Výšková nemoc
Jak se bojuje v řídkém vzduchu?

Jana Kubalová

ZZS Kraje Vysočina, Lékařská komise ČHS

Vojenská historie ve vysoké Asii I.

- Alexandr Veliký – chtěl posunout hranice říše „až tam, kde bohové určili hranice Země“… prošel přes pohoří Hindúkuš až do Indie, cca 330 př.n.l.
- 30 př. n. l.: klasická čínská historie Ch´ien Han Shu – zmínka o Great Headache Mountain a Little Headache Mountain (Karakoram?) „….mnoho mužů dostalo horečku, ztratili barvu, měli bolesti hlavy a zvraceli ….“
- 18 stol. – počátek 20. století „Great Game“ – soutěž Velké Británie a Ruska o vliv v JZ a V Asii, arénou pás 3000 km horského terénu s vrcholy nad 6000m a sedly nad 5000 m.n.m.

Vojenská historie ve vysoké Asii II.

- 1903-1904 – 2 dokumentované bitvy mezi VB a Tibetem v sedlech nad 5600m
- 1962 – válka Pákistán, Indie, Čína – pohoří Karákoram, vojenské oddíly vysazeny ve výškách nad 4000m, letní výbava, mortalita na nemoci z výšky > 20%
- 1978 – válka Sovětský Svaz – Afgánistán, „Horské válečné tréninkové centrum“
- 1985 – Kašmírský konflikt (Indie – Pákistán) – Siachenský ledovec, Karakoram, 3 indické oddíly nad hranicí 6647 m!!, 2000 † a 12 000 zraněných, > 90% výška + chlad
- 1999 Kargil konflikt (Indie – Pákistán), za 74 dní >1000 obětí na každé straně, oddíly z 0 m do 4500m za 2 dny!!

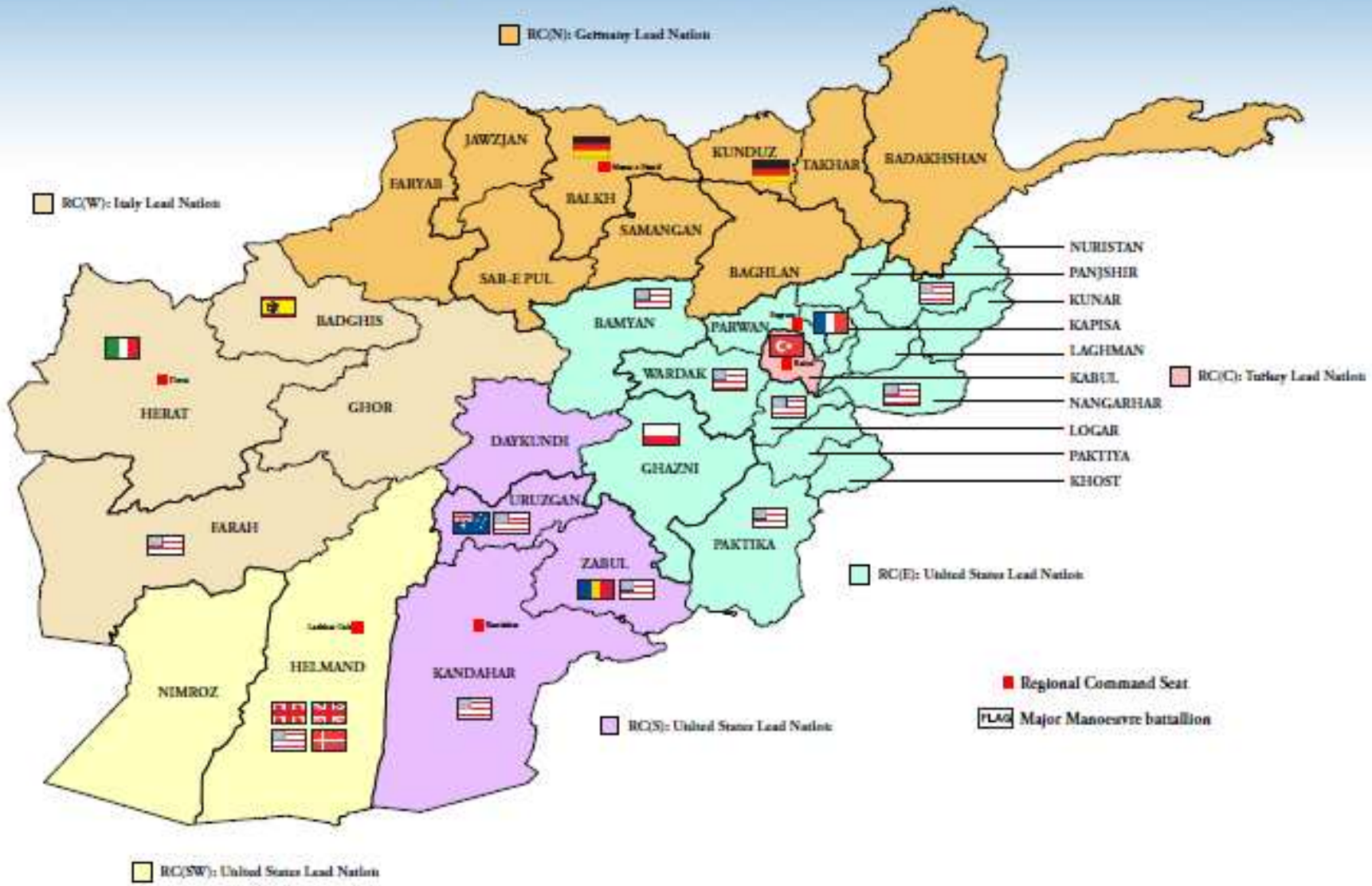
AFGHANISTAN
Admin. by
Claimed by
Aksai Chin China India
Shaksam Valley China India
Azad Kashmir Pakistan India
Northern Areas Pakistan India
Siachen Glacier India Pakistan
Jammu & Kashmir India –
KARAKORAM RANGE
Shaksam Valley
K2
Gilgit
Northern Areas
Siachen Glacier
Karakoram Pass
Aksai Chin
Chorbat La
Kargil
Muzaffarabad
Srinagar
Leh
LADAKH RANGE
Azad Kashmir
Jammu and Kashmir
CHINA (TIBET)
Jammu
PAKISTAN
Demchok
INDIA
N
Kashmir
(Not to scale)
36 N
34 N
32 N
74 E
76 E
78 E

Úloha ČR v Afgánistánu

- Český provinční rekonstrukční tým AČR - mise NATO ISAF 3/2008, provicie Lógar
- Jednotka poradního a výcvikového týmu (Operational Mentoring and Liaison Team) – 4 - 10/2012, provincie Wardak
- Vojenská policie ČR, ISAF, 4 – 9/2012, provincie Wardak
- Jednotky Úkolového uskupení AČR ISAF, od od 6/2010, organizačně zastřešuje všechny jednotky a prvky AČR, podpora všech jednotek na území Afgánistánu
- Zdroj: http://www.mise.army.cz/aktualni-mise/default.htm

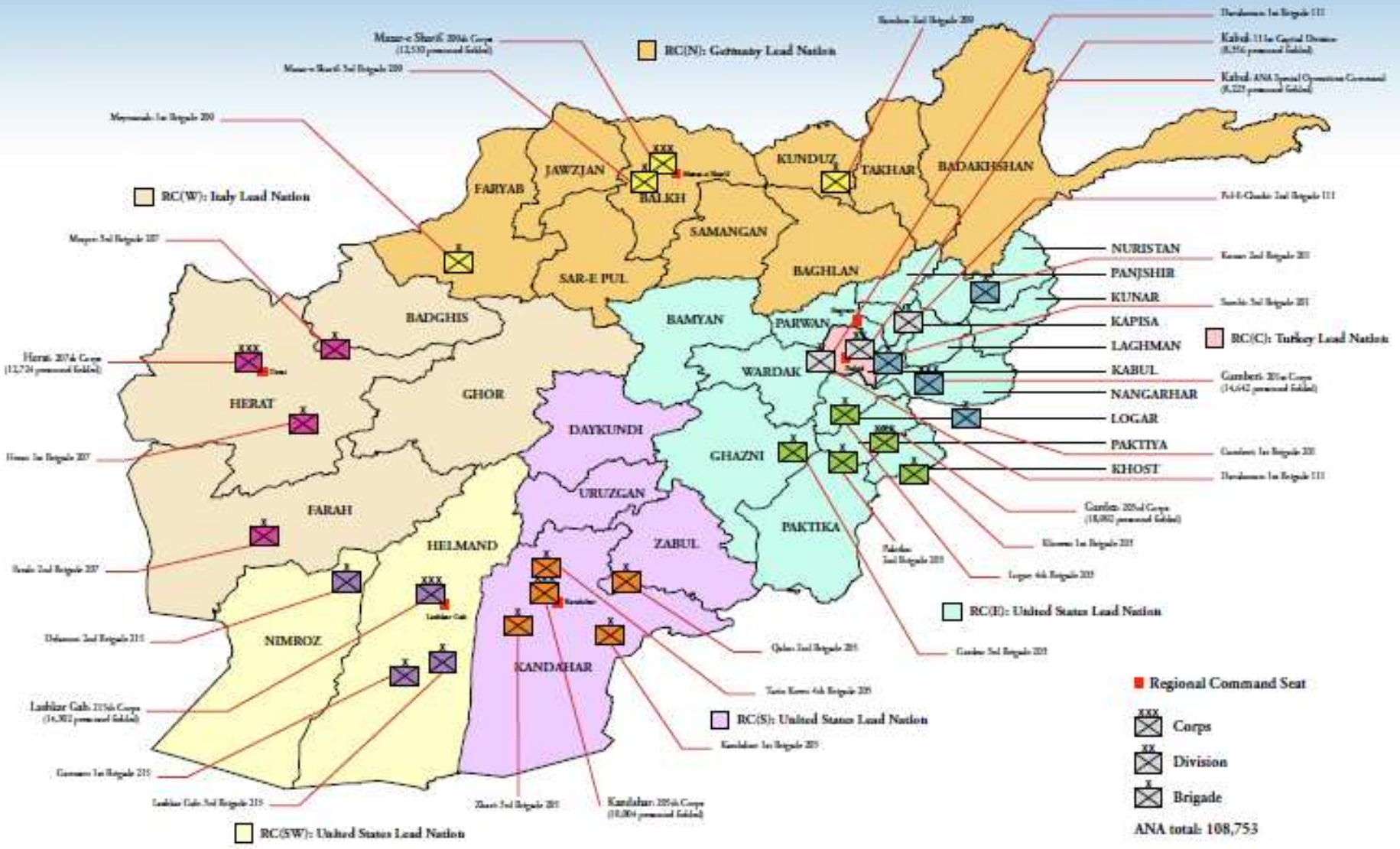
International Security Assistance Force

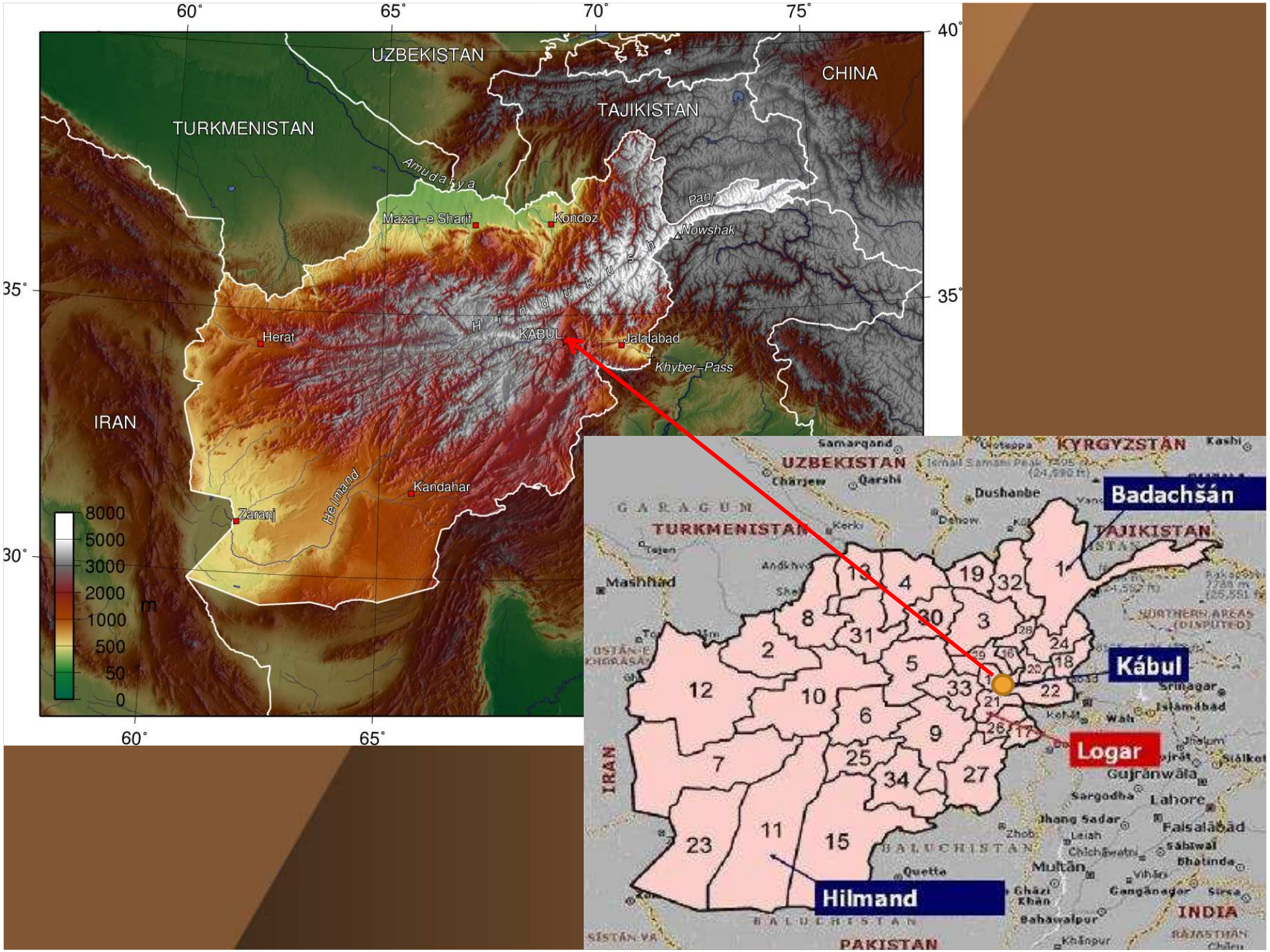
Regional Commands & Major Units (>700 troops)



International Security Assistance Force

Afghan National Army (ANA) - Deployment




60°
65°
70°
75°
40°
35°
30°
UZBEKISTAN
CHINA
TAJIKISTAN
TURKMENISTAN
IRAN
Amudarya
Panj
Mazar-e Sharif
Kondoz
Nowshak
Hindukush
Herat
KABUL
Jalalabad
Khyber-Pass
Kandahar
Helmand
Zaranj
8000
5000
3000
2000
1000
500
50
0
m
KYRGYZSTAN
Samarqand
Dushanbe
Mashhad
Badachšán
Kábul
Logar
Hilmand
INDIA
PAKISTAN
Lahore
Faisalābād
Multān
Quetta
Gujranwāla
Sargodha
Islāmābād
Srīnagar
Bahawalpur
Gangānagar
Sirsa
Bhatinda
Sāhiwāl
Jhang Sadar
Ghāzi Khān
Khānpur
Chārjew
Qarshi
Kerki
Tejen
Andkhvoy
Dehow
Kashi
Jhelum
Sialkot
Wah
Kohat
Zhob
Leiah
Chichāwatni
Vihāri
Sibi
Kalat
Khuzdar
Panjgur
Turbat
Gwadar
Pasni
Jiwani
Kandahar
Herat
Mashhad
Tehran
Esfahan
Yazd
Kerman
Zahedan
Bandar Abbas
Chabahar
Zaranj
Farah
Lashkar Gah
Ghazni
Gardez
Khost
Jalalabad
Kabul
Mazar-e Sharif
Kondoz
Faizabad
Pul-e Khumri
Ashkasham
Sheberghan
Maymana
Qala-i Naw
Chaghcharan
Asadabad
Sarobi
Ghorband
Bamyan
Shibirghan
Aybak
Taloqan
Khanabad
Kunduz
Sar-e Pol
Ghowrmach
Ghowr
Dowlatyar
Sangin
Musa Qala
Nawa
Garmsir
Khakrez
Qalat
Shinkai

Provincie Lógar

- V a J část: 1800 – 4000m (nejvyšší vrchol 4754m)
- Z část: 1900m, v okolí horský terén 2000 – 3500m

Konflikt v Afgánistánu

- 2001 USA a NATO v Afgánistánu:
  - ✓Operace Mountain Storm: 2500m, Korengal Valley: 2560m, operation Buzzard: 2700m,Takur Ghar: 3191m, Operation Warrior Sweep: 3260m, Operation Snipe: 3962m, Tora Bora: 4382m
  - ✓Operace Anakonda: 14,6% těžká AHN
- „armáda neefektivní“, „neschopnost pronásledovat nepřítele“, „přerušené mise z důvodu výškové nemoci“, „nad 8000 – 9000ft (2400 – 2750m) všichni vojáci kompletně vyčerpaní během několika hodin“….

USARIEM. *American Institute of Biological Sciences Review: Mountain Medicine Research Program*. Natick, MA: United States Army Research Institute of Environmental Medicine, Thermal & Mountain Medicine Division; 2009.

Nadmořská výška

- Složení vzduchu je konstantní do výšky 10 km - troposféra (O2 21%..)

  (normální tlak při hladině moře 101,325 kPa – 760 mmHg)
- Klesá barometrický tlak – vzduch „řídne“ zhoršuje se dostupnost pro organismus = HYPOBARICKÁ HYPOXIE
- Důsledek nepřizpůsobení organismu nadmořské výšce = výšková nemoc
- Akutní (vznik po několika hodinách až dnech), subakutní (po cca 10 týdnech), chronická (vznik po několika měsících pobytu)

Aklimatizace

proces přizpůsobování nižšímu tlaku O2 a překonávání změn, které vyvolá nadmořská výška

- od 2500 m. n. m.
- nad 5300 – 5500m se nelze přizpůsobit, lze po určitou dobu tolerovat
- po úspěšné aklimatizaci na dosaženou výšku je nutné se nově dosažené výšce znovu přizpůsobit
- doba potřebná na aklimatizaci je individuálně odlišná a závislá na nadmořské výšce

Faktory ovlivňující aklimatizaci

- Rychlost výstupu
- Dosažená absolutní výška
- Překonaný relativní výškový rozdíl
- Zdravotní stav jedince
- Genetické predispozice
- Nezáleží na zdatnosti jedince! (VO2max)

Kompenzační mechanismy

- Plíce: hlavní úloha v časné i pozdní odpovědi na HA

↑ min□tové ventilace

- další orgány: srdce, ledviny, krev

↑min□tového srdečního objem□

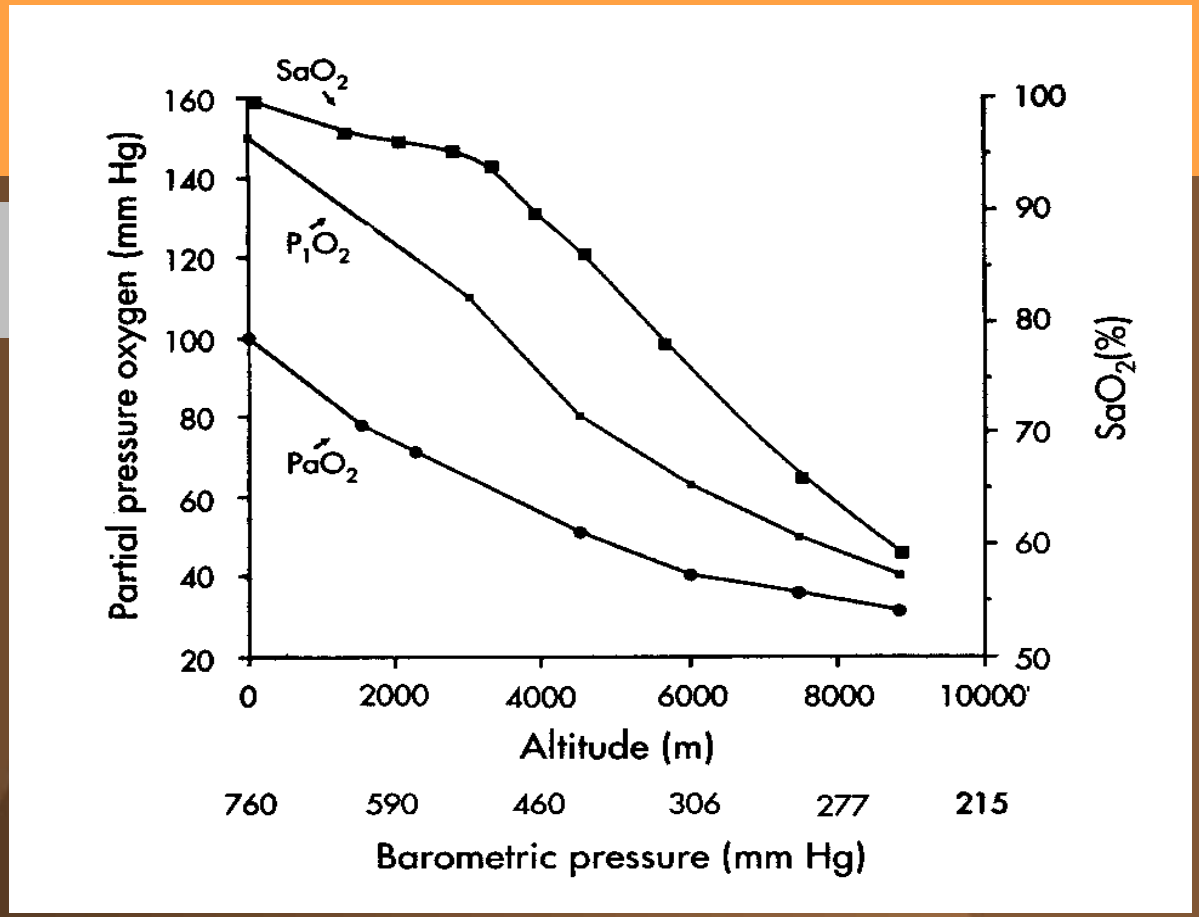
↑počt□ Ery (↑sekrece erytropoetin□)

↑mitochondrií, myoglobin□, cytochromoxidázy

	0 m n.m.	8850 m n.m.
dech	12/min.	35/min.
tep	70/min.	180/min.
Hb	140 g/l	200 g/l
Pa O_2	13 kPa	3 kPa
Sp O_2	100 %	40 %

Fyziologie

Rotman, I.: Aklimatizace v horách, Alpy 1997



- Snížená fyzická výkonnost a zvýšení ventilace již od 1500m

LaRavia, D., Lahasky, R., Pittman-Colley, L., Finayagan, V.: A case review of cerebral edema, high altitude illnes, U.S. Army Med. Dep. Yournal, Jan./Mar. 2000, p 42-45

Fyziologické změny

- Před aklimatizací
- Zvýšení srdeční frekvence
- Nadměrné rychlé dýchání
- Pocit nedostatku vzduchu (dušnost) při námaze, mizí při odpočinku
- ↑močení
- Změna rytmu dýchání v noci - periodické dýchání
- Časté probouzení, zvláštní sny

- Po aklimatizaci
- Zpomalení srdeční frekvence (ráno po probuzení)
- Přetrvává nadměrné dýchání během odpočinku i práce
- Není dušnost!
- Zvýšená diuréza
- Přetrvává periodické dýchání

Zvláštnosti vysokohorského prostředí

↑ intenzita záření
↑ proudění (vítr)
↑ náročnost terénu

↓ tlak vzduchu
↓ teplota vzduchu
↓ vlhkost vzduchu

An avalanche buried at least 100 Pakistani soldiers near the Siachen glacier on the border with India.—AP Photo

ISLAMABAD: An avalanche smashed into a Pakistan army camp Saturday burying at least 100 soldiers in a remote area billed as the world's highest battleground, with no sign of survivors over 12 hours later.

http://dawn.com/2012/04/07/avalanche-traps-about-150-pakistani-soldiers-media/

http://www.pakimag.com/misc/siachen-glacier-ispr-list-of-army-officers-and-soldiers-in-detail.html

Altitude Illness = výšková nemoc

- Akutní horská nemoc – Acute Mountain Sickness (AMS) – mild, moderate, severe
- Výškový otok mozku – High Altitude Cerebral Edema (HACE)
- Výškový otok plic – High Altitude Pulmonary Edema (HAPE)
- Výškový otok plic a mozku - HAPE + HACE
- Subakutní horská nemoc – minim. 10 týdnů, hypoxická plicní vazokonstrikce
- Chronická horská nemoc – minim. 1 rok

AMS – Acute mountain sickness

- 22 – 53% cestovatelů ve výškách od 1850 do 4210 m /civilní data - cestovatelé/
- Vojenská data /osoby bez aklimatizace/:
  - Nad 3000m …25 – 35%
  - Nad 3500m …50 – 60%
  - Nad 4000m …80 - 90%
  - Nad 4500m …90 – 100%
- Mild, moderate, severe ≈ HACE
- Typicky nad 2500m, počátek za 6 – 10 hodin po výstupu
- Příznaky: Lake Louise AMS Scoring system

Zdroj: Dr. Stephen Muza, USARIEM

Lake Louise Scoring System

- AMS = nadmořská výška nad 2500m + bolest hlavy + minim. jeden další příznak, minim. skóre = 3

- 1. bolest hlavy (0 není, 1 lehká, 2 střední, 3 těžká, zneschopňující)
- 2. GIT symptomy (0 nejsou, 1 nechuť k jídlu nebo nausea, 2 nausea nebo zvracení, 3 těžká nauzea a zvracení)
- 3. Únava a vyčerpání (0 ….3)
- 4. Závrať (0 …3)
- 5. Špatné spaní (0 spí jako obvykle, 1 spí hůř než obvykle, 2 často vzhůru, špatná noc, 3 neschopen usnout)

Proč jsou vojáci ohroženi častěji?

- Velmi rychlý výstup /vrtulník, auto/
- Okamžitá intenzívní fyzická námaha + hmotnost výbavy
- Výborná fyzická kondice v nížinách, ale její výrazný pokles ve vyšších nadmořských výškách
- Pocházejí z nížin

Proč jsou bojovníci Talibanu tak úspěšní?

- Adaptace genomu
- Výborná znalost a přizpůsobivost prostředí
- Malé skupiny v horách flexibilnější
- Smělost

- Navzdory:
- Horší organizace
- Horší vybavení

Nemoci způsobené nadmořskou výškou – AI

Dg.:	Poznámky	Příznaky:
AMS	Nadmořská výška > 2500m (vyjímečně i méně) **Bolest hlavy + minim. 1 následující příznak** ***Viz LLSS***	• GIT potíže – nauzea, zvracení, ztráta chuti k jídlu • Únava, vyčerpání • Závrať • Nespavost
HACE	Většinou příznaky AMS + bolest hlavy nereagující na běžná analgetika, typicky nad 4000m	• Poruchy rovnováhy • Dezorientace, zmatenost • Změna chování a myšlení
HAPE	Obvykle nad 3000m, 2 – 5. den výstupu, často i bez předchozích symptomů AMS a HACE Min. 2 příznaky (A) + 2 příznaky (B)	**A:** • Snížená fyzická výkonnost • Dušnost v klidu • Kašel (suchý ➔ růžové zpěněné sputum) • Tlak na hrudi **B:** • Chrůpky nebo pískoty • Cyanóza (rty …obličej, končetiny) • Zrychlený puls 110/min • Zrychlené dýchání > 20/min • Horečka max. 38° C

Léčba výškové nemoci

- Při příznacích nikdy nepokračovat ve výstupu
- Těžké formy AI: SESTUP nebo EVAKUACE do nižších nadmořských výšek!!!
- Bolest hlavy: ibuprofen, paracetamol

  + minimální námaha

  + dostatek tekutin (symptomy dehydratace ~ symptomy AMS)

  + dostatečná výživa

  + tepelný komfort

ACCP (American Collegue of Chest Physicians) classification

Stupeň	Doporučení	Výhody vs. riziko	Metodologické kvality studií podporující důkazy
1A	silné doporučení, důkazy vysoké kvality	výhody jednoznačně převažují nad riziky	randomizované kontrolní studie jsou bez omezení, existují zdrcující důkazy z výzkumu o efektu léku nebo metody
1B	jednoznačné doporučení, důkazy střední kvality	výhody jednoznačně převažují nad riziky	randomizované kontrolní studie mají určitá omezení, existují mimořádně silné důkazy z výzkumu
1C	jednoznačné doporučení, důkazy nízké nebo velmi nízké kvality	výhody jednoznačně převažují nad riziky	existují důkazy z výzkumu a nebo případové studie podporující podání léku
2A	slabé nebo nedostatečné doporučení, existuje pro to evidence vysoké kvality	efekt úzce balancuje mezi výhodami a riziky při podání	randomizované kontrolní studie jsou bez omezení, existují zdrcující důkazy z výzkumu o efektu léku nebo metody
2B	slabé nebo nedostatečné doporučení, evidence střední kvality	efekt úzce balancuje mezi výhodami a riziky při podání	randomizované kontrolní studie mají určitá omezení, existují mimořádně silné důkazy z výzkumu
2C	slabé nebo nedostatečné doporučení, evidence nízké kvality	nejistota při hodnocení rizik a efektu, efekt úzce balancuje mezi výhodami a riziky při podání	výzkumné studie nebo případové studie

Přehled účinnosti nejčastěji používaných léků a metod k prevenci a léčbě AI na základě ACCP cl.

Lék	AMS + HACE		HAPE		HACE + HAPE
	prevence	léčba	prevence	léčba	léčba
Postupný výstup	1B	--------	1C	---------	----------
Sestup	---------	1A	---------	1A	ANO
O2	---------	1C	---------	1B	ANO
Přetlaková komora	---------	1B	---------	1B	ANO, není-li možný sestup z jakéhokoliv důvodu (1B)
Acetazolamid	1A	1B	2C	?	?
Dexamethazon	1A	1B	1C	---------	ANO, když se neurol. příznaky neupraví po podání O2 a norm. SpO2
Nifedipin	---------	---------	1A	1C	ANO, pozor na pokles systémového TK
Tadalafil (Cyalis, Viagra)	---------	---------	1C	2C	ANO, jen není-li nifedipin
Salmeterol	---------	---------	2B	2C	----------

Přenosná přetlaková komora

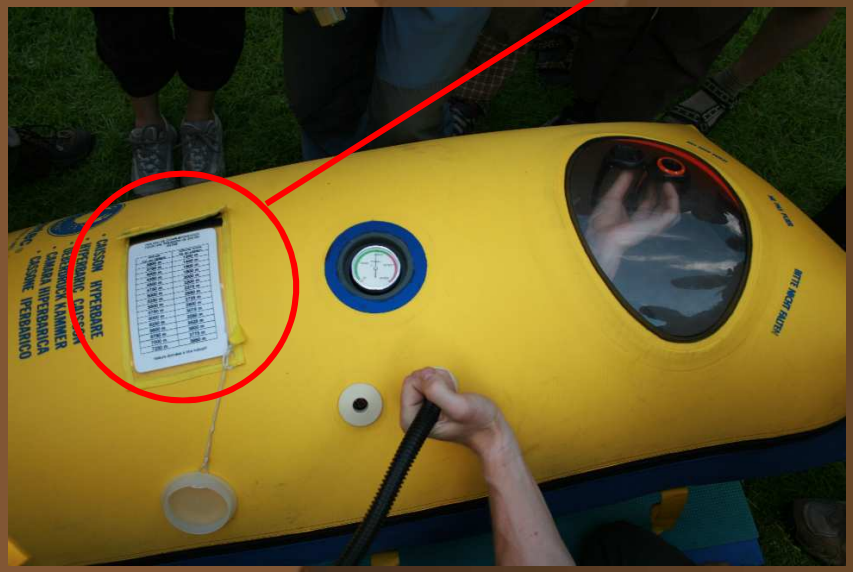


TABLEAU DE CORRESPONDANCE
POUR UNE PRESSION DE 220 MB
ENTRE

Altitude Ext. au caisson	Altitude fictive Int. au caisson
3500 m	1200 m
3750 m	1400 m
4000 m	1600 m
4250 m	1800 m
4500 m	2000 m
4750 m	2200 m
5000 m	2375 m
5250 m	2550 m
5500 m	2725 m
5750 m	2900 m
6000 m	3075 m
6250 m	3250 m
6500 m	3425 m
6750 m	3600 m
7000 m	3775 m
7250 m	3950 m

Valeurs données à titre indicatif

USARIEM – US Army Institute of Enviromental Medicine

- Založen v roce 1961 /studium vlivu tepla, chladu, tréninku, hydratace, výživy, nadmořské výšky atd. na zdraví a bojeschopnost/, Natick, Masachusetts
- 2001 – výšková fyziologická laboratoř , 4302m Pike´s Peak, Colorado

USARIEM – výzkum

U.S. DEPARTMENT OF DEFENSE

http://www.defense.gov/news/newsarticle.aspx?id=51197

USARIEM – cíle

- Vyvinout strategii pro rychlou aklimatizaci
- Vyvinout strategii pro zabránění degradace
- Vyvinout doporučení pro výživu
- Vyvinout všeobecné doporučení pro armádu a jejich velitele
- Doporučení pro léčbu a prevence medikamenty

USARIEM – strategie pro aklimatizaci

- Postupný výstup, fázování:

1. Vystupovat tak , aby byl indukována aklimatizace, ale nevyvinula se výšková nemoc
2. Neaklimatizovaní nevystupovat > 2400m
3. 4 – 6 dní od 2000 – 2400m
4. 7 – 14 dní od 1400 – 2000m
5. Postupný výstup nad 2400m max. 300m/den, je-li výstup vyšší + rest day na každé znovu dosažené výšce

Strategie pro aklimatizaci – alternativy

- preaklimatizace: intermitentní hypoxická expozice /IHE/
- Nadmořská výška je simulována nižším PiO2, v normobarickém prostředí, 25 publikovaných studií
- Optimální strategie:
  1. Simulovaná nadmořská výška ≥ 4000m
  2. Délka expozice: minim. 1,5 hodiny denně
  3. Doba preaklimatizace: minim. 1 týden

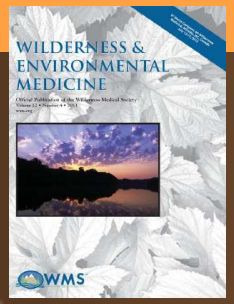
= slibný přístup pro vojáky z níže položených základen, před vypuštěním do horských regionů

Muza SR.: Military application of hypoxic training for high-altitude operations, Med.Sci Sport Exerc., 2007 Sep.; 39(9):1625-31

Strategie pro aklimatizaci – doplňky

- Dieta bohatá na uhlohydráty
- Nižší příjem, vyšší výdej, nárůst bazálního metabolismu
- Používat během prolongovaných, náročných úkolů

Medikamenty, doporučení pro praxi



Wilderness Medical Society Consensus Guidelines for the Prevention and Treatment of Acute Altitude Illness

Luks, McIntosh, Grissom, Auerbach, Rodway, Schoene, Zafren, Hackett

Wilderness and Enviromental Medicine, 21, 146-155 (2010)

Prevence AMS, HACE:

- Acetazolamid: 125 - 250mg á 12 hodin, začít podávat 1 den před, funguje však i v den výstupu, ukončení: po 2 – 3 dnech pobytu ve stejné výšce, nebo po ukončení výstupu a zahájení sestupu
- Dexametazon: 4 mg á 6 hodin, max. podávání 10 dní!! – suprese nadledvin, začít podávat v den výstupu, ukončení: viz acetazolamid

Prevence HAPE: Nifedipin: SR 60mg/den, začít podávat léky 1 den před výstupem, po celou dobu výstupu, ukončit při sestupu nebo za 5 dní strávených ve stejné výšce

Risk management recommendation at preventing altitude casualties

- Velitel má odpovědnost za bojovou jednotku, odpovědnost za management prevence a léčby AI

1. Identifikace a zhodnocení rizik /rychlý výstup, nedostatečná aklimatizace, dehydratace, vyčerpání../
2. Posouzení rizik v dané oblasti a v dané jednotce a situaci
3. Vzdělávání /příznaky, léčba, rizika, trénink, komunikace, nezatajovat potíže../
4. Supervize – poučení řadových vojáků, neustálé zhodnocování rizik a reakce na ně

USARIEM – doporučení

GTA 08-05-060

A SOLDIER'S GUIDE TO STAYING HEALTHY AT HIGH ELEVATIONS

This health threat and countermeasure information is from the most current data available from U.S. Department of Defense medical agencies at the time of production. Please note that:

- Health threats may change as a result of weather conditions, natural disaster, war, or disease outbreak.
- Health threats can become widespread with movement of displaced people and animals.
- Soldiers may be exposed to diseases common to other countries and regions when working with multinational forces.

OVERVIEW

High mountain environments are inherently dangerous. They can be unforgiving for those without adequate knowledge, training, and equipment. Commanders, medical support personnel, and soldiers must understand that the interaction of environmental conditions with mission responsibilities and individual and unit characteristics can significantly impact on the outcome of the mission. Adequate planning and preparedness can reduce or prevent adverse impacts.

The ideal condition for soldiers operating in high mountain terrain is to be in a high degree of acclimatization, since this achieves maximum physical and mental performance and minimizes the incidence of altitude illness. However, operational scenarios often limit the time needed to achieve acclimatization. All soldiers should be aware of the threats associated with operations in high altitudes and use personal protective measures in order to minimize disease and non-battle injuries, which in turn results in accomplishment of the operational mission.

DISTRIBUTION: UNLIMITED

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U.S. Army Center for Health Promotion & Preventive Medicine
Aberdeen Proving Ground, Maryland

In Coordination With:
U.S. Army Research Institute of Environmental Medicine
Natick, Massachusetts

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ensuring soldiers do not: sleep in vehicles with engines running, or cook inside tents or sleep inside tents with working combustion heaters or stoves without adequate ventilation.

Non-Battle Injuries. Hypoxia and cold can impair judgment and physical performance resulting in a greater risk of injury while maneuvering in rugged terrain. Heavy clothing worn for protection against the cold and specialized equipment can also restrict movement. Non-battle injuries can be prevented by carefully observing safety procedures.

Infectious Diseases. Although there is generally a reduced threat of disease at higher elevations, soldiers should still take precautions to avoid diseases caused by insects, plants, and animals, and diseases transmitted person to person.

At moderate to high altitudes, insect-borne disease (from mosquitoes, ticks and flies) is common in most regions. In some areas, malaria-bearing mosquitoes range as high as 6,000 ft. The threat of diseases transmitted from person to person is increased at higher, cold climates since soldiers are more likely to gather together to keep warm.

HIGH MOUNTAIN OPERATIONS

Reduced Physical Performance. Hypobaric hypoxia causes a reduction in physical performance of soldiers deployed to high altitudes. Soldiers cannot maintain the same physical performance at high altitude that they can at low altitude, regardless of their fitness level.

Countermeasures to prevent disease and injury include ensuring acclimatization; adjusting work rates and load carriage; planning frequent rests during work and exercise; and planning and performing physical training programs to altitude.

Psychological Effects. Altitude exposure may result in changes in senses (vision, taste, etc.), mood, and personality. These effects are directly related to altitude and are common at over 10,000 ft. Some effects occur early and are temporary while others may persist after acclimatization or even for a period of time after descent.

Vision is generally the sense most affected by altitude exposure. Dark adaptation is significantly reduced, affecting soldiers as low as 8,000 ft and can potentially affect military operations at high altitude.

Mental effects most noticeable at very high and extreme altitudes include decreased perception, memory, judgment, and attention. To compensate for loss of functional ability, soldiers should devise a strategy of a tradeoff between speed and accuracy – allow for extra time to accomplish a task to minimize errors (and injuries).

Alterations in mood and personality traits are common during high-altitude exposures.

* Within hours of ascent, many soldiers may experience euphoria (joy, excitement) that is likely to be accompanied by errors in judgment leading to mistakes and accidents. Use of the buddy system during this early exposure time helps to identify soldiers who may be more severely affected.

* After a period of about 6-12 hours, euphoria decreases, often changing to varying degrees of depression. Soldiers may become irritable, or may appear listless.

Instilling a high morale and esprit de corps before deployment and reinforcing these frequently during deployment will help minimize the impact of negative mood changes.

Sleep Disturbances. High altitude has significant harmful effects on sleep. The most prominent effects are frequent periods of apnea and fragmented sleep. Sleep disturbances may last for weeks at elevations less than 18,000 ft and may never stop at higher elevations.

Reports of "not being able to sleep" and "awake half the night" are common and may also contribute to mood changes and daytime drowsiness. These effects have been reported at elevations as low as 5,000 feet and are very common at higher altitudes.

Acetazolamide has been found to improve sleep quality at high altitudes and reduce AMS and other altitude illnesses, an added benefit. Sleeping pills and other medications that promote sleep or drowsiness should be taken only with medical supervision.

Dehydration is a very common condition in soldiers at high altitude. Causes include perspiration/sweating, vomiting, and hypoxia-induced diminishing of thirst sensation. Routine activities and chores performed at high altitudes require increased exertion. Even common activities, like walking, cause increased exertion, resulting in increased perspiration and contributing to hot or cold weather injuries.

Dehydration increases the likelihood of operationally significant problems including cold injuries and decreased physical abilities. Note: Many symptoms of dehydration and HACE are similar.

Soldiers can prevent dehydration by consuming 3 to 4 quarts of water or other non-caffeinated fluids (or more) per day. Thirst is not an adequate warning of dehydration. Commanders must monitor soldiers to ensure they drink enough fluids and do not become dehydrated as a result of diminished judgment or the desire to avoid latrines.

Nutrition. Poor nutrition contributes to illness or injury, decreased performance, poor morale, and susceptibility to cold injuries and can severely impact military operations. Influences at high elevations that impact nutrition include a dulled taste sensation (making food undesirable), nausea, or lack of energy or motivation to prepare or eat meals. Poor eating habits may also lead to constipation or aggravation of hemorrhoids.

Soldiers can reduce the effects of poor nutrition at high elevations by increasing the quantity of and eating all components of meals. Rations should be supplemented and frequent snacking encouraged. High carbohydrate snacks are recommended since they are easily carried by soldiers and require no preparation.

Other products that can seriously impact military operations include tobacco, alcoholic beverages, and caffeine.

Tobacco smoke interferes with oxygen delivery by reducing blood oxygen-carrying capacity; tobacco smoke in close, confined spaces increases the amounts of CO, and the irritant effect of tobacco smoke may produce a narrowing of airways interfering with optimal air movement. Smoking can effectively raise the "physiological altitude" as much as several thousand feet.

Alcohol impairs judgment and perception, depresses respiration, causes dehydration, and increases susceptibility to cold injury.

Caffeine from coffee and other sources may improve physical and mental performance; however, it also causes increased urination (leading to dehydration) and therefore should be consumed in moderation.

GTA 08-05-060

A SOLDIER'S GUIDE TO STAYING HEALTHY AT HIGH ELEVATIONS

This health threat and countermeasure information is from the most current data available from U.S. Department of Defense medical agencies at the time of production. Please note that:

- Health threats may change as a result of weather conditions, natural disaster, war, or disease outbreak.
- Health threats can become widespread with movement of displaced people and animals.
- Soldiers may be exposed to diseases common to other countries and regions when working with multinational forces.

OVERVIEW

High mountain environments are inherently dangerous. They can be unforgiving for those without adequate knowledge, training, and equipment. Commanders, medical support personnel, and soldiers must understand that the interaction of environmental conditions with mission responsibilities and individual and unit characteristics can significantly impact on the outcome of the mission. Adequate planning and preparedness can reduce or prevent adverse impacts.

The ideal condition for soldiers operating in high mountain terrain is to be in a high degree of acclimatization, since this achieves maximum physical and mental performance and minimizes the incidence of altitude illness. However, operational scenarios often limit the time needed to achieve acclimatization. All soldiers should be aware of the threats associated with operations in high altitudes and use personal protective measures in order to minimize disease and non-battle injuries, which in turn results in accomplishment of the operational mission.

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	short periods of time

Medical Terms

AMS	Acute mountain sickness
Apnea	Temporary pause of breathing
Edema	A local or general condition in which the body tissues contain an excessive amount of tissue fluid
HACE	High altitude cerebral edema (brain edema)
HAPE	High altitude pulmonary edema (lung edema)
Hypobaric hypoxia	Decreased availability of oxygen in ambient (surrounding) air
Hypoxia	Low oxygen content; decreased concentration of oxygen in inhaled air

THE HUMAN BODY'S RESPONSE TO HIGH ALTITUDE

Hypobaric hypoxia lowers the oxygen supply to the body, which in turn causes altitude illnesses and reduced physical and mental performance. Hypobaric hypoxia may also increase the likelihood of other environmental injuries (e.g., cold) or worsen preexisting medical conditions.

Altitude acclimatization allows soldiers to achieve the maximum physical work performance possible for the altitude to which they are acclimatized. Once acquired, acclimatization is maintained as long as the soldier remains at altitude, but is lost upon return to lower elevations. Exposure to higher altitudes requires further acclimatization.

For most soldiers at high to very high altitudes, 70-80% of respiratory component of acclimatization occurs in 7-10 days; 80-90% of overall acclimatization is generally accomplished by 21-30 days. Maximum acclimatization may take months to years. Note: There does not seem to be any way to speed acclimatization; some soldiers acclimatize more rapidly than others, and few soldiers may not acclimatize at all. There is no reliable way to identify soldiers who cannot acclimatize except by their experience during previous altitude exposures.

ACCLIMATIZATION

Staged Ascent: Requires soldiers to ascend (rise) to a moderate altitude and remain there for 3 days or more to acclimatize before ascending higher. When possible, soldiers should make several stops for staging during the ascent to allow a greater degree of acclimatization.

Graded Ascent: Limits the daily altitude gain to allow partial acclimatization. The altitude at which soldiers sleep is the critical element in this regard. Having soldiers spend two nights at 9,000 ft and limit the sleeping altitude to no more than 1,000 ft per day above

headache, nausea, vomiting, fatigue, irritability, and dizziness, and appear 3 to 24 hours after ascent. Everyone is susceptible.

Staging, graded ascent, or movement to a lower altitude can prevent AMS. Consuming carbohydrates can reduce AMS symptoms (whole grains, vegetables, peas and beans, potatoes, fruits, honey, and refined sugar).

In situations where there is insufficient time for staged or graded ascent, soldiers may have to use medications to prevent AMS. Acetazolamide, the preferred medication for preventing AMS, will prevent symptoms in nearly all soldiers and reduce symptoms in most others. Use of any medication, including acetazolamide, should be discussed with physicians trained in high-altitude/wilderness medicine.

AMS symptoms will normally subside in 3-7 days if soldiers do not continue to ascend. Once symptoms are resolved, soldiers can resume gradual ascent. Soldiers who continue to show signs of AMS must be observed for development of HAPE or HACE, both of which are potentially fatal.

High Altitude Pulmonary Edema (HAPE) occurs when unacclimatized individuals rapidly ascend to high altitudes or when acclimatized soldiers ascend rapidly from a high to a higher altitude. Untreated, HAPE can be rapidly fatal and is the most common cause of death among the altitude illnesses. Soldiers experiencing AMS who are not treated and continue to ascend to higher altitudes are at significant risk for HAPE.

HAPE usually begins within the first two to four days after rapid ascent to altitudes greater than 8,000 ft and generally appears during the second night of sleep at high altitude. Symptoms include coughing, noisy breathing, wheezing, gurgling in the airway, difficulty breathing, and deteriorated mental status (confusion, vivid hallucinations). Ultimately coma and death will occur without treatment.

Countermeasures for HAPE include: proper acclimatization; sleeping at the lowest altitude possible; avoiding cold exposures; and avoiding strenuous exertion until acclimatized. Immediate descent is recommended as the best treatment for HAPE. Soldiers with AMS should be monitored carefully since AMS can rapidly evolve to HAPE.

High Altitude Cerebral Edema (HACE) is the most severe illness associated with high altitudes. Individuals with HACE are frequently found to also have HAPE. As with other high altitude illnesses, HACE is caused by rapid ascent to high elevations without proper acclimatization. Soldiers with AMS who continue ascent are considered to be at high risk for development of HACE.

HACE generally occurs later than AMS or HAPE. Untreated, HACE can progress to death over 1 to 3 days and, in some instances, in less than 12 hours. Symptoms often resemble AMS (severe headache, nausea, vomiting); however, a more dramatic signal that HACE may be developing is a swaying upper body, especially when walking. Early mental changes may include confusion, disorientation, and drowsiness.

ear to be withdrawn or demonstrate behavior
ted with fatigue or anxiety.

for HACE include: following countermeasures for
acclimatization, etc.) and immediate evacuation
ers with HACE symptoms. Again, soldiers with AMS
e monitored carefully for signs of HACE.

**stances should soldiers with severe AMS symp-
ed HAPE or HACE be allowed to continue ascent.**

ain Sickness occurs in some soldiers during
ments (weeks/months) to elevations above 12,000 ft.
sleep disturbance, loss of appetite, weight loss, and
fatigue. This condition reflects a failure to acclimatize adequately.

Poor wound healing may occur at higher elevations resulting from lowered immune functions. Injuries resulting from burns, cuts, or other injuries may require descent for effective treatment and healing.

ENVIRONMENTAL THREATS

Conditions that are not unique to high mountain environments but commonly occur at high elevations include:

Cold Injuries. Once a soldier has acclimatized to altitude, cold injuries are generally the greatest threat. Frequent winds in mountain areas cause extremely low wind-chill. Because hypoxia-induced psychological effects can result in poor judgment and decision-making, a higher incidence of cold injuries should be anticipated.

Countermeasures for cold injuries include command emphasis in maintaining nutrition; drinking plenty of fluids; and dressing in layers.

Injuries Caused by Sunlight. The potential for solar radiation injuries, caused by sunlight, is significant at high altitudes due to increased ultraviolet (UV) radiation (resulting from thinner atmosphere), and reflection of light from snow and rock surfaces. Solar radiation injuries can be severe and occur with much shorter exposure at high altitude. Injuries include sunburn and snow blindness.

Sunburn may be more likely to occur on partly cloudy or overcast days when soldiers may not be aware of the threat and do not take appropriate precautions. Some medications can also increase the threat of injury, including Acetazolamide. Application of sun block (at least 15 SPF) to exposed skin, face, and neck will help prevent instances of sunburn.

Snow blindness results from UV light absorption by the external parts of the eyes, such as the eyelids and cornea. There is no sensation, other than brightness, as a warning that eye damage is occurring with resulting sunburn-like damage occurring in a few hours. Sunglasses or goggles with UV protection will prevent snow blindness. Sunglasses with side protectors are recommended.

Terrain Injuries. Soldiers should be aware of the dangers of high altitude including avalanches and falls. Poor judgment at high altitude increases the risk of injury. The potential for being struck by lightning is also increased at higher altitudes, especially at areas above tree lines. Protective measures include taking shelter in solid-roofed structures or vehicles, staying low, and avoiding tall structures or large metal objects.

Carbon Monoxide (CO) Poisoning is a frequent hazard and is caused by the inefficient fuel combustion resulting from the low oxygen content of air and higher usage of stoves, combustion heaters, and engines in enclosed, poorly ventilated spaces. Cigarette smoking is another source of CO. Countermeasures to prevent CO poisoning include

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U.S. ARMY GUIDE TO STAYING HEALTHY

construct windscreens to reduce heat loss; watch for shivering

HOT AND COLD WEATHER INJURIES CAN KILL!
Seek immediate medical attention for:

- Heat injury (heat cramps, exhaustion, or stroke)
- Cold injury (loss of sensitivity in any body part)

All Environmental/Climate Conditions: The following measures are recommended for any environment:

- Wear uniforms properly and use unscented sun block (SPF 15 or higher), sunglasses, lip balm, and skin moisturizer
- Follow work/rest guidance (see back panel) for water consumption (urine color should be light with no strong odor)
- Avoid over-the-counter medications, alcohol, tobacco, and caffeinated beverages since any of these can cause or increase the effects of dehydration or solar radiation (sunburn) injury
- Use the buddy system – personnel who have had previous heat/cold injuries are especially susceptible to new or more serious injuries
- Be prepared for temperature changes at night; do not rest or sleep in tents or vehicles unless well ventilated to avoid potentially fatal carbon monoxide poisoning

High Altitude: During operations at elevations over 8,000 feet:

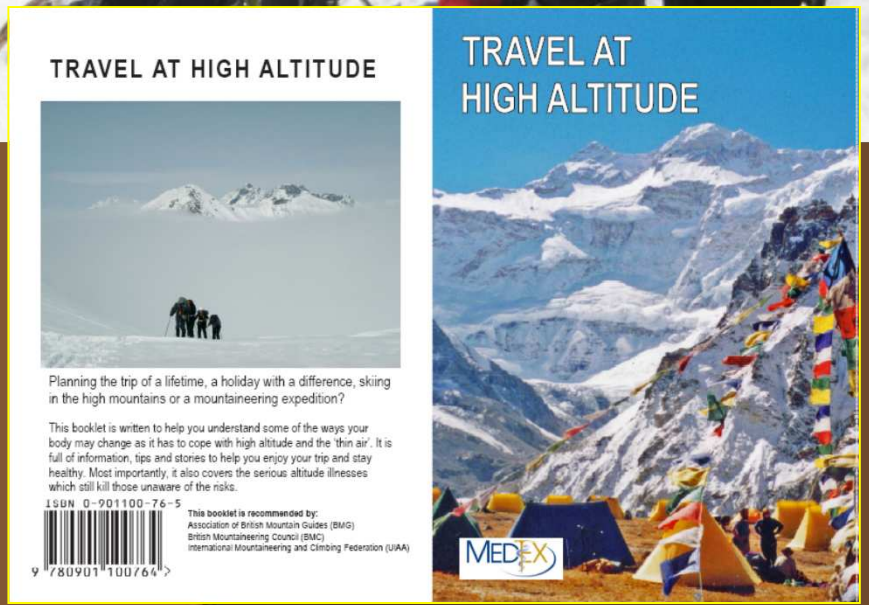
- Personnel must adapt to higher elevations by ascending (climbing upwards) slowly to avoid serious illness or death – which can occur quickly if suddenly exposed to high altitudes
- Staged or graded ascent improves personal performance and reduces DNBI while adapting to higher elevations; personnel can maintain acclimatization only by remaining at altitude (acclimatization is lost after returning to lower elevations)
- Personnel with altitude sickness who continue to ascend are at risk for more serious illness or death, and must get immediate medical treatment and/or move to a lower altitude
- Prepare for other DNBI threats, including:
  - ✓ Environmental conditions, including greater threat of cold weather injury due to wind chill from mountain winds: solar radiation injuries (sunburn, snow blindness) from increased sunlight and reflection from snow and rock surfaces
  - ✓ Accidents resulting from: reduced physical capability and dehydration; increased effort needed to perform duties; physical and psychological effects of altitude sickness
  - ✓ Terrain injuries (falls, avalanches, lightning)
  - ✓ Carbon monoxide poisoning from lower oxygen content of air and use of stoves/heaters in poorly ventilated space

NUTRITION GUIDELINES DURING DEPLOYMENT

- Food and water play a major role in sustaining your health, performance and morale. To maximize physical performance and aid your body's ability to heat/cool, you must consume adequate amounts of food and fluids each day
- Energy needs typically increase in the field environment due to higher physical demands. To ensure optimum physical and mission performance, you should consume enough food to relieve hunger and avoid weight loss (maintain your weight; do not avoid food or attempt weight loss during field operations)
- Energy needs can vary based on individual body size, weight, walking/working surface, and level of fitness. Climate can also affect energy requirements, for example:
  - ✓ Work in cold weather can increase energy needs by 10-25%
  - ✓ Operations in high-altitude areas can increase energy needs by 50% or more

A SOLDIER'S GUIDE TO STAYING HEALTHY IN AFGHANISTAN AND PAKISTAN

This country-specific guide should be used in conjunction with GTA 08-05-062, *Guide to Staying Healthy*, and is intended to provide information that can help reduce your risk of Disease and Non-battle Injuries (DNBI) when deployed. This health threat and countermeasure information is based on the most current data available from U.S. Department of Defense medical agencies at the time of production. In addition to the information in this guide, you should also receive force health protection, health threat, and preventive medicine countermeasures training/briefings prior to and, as required, throughout the length of your deployment.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This booklet is written to help you understand some of the ways your body may change as it has to cope with high altitude and the 'thin air'. It is full of information, tips and stories to help you enjoy your trip and stay healthy. Most importantly, it also covers the serious altitude illnesses which still kill those unaware of the risks.
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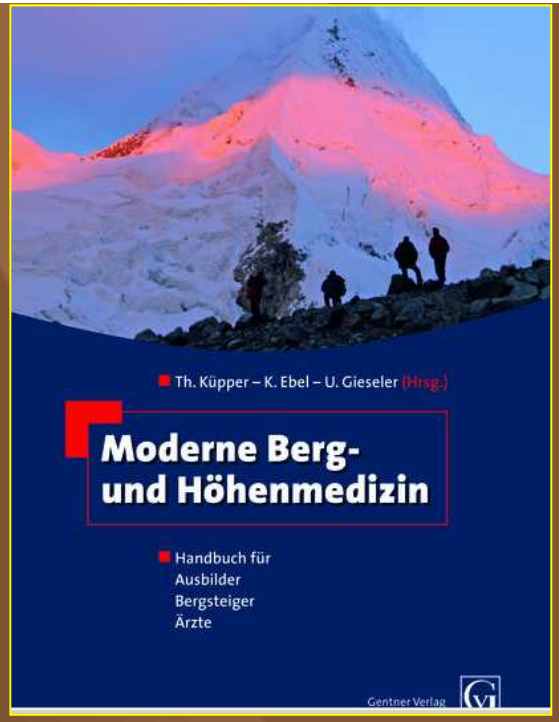
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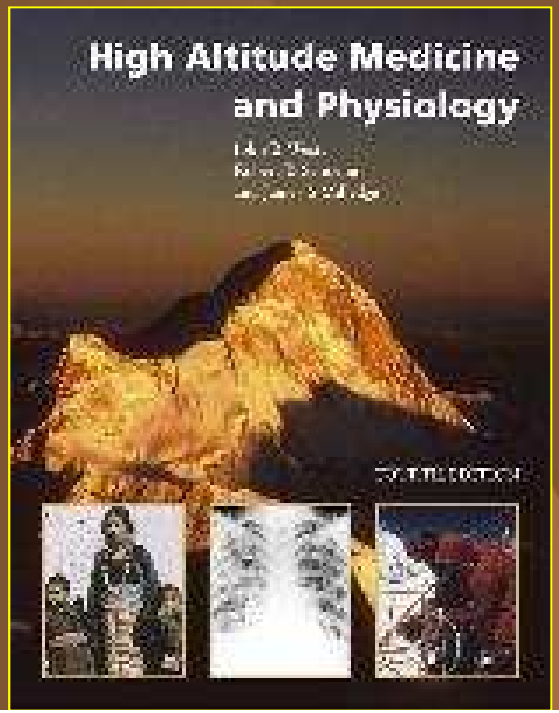
High Altitude Medicine and Physiology

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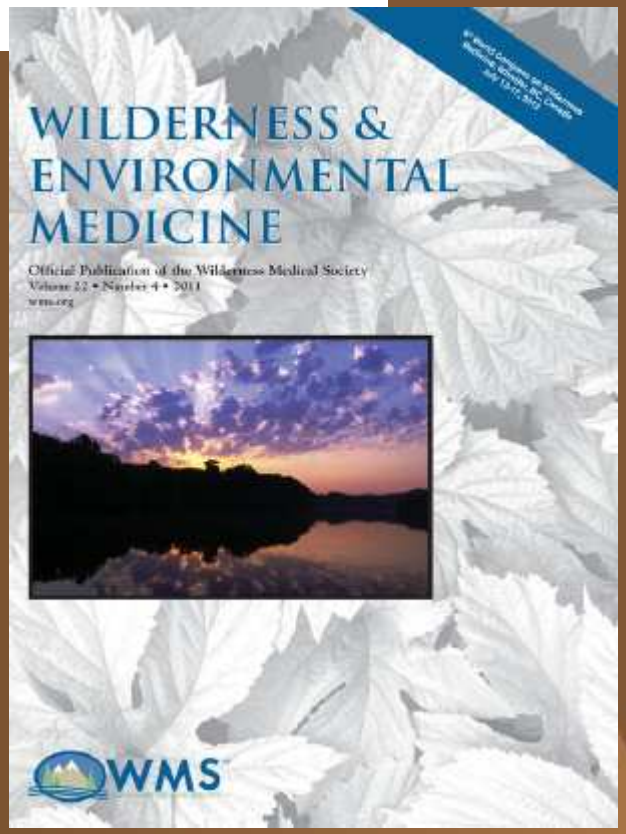
OPERATIONAL AND TACTICAL MEDICINE

Fighting in Thin Air: Operational Wilderness Medicine in High Asia

George W. Rodway, PhD, APRN; Stephen R. Muza, PhD

From the University of Utah College of Nursing and School of Medicine, Salt Lake City, UT (Dr Rodway); Thermal and Mountain Medicine Division, United States Army Research Institute of Environmental Medicine, Natick, MA (Dr Muza).



- „Je ironické, že navzdory sofistikovaným zbraním, oblečení a stravě, navzdory podpoře vzdušných sil a transportních prostředků, opakovaně selhává poučení se z minulosti ze základních lekcí válčení v horách, což vede ke vzniku zbytečných obětí a také často k porážce.“

Houston CS. Selected military operations in mountain environments: Some medical aspects. In: Pandolf KB, Burr RE, eds. *Medical Aspects of Harsh Environments.* Washington, DC: Office of the Surgeon General, Department of the Army, USA; 2002, pp.621–645.

Děkuji za pozornost

Dotazy?