE 1
Proper names of sites

Modern name	Alternate name
Afghanistan	Ke-pin
Anxi	Ansi
Dunhuang	Tunhwang
Hindu Kush	Hsientu
Hotan	Khotan
Kashi	Kashgar
Kongur Shan	Kongur Mountain
Shache	Yarkand
Sinkiang	Chinese Turkestan
Taxkorgan	Tash Kurghan
Turan	Turfan
Xian	Sian

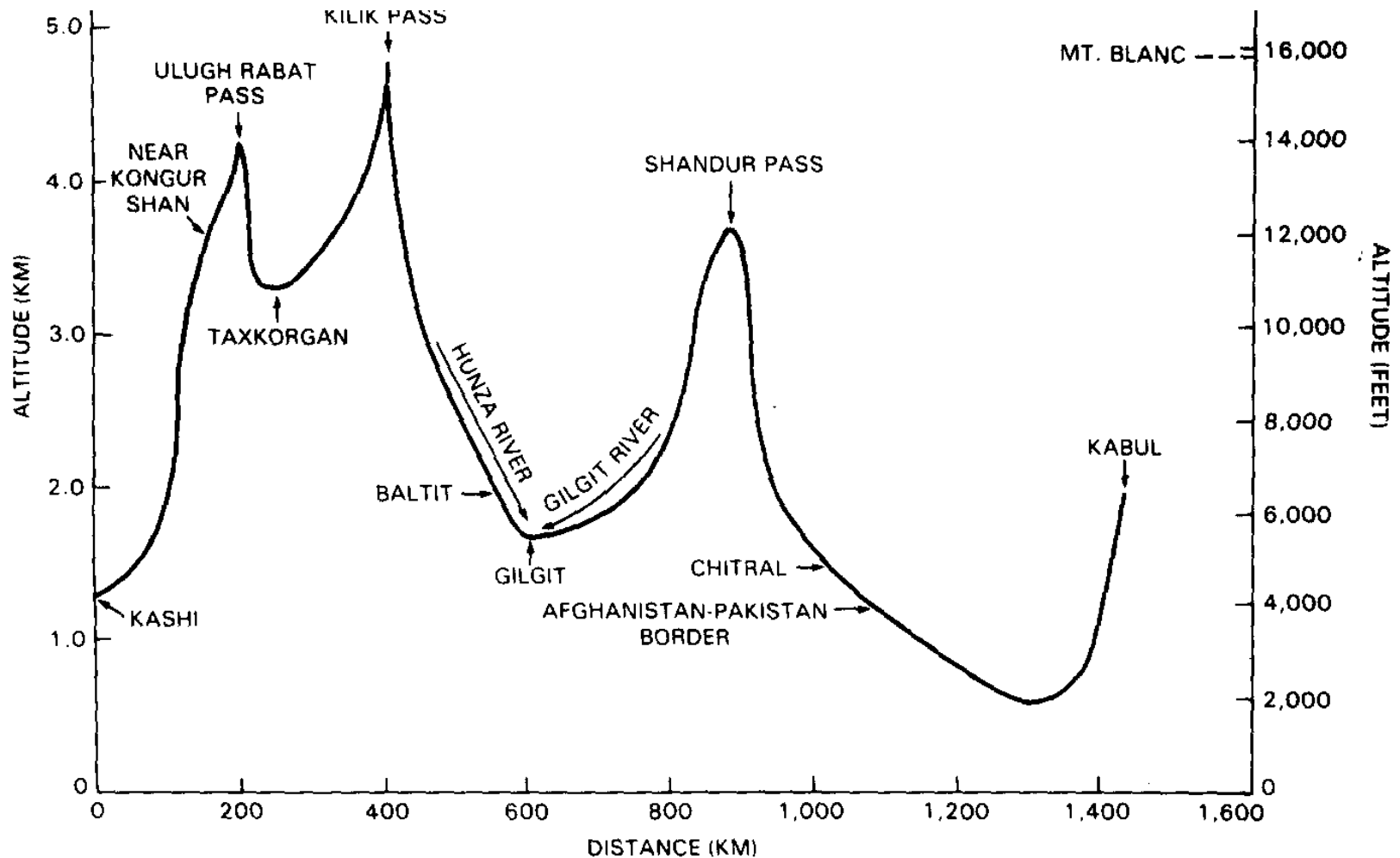


Fig. 3. Altitude profile of the Kashi-Gilgit-Chitral-Kabul route or Route A. The altitudes and distances were estimated from several contour maps (Maps of Asia, 1980, 1981a,b,c, Maps of India and Pakistan, 1955, 1962a,b). The pass near the Muztagata Peak is the Uluğ Rabat Pass (Tilman, 1949). The contour interval was either 1000 or 2000 ft. The altitude profile was subjected to a smoothing procedure so that the major features could be illustrated.



J. Carrillo
HISTORIA
NATURAL
Y
MORAL DE LAS
INDIAS,

EN QUE SE TRATAN LAS COSAS
notables del cielo, y elementos, metales, plantas, y ani-
males de ellas: y los ritos, y ceremonias, leyes, y
gobierno, y guerras de los Indios.

Compuesta por el Padre *José de Acosta Religioso*
de la Compañía de Jesús.

DIRIGIDA A LA SERENISSIMA
Infanta Doña Isabel Clara Eugenia de Austria.



CON PRIVILEGIO.
Impreso en Sevilla en casa de Juan de Leon.
Año de 1590.

- Humans
- Neanderthals
- Early hominids

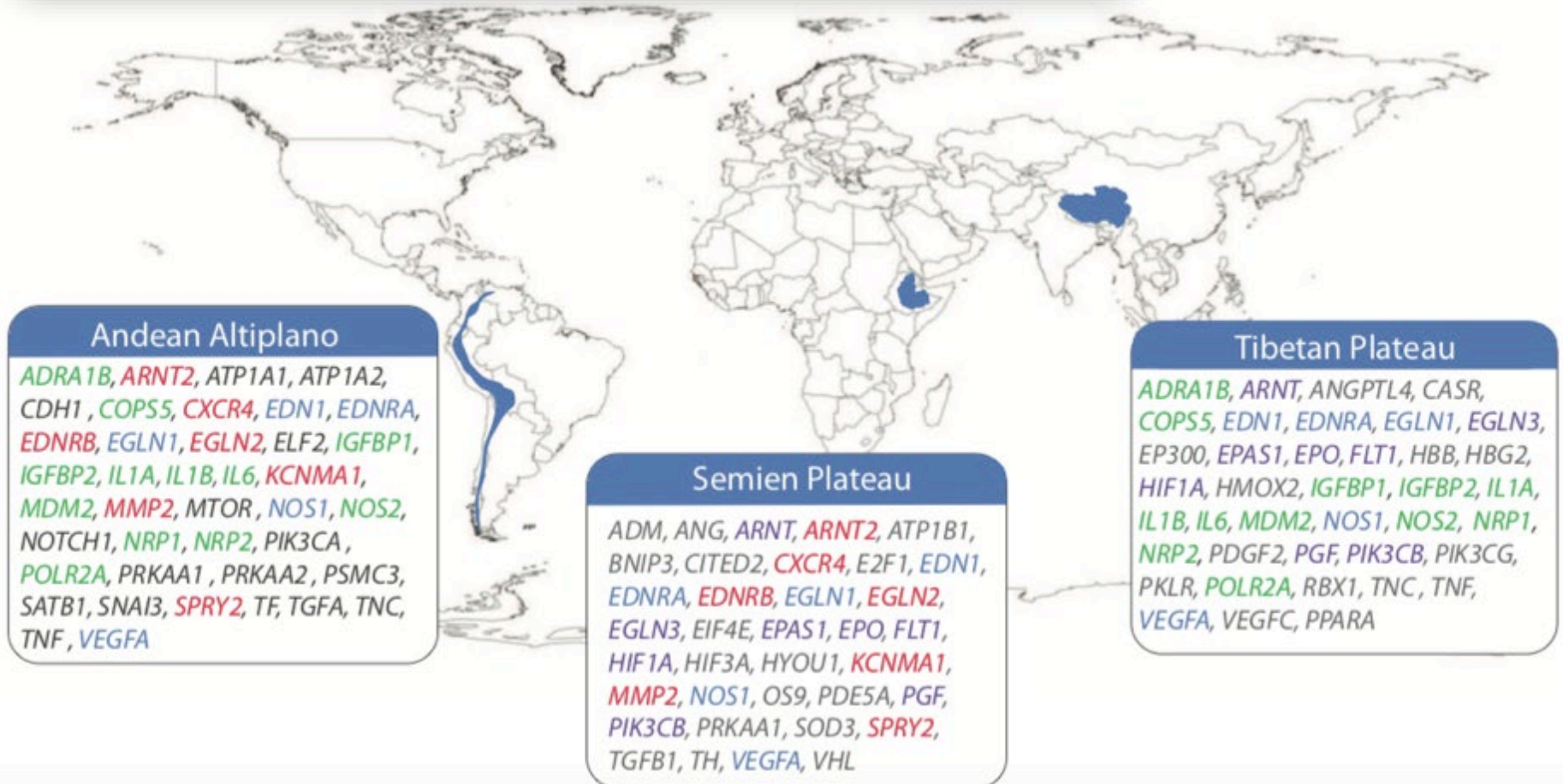


The migration of Homo sapiens.

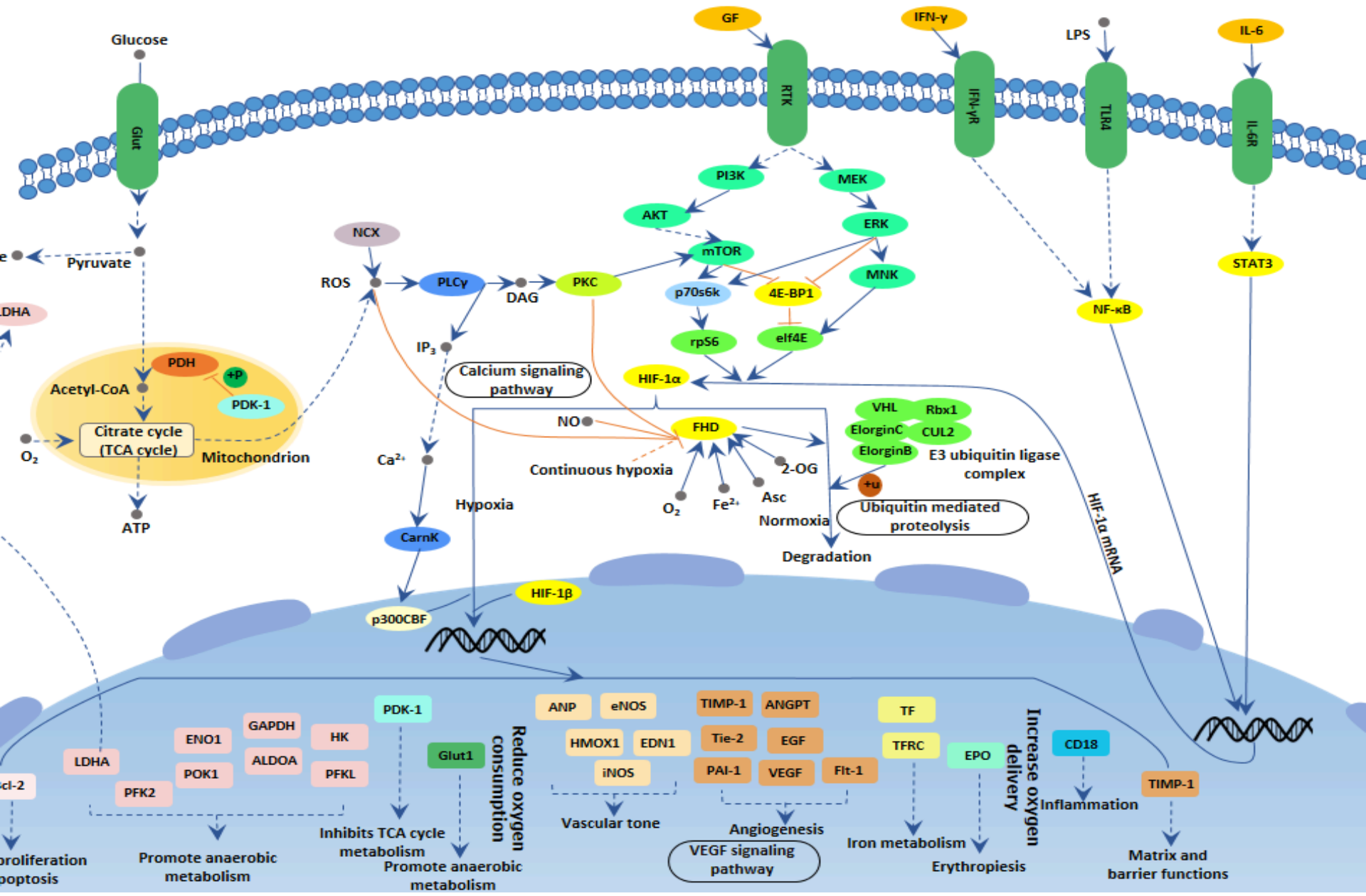


- Člověk se **NE**vyvinul primárně pro život ve vysokohorském prostředí

Genetics Of Human Origin and Evolution: High-Altitude Adaptations



- Geneticky podmíněné změny v HIF pathway



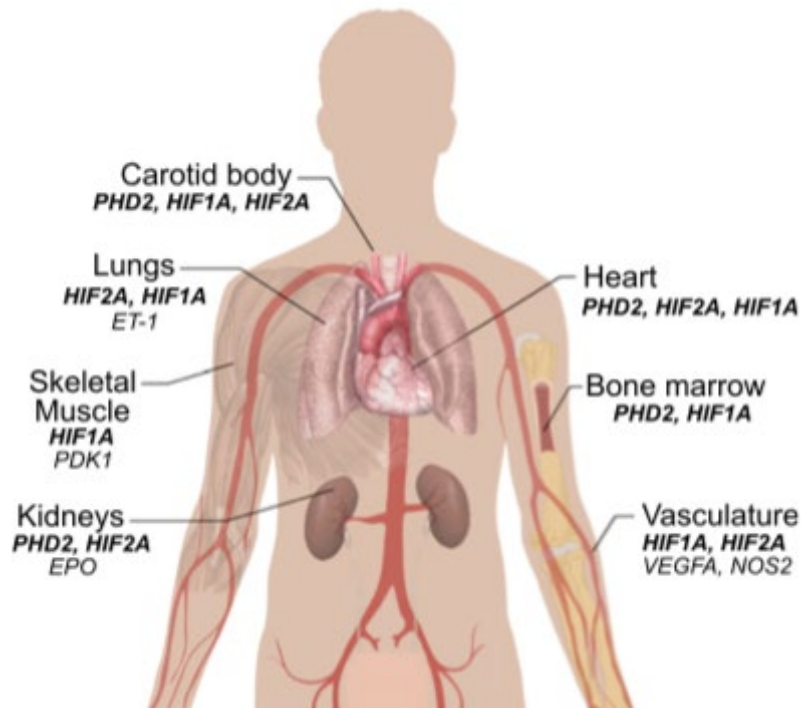
- Hypoxia-inducible factor pathway

Human high-altitude adaptation: forward genetics meets the HIF pathway

Table 1. *Physiologic adaptations to high-altitude hypoxia among high-altitude populations*

Phenotype	Andean	Tibetan	Ethiopian
Resting ventilation	No increase	50% higher	NR
Hypoxic ventilatory response	Blunted (low)	Similar to sea level	NR
Arterial oxygen saturation	Elevated	No increase	Elevated
Hemoglobin concentration	Elevated	Minimal increase	Minimal increase
Pulmonary arterial pressure	Elevated	Minimal increase	Elevated
Nitric oxide	Elevated	Markedly elevated	NR
Birth weight	Elevated	Elevated	NR

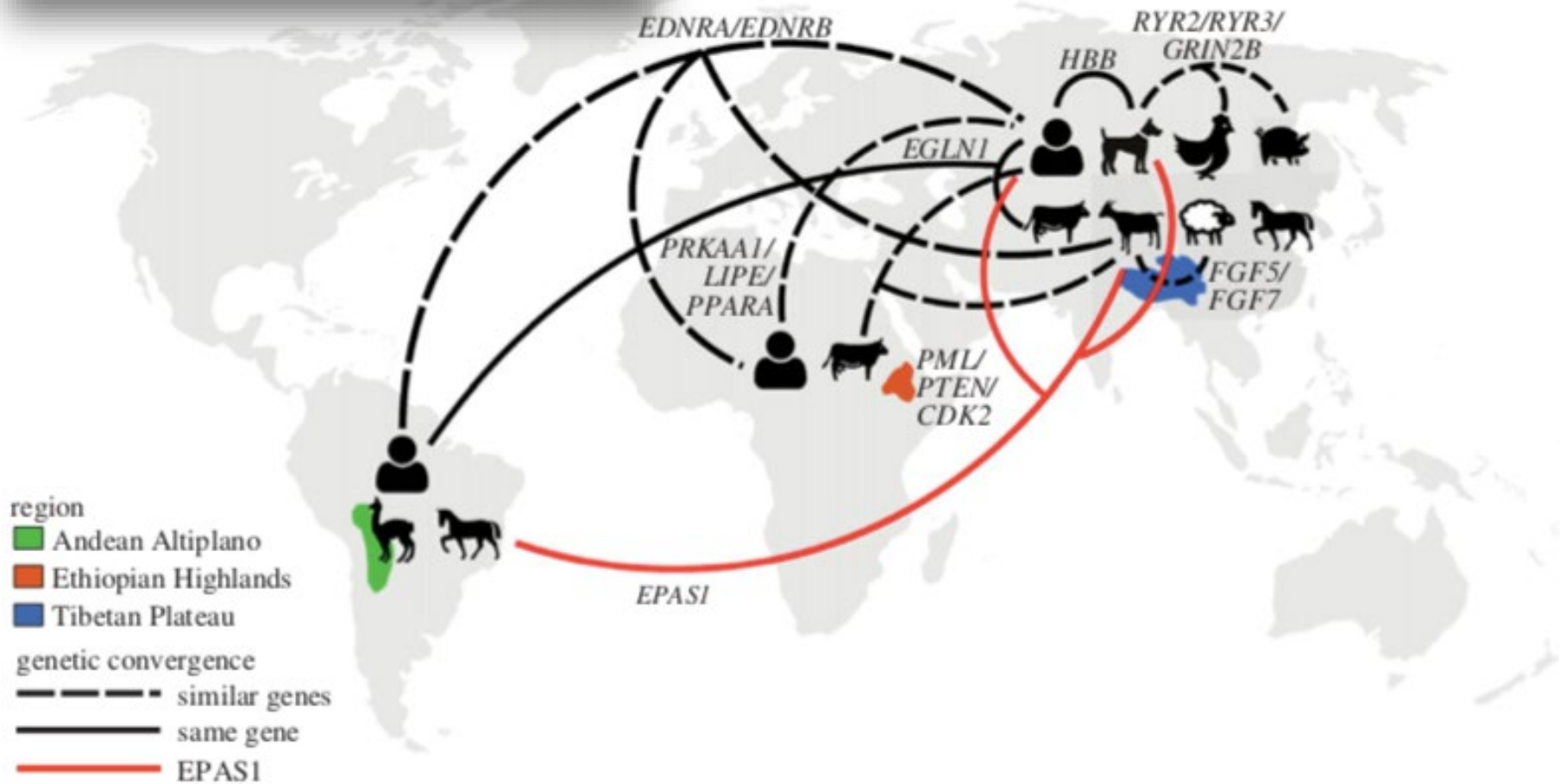
(NR) Not reported.



- Změny v makro i mikrovaskulatuře
- Koncentrace hemoglobinu
- Změny minutové ventilace

Convergent evolution in human and domesticate adaptation to high-altitude environments

Kelsey E. Witt¹ and Emilia Huerta-Sánchez^{1,2,3}





Phyllotis xanthopygus

6732 m n.m.



Kráter Lullaillaco





Ale co my "z nížin"?

*Machu Picchu 2015
Original Chinese tourist*

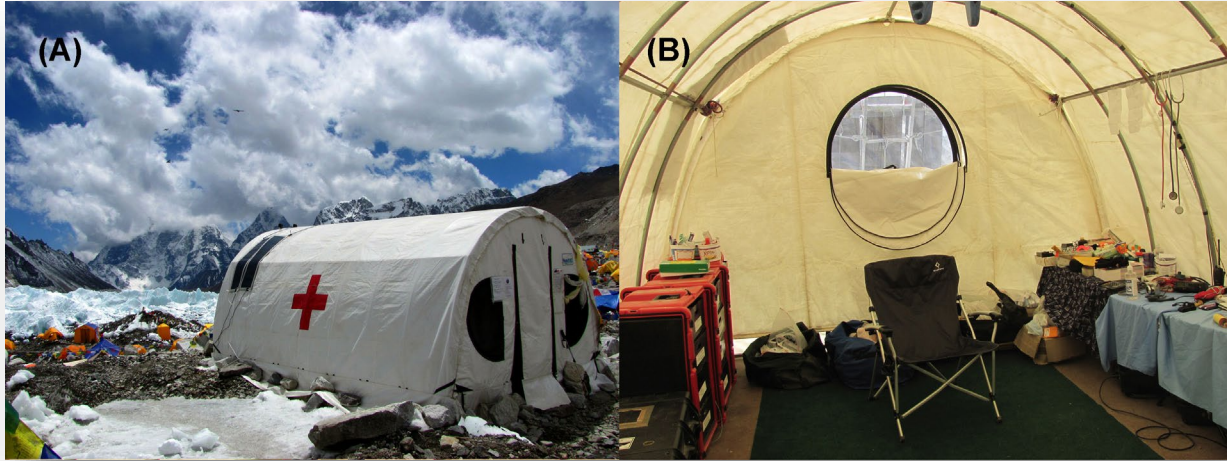


JAK SE JMENUJE TATO HORA?

MT. EVEREST



Mt Everest Base Camp Medical Clinic “Everest ER”: Epidemiology of Medical Events During the First 10 Years of Operation

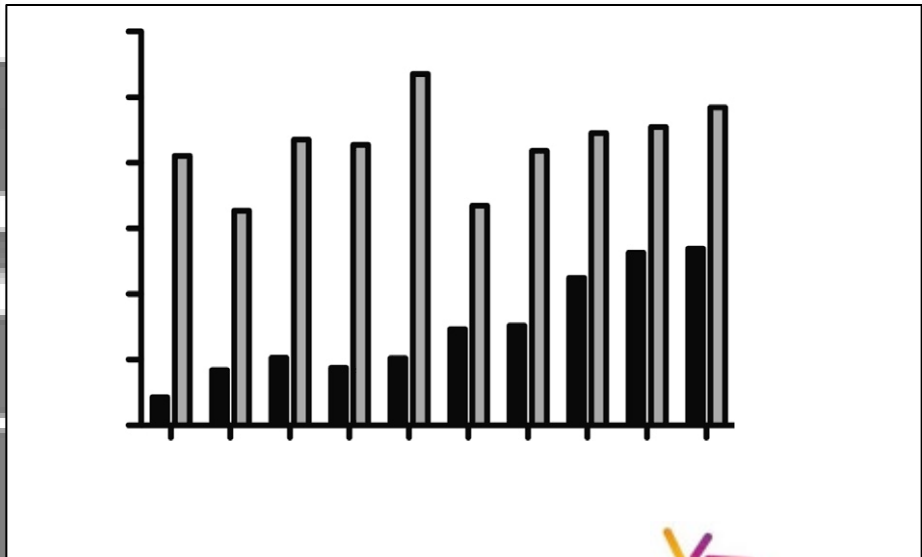


5364 m n.m.

Mt Everest Base Camp Medical Clinic “Everest ER”: Epidemiology of Medical Events During the First 10 Years of Operation

Table 1. Categories of medical diagnoses seen at the Everest ER, 2003–2012

<i>Diagnosis category</i>	<i>Number</i>	<i>Percent</i>
Pulmonary	1164	38.2
Gastrointestinal	480	15.8
Ear, nose, throat	439	14.4
Neurology	199	6.5
Musculoskeletal	144	4.7
Constitutional	139	4.6
Dermatology	106	3.5
General	81	2.7
Dental	70	2.3
Eye	51	1.7
Cardiovascular	50	1.6
Psychiatric	42	1.4
Genitourinary	40	1.3
Allergic/immunologic	15	0.5
Endocrine	13	0.4
Toxicology	11	0.4
Hematologic/lymphatic	1	0
Total	3045	100



Co vám hrozí při pobytu v horách?

Acute mountain sickness (AMS)

High-altitude pulmonary edema (HAPE)

High-altitude cerebral edema (HACE)

Hypotermie

Omrzliny

Trauma

Ostatní netraumatické akutní stavy



- Mírnou formou AMS postižen každý druhý cestovatel
- Při cestách do výšek 4000 – 5000 m n. m. je šance na úmrtí 3/100 000
- Tolerance nadmořských výšek souvisí spíše s:

Individuální vnímavostí

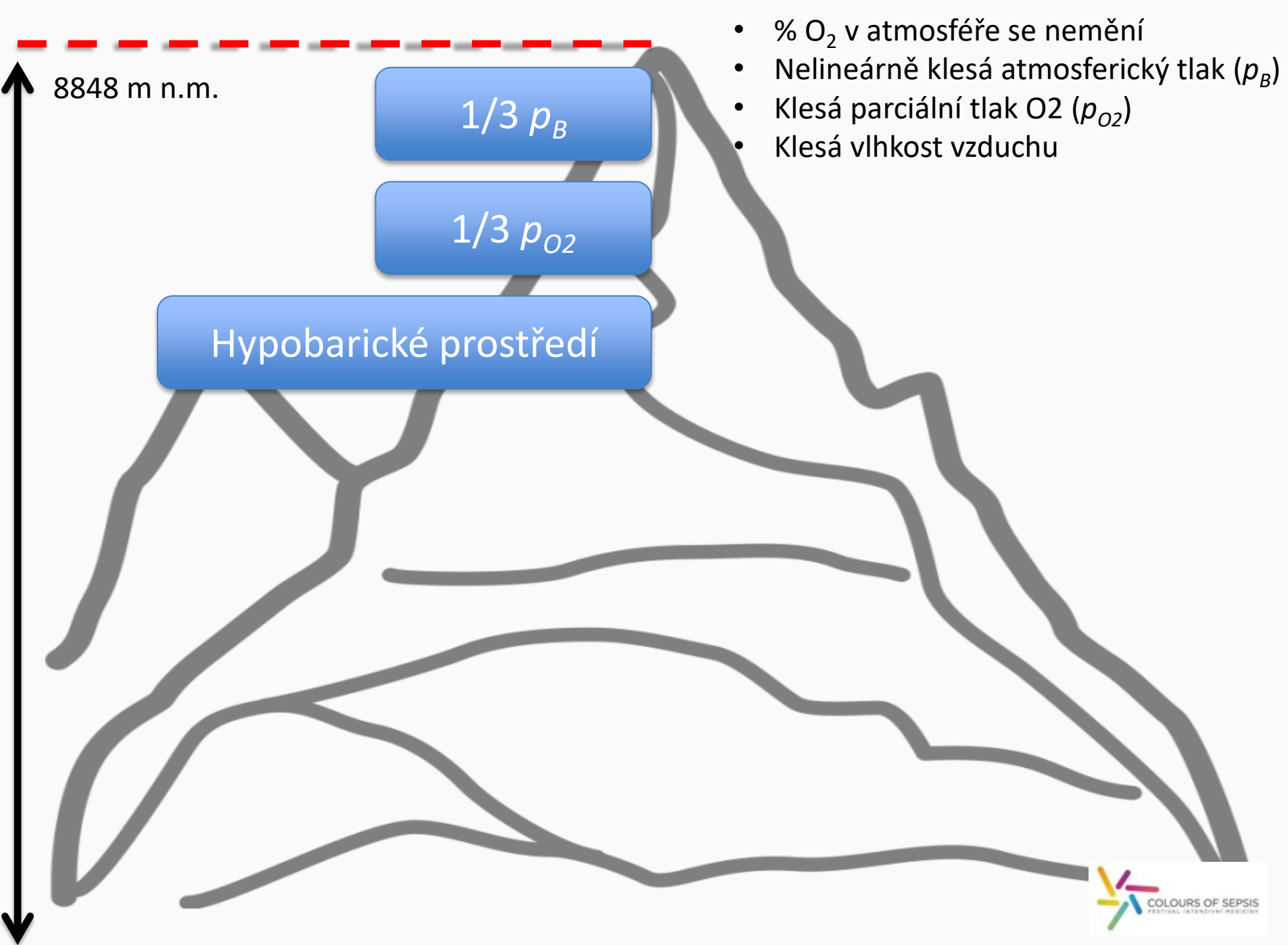
(Věkem)

Stupněm fyzické zátěže

- Příliš nesouvisí s:

Fyzickou kondicí





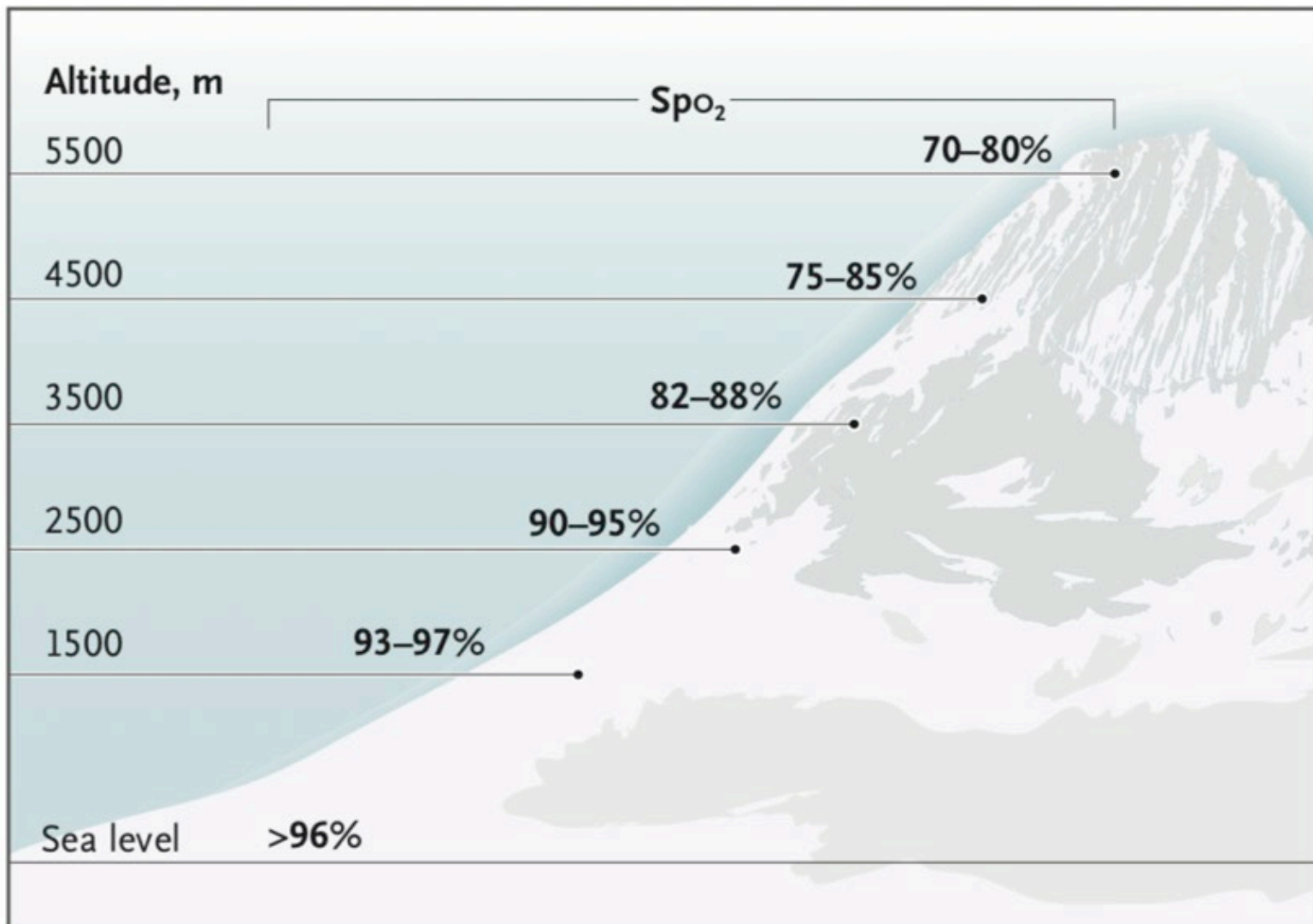


Figure 2. Expected Changes in Resting Oxygen Saturation with Increasing Altitude.



- Barometrický tlak je v dané nadmořské výšce vyšší v oblasti kolem rovníku
- Barometrický tlak je v dané nadmořské výšce vyšší v létě než v zimě

A Prospective Epidemiological Study of Acute Mountain Sickness in Nepalese Pilgrims Ascending to High Altitude (4380 m)



Table 2. Statistical relationships between dichotomous variables and the incidence of acute mountain sickness (AMS) in Nepalese pilgrims upon arrival to Gosainkunda (4380 m).

Category	Subcategory	Sample size (n (%))		X ²		Relative Risk	
		Total	AMS+	Statistic	p-value	Statistic	95% CI
Sex	Male	344 (70.1)	100 (29.1)				
	Female	147 (29.9)	67 (45.5)	12.5*	<0.001	1.57*	1.23, 2.00
Age [†]	≤35 years	261 (53.5)	63 (24.1)				
	>35 years	227 (46.5)	104 (45.8)	25.3*	<0.001	1.63*	1.36, 1.95
Smoking	Yes	147 (29.9)	42 (25.1)				
	No	344 (70.1)	125 (36.3)	2.77	0.096	1.27	0.95, 1.70
Ascent [‡]	2 days	366 (80.3)	113 (30.9)				
	1 day	90 (19.7)	38 (42.2)	4.20*	0.040	1.37*	1.03, 1.82
First ascent to Gosainkunda?	No	85 (17.3)	23 (27.1)				
	Yes	406 (82.7)	144 (35.5)	2.21	0.137	1.31	0.90, 1.90

Conclusions: The incidence of AMS upon reaching 4380 m was 34% in a large population of Nepalese pilgrims. Sex, age, and ascent rate were significant factors in the development of AMS, and traditional Nepalese remedies were ineffective in the prevention of AMS.

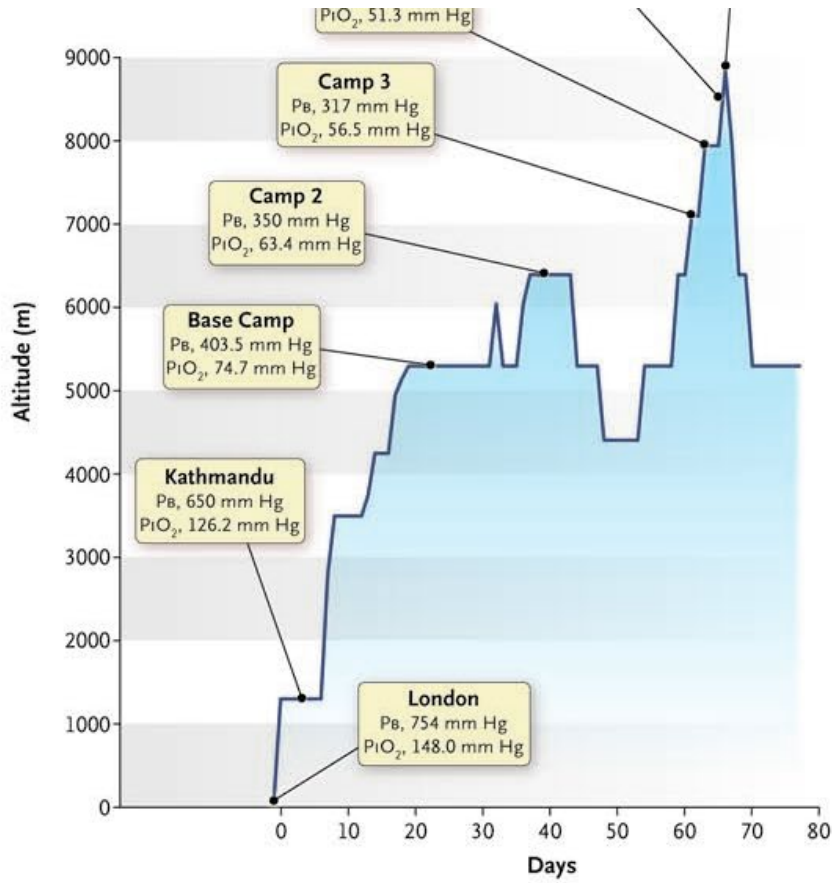


NIRUANA

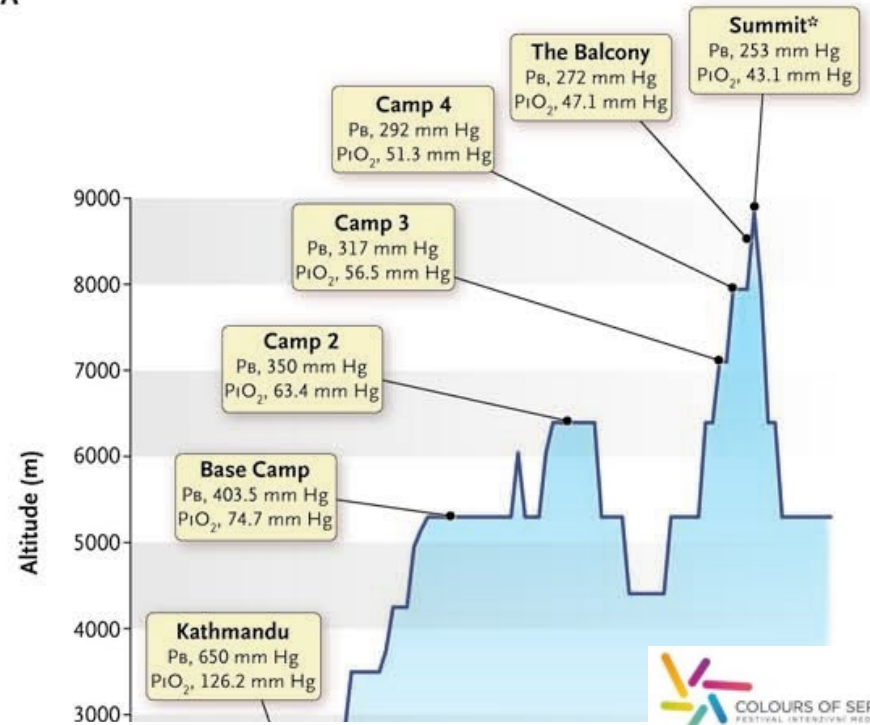
The logo for Nirvana features the word "NIRUANA" in a bold, black, sans-serif font, arched over a stylized face. The face has large, yellow eyes with red outlines and a red, flame-like mouth. A small red dot is positioned above the bridge of the nose.

ORIGINAL ARTICLE

Arterial Blood Gases and Oxygen Content in Climbers on Mount Everest



A



B

Summit of Mount Everest

Arterial blood sampling taken at the Balcony

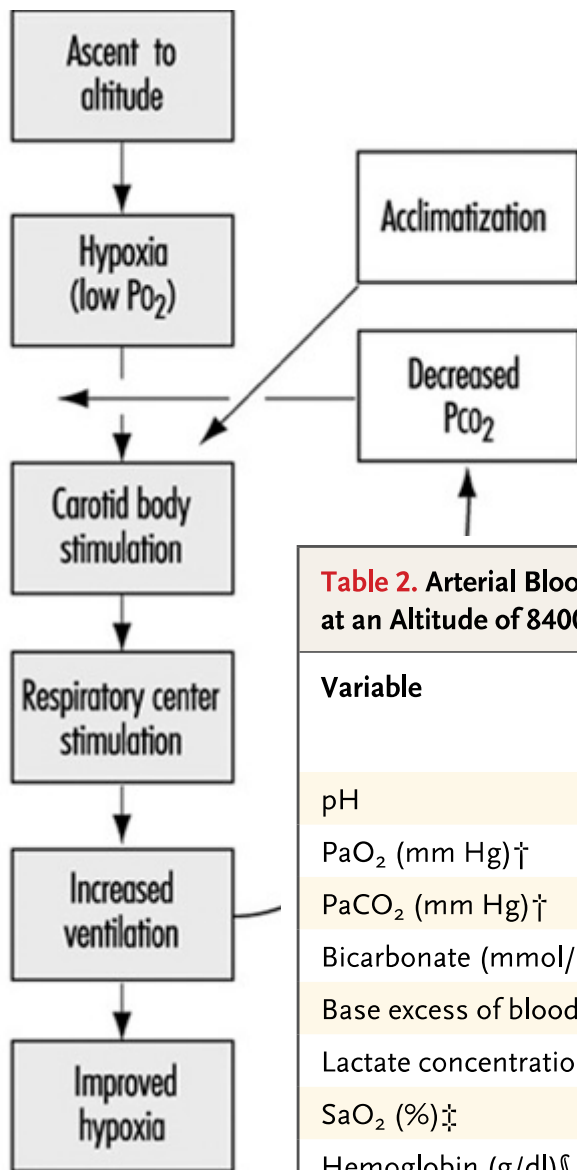


Table 2. Arterial Blood Gas Measurements and Calculated Values for Pulmonary Gas Exchange from Four Subjects at an Altitude of 8400 m, during Descent from the Summit of Mount Everest.*

Variable	Subject No.				Group Mean
	1	2	3	4	
pH	7.55	7.45	7.52	7.60	7.53
PaO ₂ (mm Hg) †	29.5	19.1	21.0	28.7	24.6
PaCO ₂ (mm Hg) †	12.3	15.7	15.0	10.3	13.3
Bicarbonate (mmol/liter) ‡	10.5	10.67	11.97	9.87	10.8
Base excess of blood ‡	-6.3	-9.16	-6.39	-5.71	-6.9
Lactate concentration (mmol/liter)	2.0	2.0	2.9	1.8	2.2
SaO ₂ (%) ‡	68.1	34.4	43.7	69.7	54.0
Hemoglobin (g/dl) §	20.2	18.7	18.8	19.4	19.3
Respiratory exchange ratio ¶	0.81	0.74	0.72	0.70	0.74
PAO ₂ — mm Hg †**	32.4	26.9	27.4	33.2	30.0
Alveolar–arterial oxygen difference — mm Hg †	2.89	7.81	6.44	4.51	5.41

Fyziologická reakce organismu na výšku:

Zvýšení tepové frekvence
(o 20 tepů/min)

Zvýšení minutové ventilace

Zvýšení diurézy

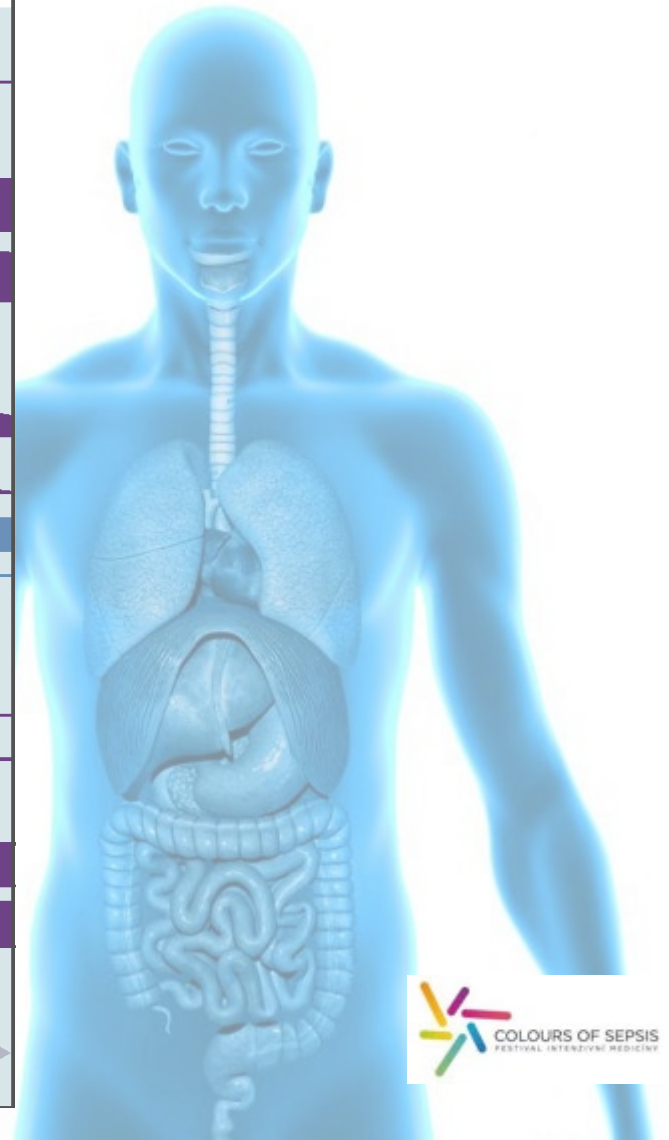
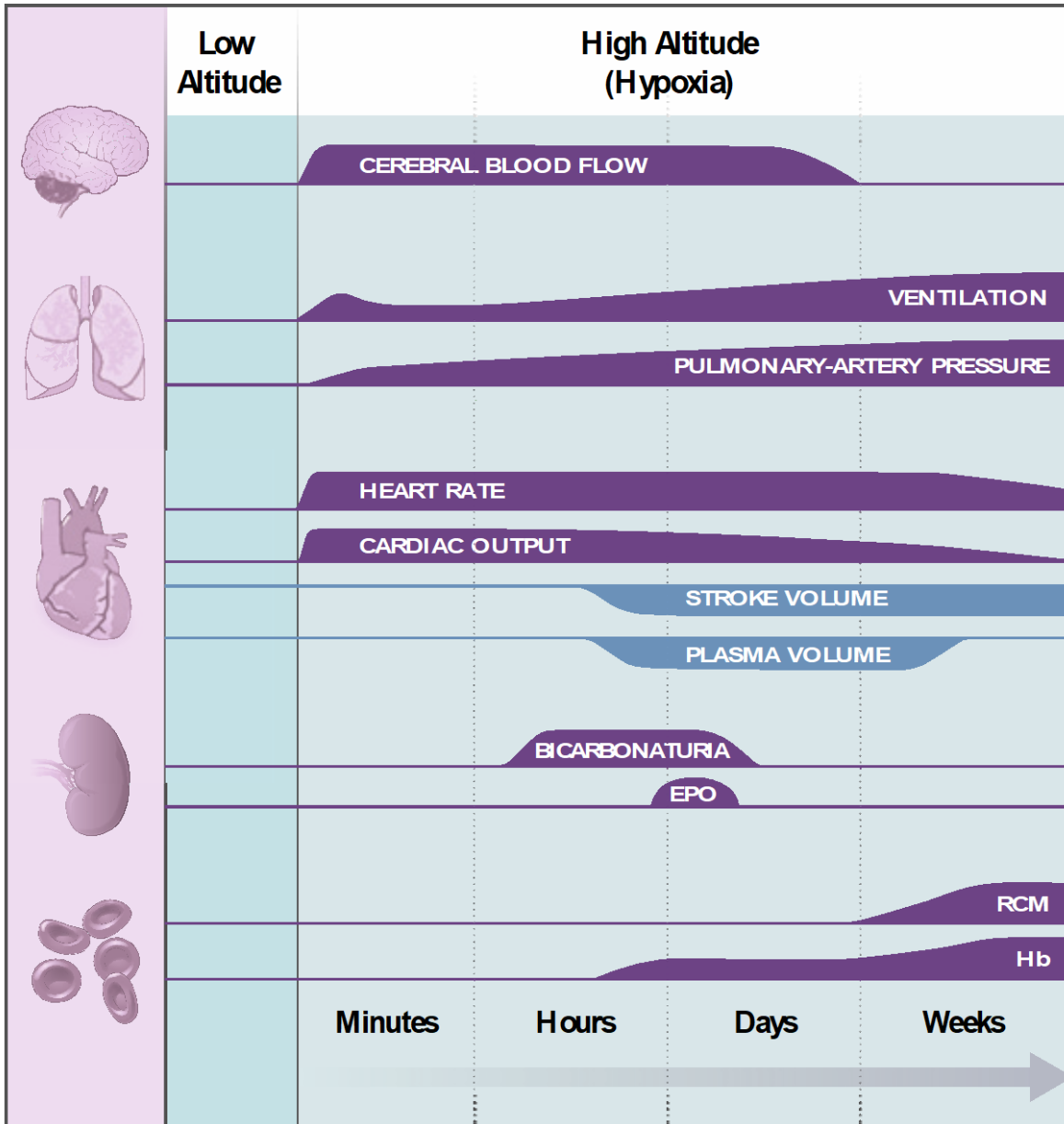
Cheyne-Stokesovo dýchání ve spánku

Pocit dušnosti

Podivné sny



Fyziologická reakce organismu na výšku:

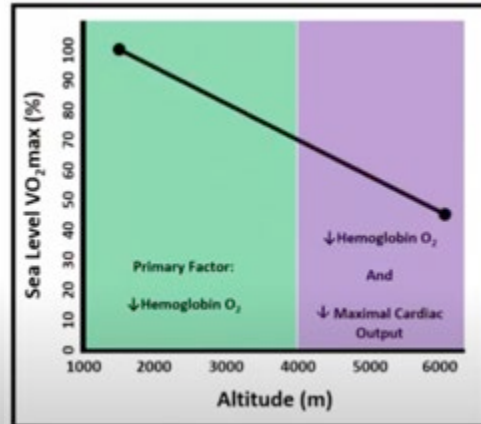
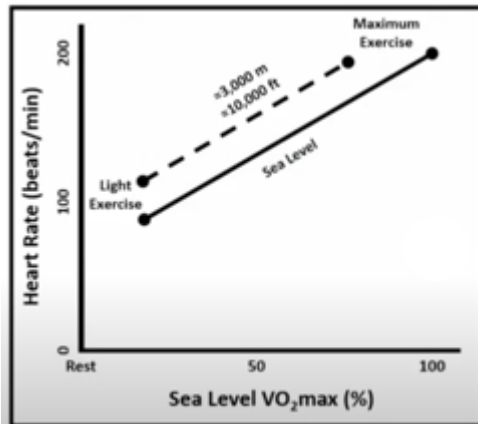


Fyziologická reakce organismu na výšku:

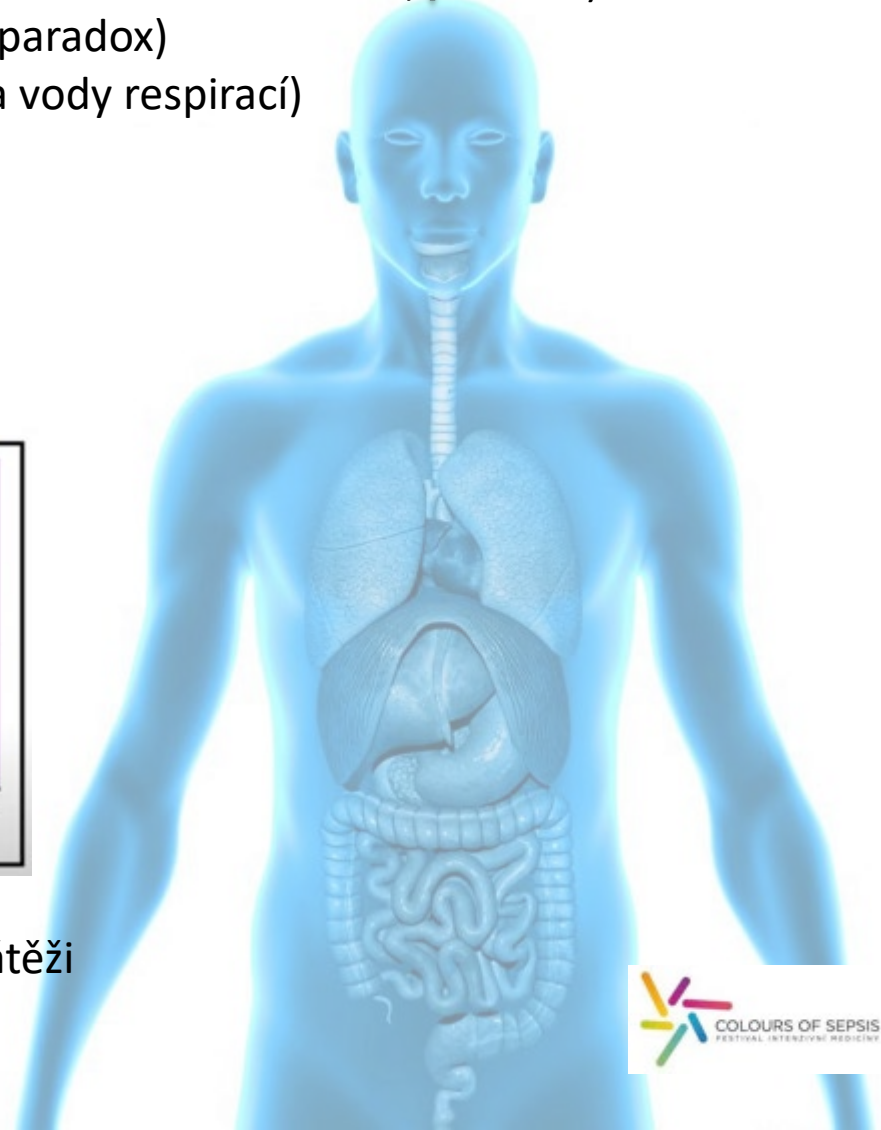
- Metabolický obrat, tyroxin, hladiny katecholaminů ↑
- Vyšší dependence na karbohydrátech (↑anaerobní metabolismus, ↑laktátu)
- (po několika týdnech aklimatizace: laktátový paradox)
- ↓ plazmatický objem (↑močový výdej, ↑ztráta vody respirací)
- Krátkodobý vzestup Hb
- Po týdnech pobytu: ↑ EPO, Hb, HCT)
- Ztráta svalové hmoty

Po 6-10 dnech:

- ↑ A-V O₂ difference

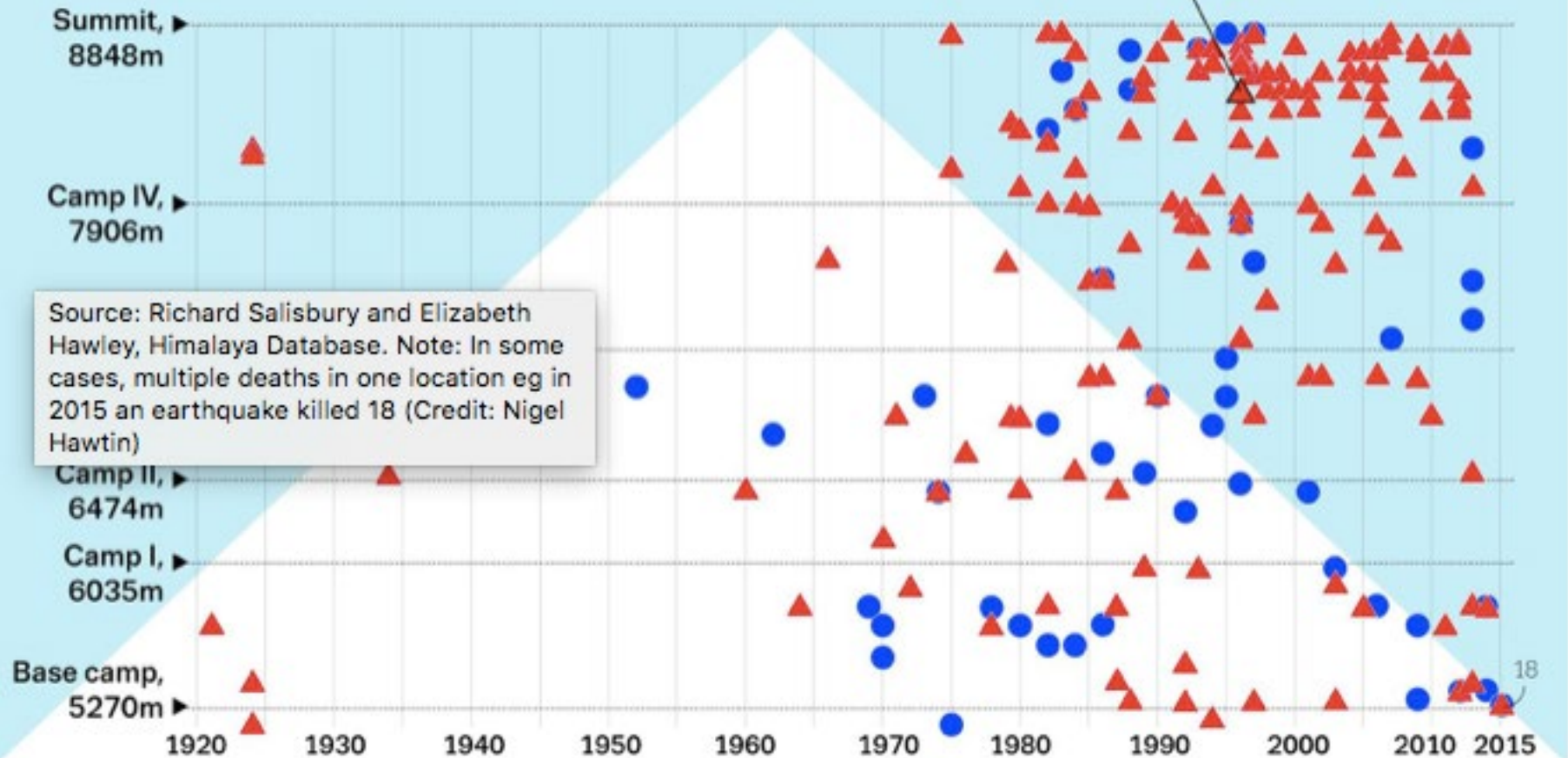


- Redukovaná výkonnost při sub i maximální zátěži
- ↓ Q_{max} = ↓ HR x ↓ SV



Deaths on Everest

Climbers ▲ Sherpas ●



Deaths on Everest

How did they happen?

Ascending in summit bid **20**

Descending from summit bid **90**

Expedition evacuation **11**

Route preparation **120**

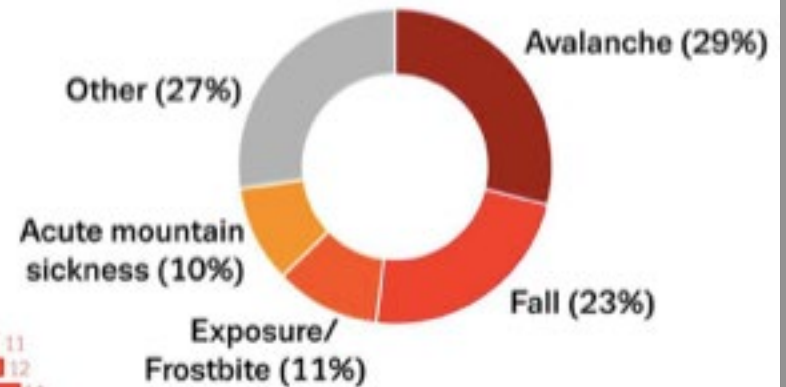
At Base Camp **36**

Enroute to Base Camp **6**

Where did they come from?



Most common causes of death?



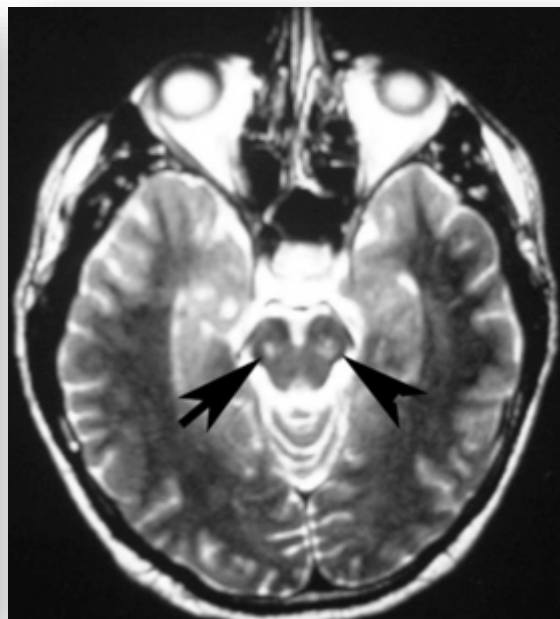
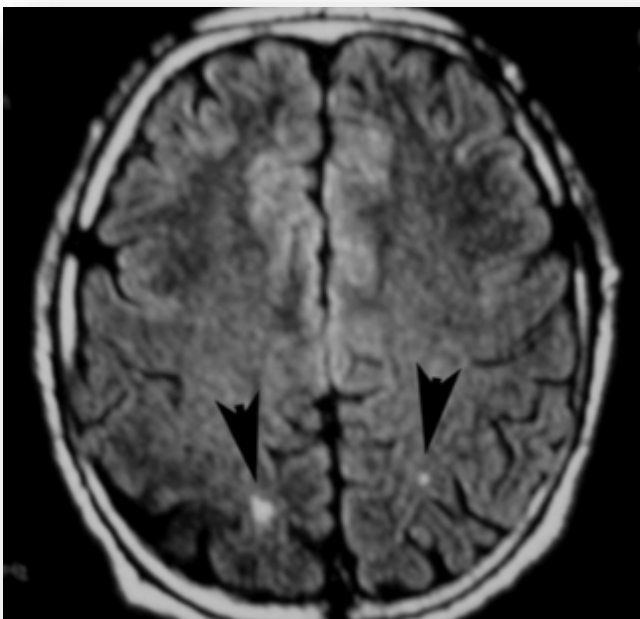
Evidence of Brain Damage after High-altitude Climbing by Means of Magnetic Resonance Imaging

Nicolás Fayed, MD,^a Pedro J. Modrego, MD,^b Humberto Morales, MD^a

Table The most common abnormalities found on brain MRI by expeditions

Type of abnormality	Number of climbers by every expedition and number of climbers showing abnormalities			
	Everest (n = 13)	Aconcagua (n = 8)	Mont Blanc (n = 7)	Kilimanjaro (n = 7)
Cortical atrophy	8	8	1	0
Enlargement of VRS	11	7	2	1
Subcortical lesions	1 (amateur)	4	1	0
Normality in the MRI scan	1	0	4	5

VRS = Virchow-Robin spaces.



Kontraindikace výstupu do vysokých výšek

The NEW ENGLAND JOURNAL of MEDICINE

REVIEW ARTICLE

C. Corey Hardin, M.D., Ph.D., *Editor*

Medical Conditions and High-Altitude Travel

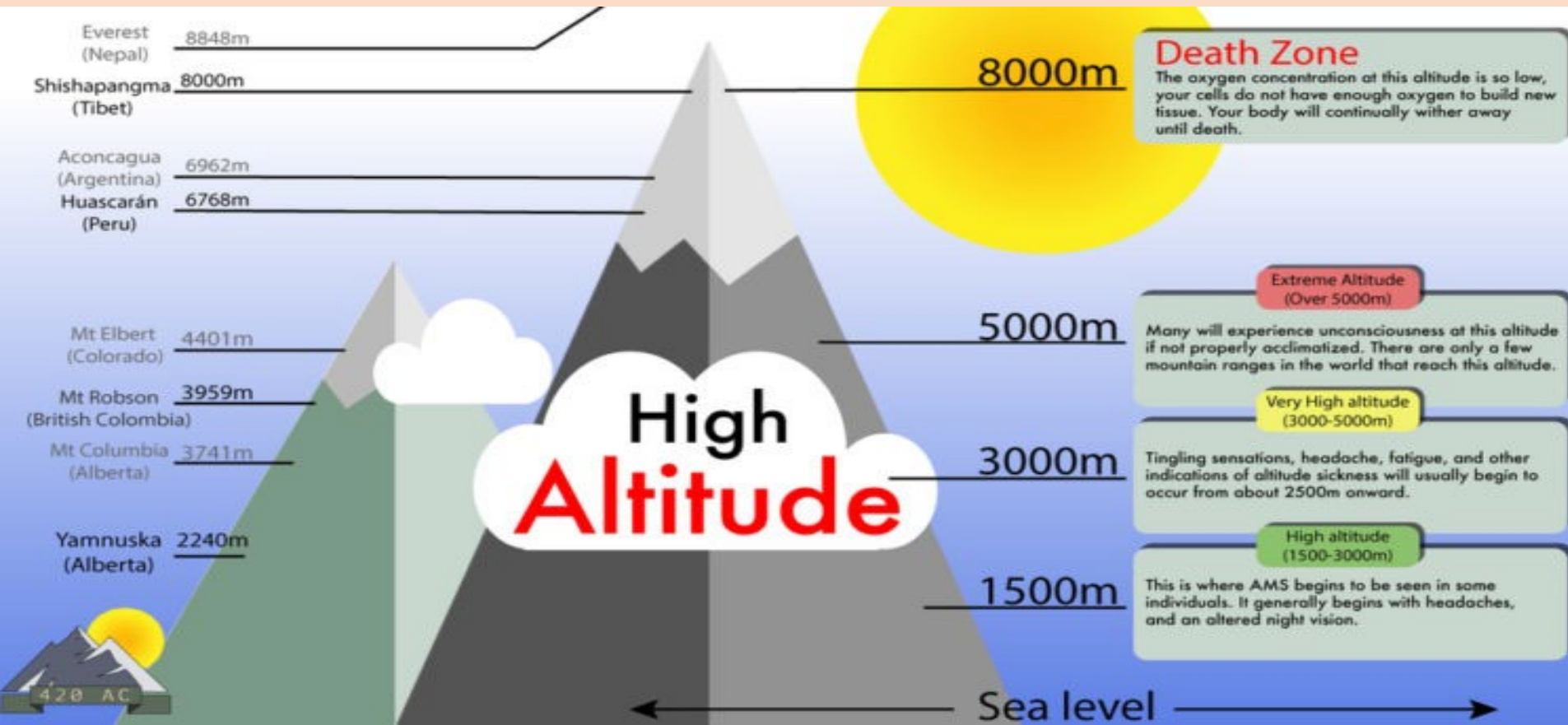
Andrew M. Luks, M.D., and Peter H. Hackett, M.D.



**Výšce nad 5300 m n.m. se nelze přizpůsobit,
lze ji jen krátce tolerovat.**

Tipy na aklimatizaci před/během výstupu

- Ascend gradually, if possible. Avoid going directly from low elevation to more than 9,000 ft (2,750 m) sleeping elevation in 1 day. Once above 9,000 ft (2,750 m), move sleeping elevation no higher than 1,600 ft (500 m) per day, and plan an extra day for acclimatization every 3,300 ft (1,000m).
- Consider using acetazolamide to speed acclimatization if abrupt ascent is unavoidable.
- Avoid alcohol for the first 48 hours; continue caffeine if a regular user.
- Participate in only mild exercise for the first 48 hours.
- Having a high-elevation exposure (greater than 9,000 ft [2,750 m]) for 2 nights or more, within 30 days before the trip, is useful, but closer to the trip departure is better.



Translační výzkum



Levett et al. *BMC Medical Research Methodology* 2010, **10**:98
<http://www.biomedcentral.com/1471-2288/10/98>

RESEARCH ARTICLE

Design and conduct of Caudwell Xtreme Everest: an observational cohort study of variation in human adaptation to progressive environmental hypoxia

FIFA

Estadio Daniel Alcides Carrión
(Cerro de Pasco, Perú)

4,380

Estadio Municipal de El Alto
(El Alto, Bolivia)

4,090

Estadio Victor Agustín Ugarte
(Potosí, Bolivia)

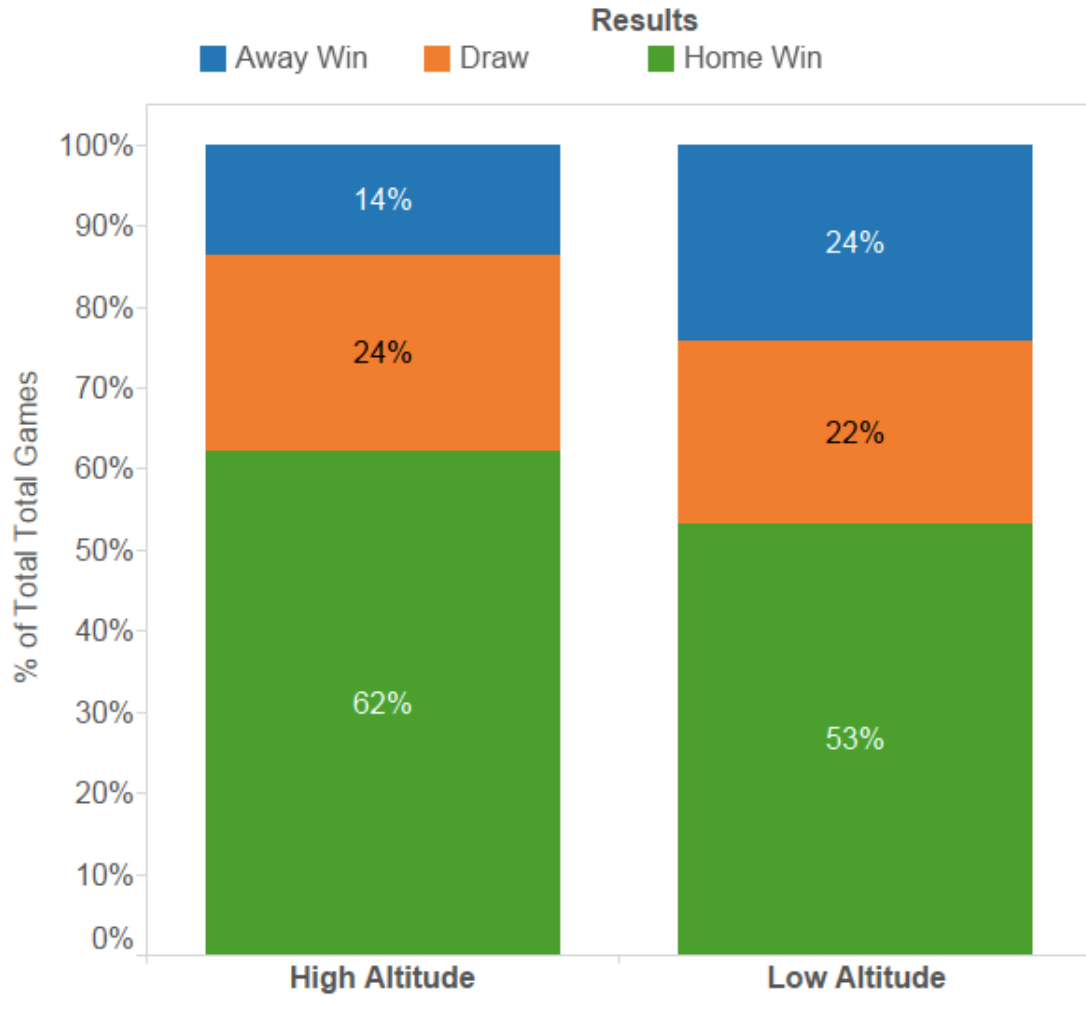
3,960

Estadio Hernando Siles
(La Paz, Bolivia)

3,637

Altitude in meters above sea level

Result Distribution Copa Libertadores - Plot 1



- Statisticky významná výhoda pro domácí týmy hrající ve vysoké nadmořské výšce
- Nepatrně vyšší šance na výhru pro tým mající stadion ve vyšší nadmořské výšce
- (platí i pro Champions League)

GAMBLING

★ LIVE ★



GROUP A

30 MINUTES +					CASH IN
★ LIVE AT 9:00 AM	9:00 AM	TEAM D - TEAM B	W 1:1	▲	
★ LIVE AT 9:00 AM	9:00 AM	TEAM W - TEAM C	L 1:2	▲	
★ LIVE AT 9:00 AM	9:00 AM	TEAM P - TEAM A	D 1:4	▲	
07:00	9:00 AM	TEAM D - TEAM B	W 1:1	▲	
07:00	11:45 AM	TEAM B - TEAM D	L 1:0	▼	
09:00	14:00 AM	TEAM W - TEAM C	L 1:2	▲	
09:00	14:00 AM	TEAM P - TEAM A	W 1:2	▲	
09:00	17:30 AM	TEAM D - TEAM B	L 1:2	▲	
09:00	20:00 AM	TEAM D - TEAM B	L 1:0	▲	
09:00	2:00 PM	TEAM W - TEAM C	L 1:1	▲	
09:00	2:30 PM	TEAM P - TEAM A	L 1:4	▲	
09:00	11:00 AM	TEAM D - TEAM B	W 1:1	▲	



GROUP B

30 MINUTES +					CASH IN
★ LIVE AT 9:00 AM	9:00 AM	TEAM D - TEAM B	W 1:1	▲	
★ LIVE AT 9:00 AM	9:00 AM	TEAM W - TEAM C	L 1:2	▲	
★ LIVE AT 9:00 AM	9:00 AM	TEAM P - TEAM A	D 1:4	▲	
★ LIVE AT 9:00 AM	9:00 AM	TEAM D - TEAM B	W 1:2	▲	
07:00	11:45 AM	TEAM D - TEAM B	L 1:0	▲	
09:00	14:00 AM	TEAM W - TEAM C	L 1:2	▲	
09:00	14:00 AM	TEAM P - TEAM A	W 1:1	▼	
09:00	17:30 AM	TEAM D - TEAM B	L 1:2	▲	
09:00	20:00 AM	TEAM D - TEAM B	L 1:0	▲	
09:00	2:00 PM	TEAM W - TEAM C	L 1:1	▲	
09:00	2:30 PM	TEAM P - TEAM A	L 1:4	▲	
09:00	11:00 AM	TEAM D - TEAM B	L 1:1	▲	



MISSION POSSIBLE



Děkuji za pozornost