Medicina Sportiva
Med Sport 15 (3): 163-187, 2011
DOI: 10.2478/v10036-011-0026-9

5TH SYMPOSIUM
HIGH ALTITUDE PHYSIOLOGY

UNDER THE PATRONAGE OF THE GERMAN SOCIETY FOR TRAVEL, MIGRATION AND TOURISM MEDICINE (DGRMT E.V.)

2nd – 4th September, 2011 at the Trainings Centre of the German Federal Police, Kührointalm in the Königssee National Park, Watzmann region near Berchtesgaden

NEOCYTOLYSIS OF RED BLOOD CELLS FOLLOWING HIGH ALTITUDE EXPOSURE

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Of the several cells and tissue types sensitive to hypoxia, red cells and the erythropoietic system have been one of the most extensively studied for years both in man and other mammals.

The discovery of erythropoietin (EPO) and of its key role in erythropoiesis allowed a comprehension of the erythropoietic response to hypoxia in molecular terms. Furthermore, studies on the activation of EPO gene paved the way for the identification of the oxygen sensing HIF (Hypoxia Transcription Factor) pathway, a molecular machinery that senses and controls a wide range of tissue specific and systemic responses to hypoxia (Semenza GL, Curr. Opin. Genet. Dev. (1998), 8, 588; Kaelin WG, Proline hydroxylation and gene expression. Ann. Rev. Biochem. (2005), 74, 115). Recent genomic analysis of the Tibetan highlander population, that has been living at high altitude since more than 10000 years, has revealed a positive selection has favored variants of HIF 2 alpha associated with reduced blood concentration of hemoglobin and reduced haematocrit (Simonson TS et al., Science (2010), 329, 72; Yi X et al, Science (2010), 329, 75). This is associated with the haematological profile of Tibetan highlanders which is similar to the one typical of lowlanders. On the basis of these data, it has been suggested that the HIF-mediated increase of erythropoiesis is a misdirect response to hypobaric hypoxia that originally evolved as a response to anemia (Storz JF, Science (2010), 329, 40).

In keeping with this conclusion is the process occurring upon transition of lowlanders from hypoxia to normoxia (for instance, mountain climbers returning to sea level after high altitude acclimatization), which consists of a decrease of EPO plasma level and a fast reduction of erythrocyte mass through neocytolysis, i.e. lysis of young erythrocytes.

Neocytolysis has been observed in healthy subjects after return from high altitude to sea level. (Rice L et al, Ann. Intern. Med. (2001), 134, 652; Risso A et al., Blood Cells, Mol. Dis. 2007, 38, 83) and has been shown to occur also in astronauts. (In fact in microgravity, a central blood poling occurs, associated to plasma release into tissues. The consequent increased diuresis and decreased plasma volume cause haematocrit augementation, leading to EPO decrease and neocytolysis, so that red cells mass is reduced in a few days (Alfrey CP et al., J. Appl. Physiol.(1996), 81, 98; Risso A et al., J.Gravit. Physiol, (2008), 15, 61).

Neocytolysis is involved also in anemias associated to reduced production of EPO, for instance in renal diseases (Rice L et al., Am. J. Kidney Dis. (1999), 33, 59). It may be caused also by artificially induced EPO fluctuations, in cases of blood doping.

In subjects exposed to conditions triggering neocytolysis, beside the dramatic reduction of young red cells counts, changes in neocytes membrane components have been observed, and that contributes to a “senescent-like” phenotype and likely

targets them to macrophage phagocytosis. The mechanism(s) leading to these membrane changes are not known, nor it is known if, and how, they could be related to decreases in the level of EPO, or other factors, in plasma. Evidence from the literature seems to support both views. After hypoxia exposure, neocytolysis could eliminate those red cells, that, after a maturation from erythroid precursors under low oxygen partial pressure condition, could have phenotypic and functional properties not appropriate to a normoxic environment. Indeed a different composition in membrane lipids (González G et al., High Alt. Med. Biol. (2005), 6, 320), a higher concentration of intracellular ATP (Risso A et al., Blood Cells, Mol. Dis. 2007, 38, 83), and a partial fragmentation of actin (Risso A et al, Acta Haematol. (2010), 123, 6), have been observed in a fraction of red cells populations from mountain climbers after high altitude acclimatization and return to sea level.

EARLY OXYGEN DESATURATION IS RELATED TO AMS DEVELOPMENT DURING ACUTE EXPOSURE TO HIGH ALTITUDE

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Objective: The role of arterial oxygen saturation (SpO2) in predicting acute mountain sickness (AMS) has been suggested by few studies in the last years.

Methods: SpO2 and heart rate were monitored in 44 subjects (8 females) during the ascent from Alagna Valsesia (1154 m A.M.S.L.; 3786 ft) to the Capanna Regina Margherita (4559 m A.M.S.L.; 14 957 ft); the first 2000 m (6560 ft) were ascent within 45 minutes by cable car, the remaining were walked. All the subjects spent a night at 3647 m (11 965 ft). The Lake Louise acute mountain sickness symptom score questionnaire was filled in five different moments of the ascent.

Results: The AMS prevalence increased with altitude, and reached the top value on the morning of the second day (15 out of 44, 34%). The mean oxygen saturation decreased with the increase of altitude. The SpO2 recorded at the arrival at high altitude was predictive for AMS development three to six hours later: AMS+ 84.04%, AMS- 86.77% *P*=0.049). The mean SpO2 recorded at Rifugio Gnifetti at rest before the night was predictive of AMS onset, too: AMS+ 84.04%, AMS- 86.15% (*P*<0.01). The mean SpO2 during the night was not different between the two groups. Periodic breathing during sleep was related to the age and BMI of the subject, but not to the LL score recorded during the day after. A diagnostic test based on the value of SpO2 during the acute exposure to hypoxia is able to identify correctly the AMS-resistant climbers (NPV 0,92 for a 85% SpO2 value).

Conclusions: The saturation observed early during the exposure to hypobaric hypoxia is a predictor of later AMS development; continuous SpO2 recording is a valid method for this type of research and a screening test based on this easily measurable quantity is feasible.

SUSPENSION TRAUMA – PHYSIOLOGY, PROPHYLAXIS AND THERAPY

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Suspension trauma and rotation trauma are special emergencies in the field of mountain rescue. Suspension trauma may also occur in Occupational Medicine since everybody is exposed who is secured by a harness while hanging free. Any prolonged hanging in a harness may cause suspension trauma. In extreme circumstances this may cause death within less than 10 minutes, depending on the harness used.

The mechanism of suspension trauma is similar to those of orthostatic shock. Gravity and the loss of muscular tension while hanging free cause a shift of blood volume to the capacity vessels in the legs. Additionally the blood flow back to the heart may be impaired by the harness. Both mechanisms cause an accumulation of blood in the legs and a relative hypovolaemia with shock symptoms. The hypovolaemia then causes a decrease of cardiac output and of blood pressure. Later impairments of microcirculation will follow which causes organ failure. Te latter may cause death. Normally the hypoxaemia of the brain will cause unconsciousness, if the victim wasn't unconscious before e.g. by a fall or rock fall. This increases the risk of suspension trauma.

For some degree a compensation is possible by endogeneous release of catecholamines (caused by hypotension, pain, or anxiety), but this also increases the hypoxiaemia induced acidosis. The harness may also cause a significant stress to the thorax which inhibits the auxiliary respiratory muscles. In combination with the onset of the hypovolaemic shock this increases breathing frequency and breathing volume per minute significantly. But this increases mainly dead space breathing without a relevant increase of alveolar ventilation. The latter also increases hypoxia.

In consequence, patients should be admitted to a hospital for monitoring and to exclude relevant organ damage. Renal failure is not uncommon, therefore haemodialysis should be available. Symptoms which may indicate a suspension trauma are: paresthesia, nausea, dizziness, visual impairment and general sings of shock as there are shortness of breath, sweating, and paleness. First there will be tachycardia, but later bradycardia induced by hypoxia.

The best prophylaxis is an optimal fitting harness in combination with a chest harness. If the latter should be used only, a suspension trauma may occur after 10-15 minutes. When modern sport climbing harnesses are used, this may occur within 30 minutes and with systems used for occupational safety even longer. If a sling is at one's fingertips which may be used to step in with the feet, the risk for suspension trauma is low, especially when additional manoeuvres may be done like moving arms and legs, changes of the position etc. In such cases the risk of exhaustion or hypothermia predominates above those of suspension trauma.

The most important First Aid manoeuvre is to avoid horizontal positioning of the patient after rescue, because then the large blood volume which flows back from the capacity vessels to the heart and the metabolites may cause acute cardiac arrest or cardiac fibrillation. Depending on other injuries and the cerebral situation it may be the best strategy if the patient keeps standing for about 5 minutes, before he switches to crouch position or sitting with thorax-up position for another 15 minutes. Then a position which takes injuries etc. into account should be taken into account, shock position may be appropriate. A passive transport of the patient may be beneficial, if necessary in crouch position. In any case the patient should see an emergency physician.

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INCREASE OF OXYGEN SATURATION IN SLEEPING MOUNTAINEERS DURING THE SECOND PART OF THE NIGHT AT A LONG TIME STAY AT HIGH ALTITUDE (3000M-6768M)

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Introduction: Measurement of oxygen saturation is a common tool to evaluate the distinctive hypoxia occurring during a stay at high altitude. As intermittent monitoring of the SaO2 in sleeping mountaineers is a disturbing process for the test person and acquires additional effort, we approached this problem with continuous SaO2 measurement.

Objective: The aim of the study was to describe the trend of the saturation and to make a conclusion about the maximum decrease of the SaO2 in sleeping mountaineers at high altitude in comparison with the daily saturation at rest.

Methods: A homogenous group of ten experienced mountaineers were equipped with pulse oxymeters that can memorize 72h of SaO2 measurements. The data contains the heart rate, SaO2, date and time. Every 4 seconds those four parameters are recorded and saved. This data collected for each mountaineer is transferred on a notebook at least every third day. While the mountaineers stay in Peru from 30.05.-30.6.2010 about 240.000 SaO2 measurements per person have been collected. During ascents the group used ear clips as sensors, in the night they changed to finger clips. Every participant had to keep a diary to journalize special events or the periods in which they had been awake at night. To evaluate the sleeping saturation we extracted 2 hours of measurement before 12 a.m. (N1) and 2 hours afterwards (N2). To make sure that the subjects are sleeping we referred to their records in their diaries. In addition we extracted those measuring periods in which an increasing heart rate showed us the alertness of the test persons. As a reference each morning the SaO2 of every test person at rest was measured.

Results and Conclusions: An enormous decrease of the SaO2 during sleep in comparison with the day SaO2 at rest can be seen. In the first night after arrival in Huaraz (3050m) for example, the N1 night SaO2 of the Group was MED 83,5% (Min: 77%; Max: 86%) whilst the day saturation was 9%-points higher, MED 92,5% (Min: 91%; 96%). For the second part of the night we measured SaO2 with MED 86,5 (Min: 84%; Max: 88%). These results lead us to compare the mean saturation of the N1 measurement in each subject with the correspondent N2 saturation in further nights. We surprisingly found, that in most cases the mean saturations in the second part of the night are significantly higher. This difference could be due to the circadian excretion of adrenocortical hormones.Exact calculations on the degree of saturation increase between N1 and N2 are in progress and could be discussed in the audience.

ON THE PEAK LENIN 7134 EXPEDITION THERE WAS CORRELATION BETWEEN VO2MAX AT SEA LEVEL AND UPHILL WALKING PERFORMANCE AT 4100M BUT NOT WITH MAXIMAL REACHED ALTITUDE

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Objective: Uphill walking performance on high altitude is, because of lower partial oxygen pressure, reduced. Reduction depends primary on altitude and fitness of the walker and less on process of acclimatization. The main purpose of this final thesis was to research the correlations of sea level walking performance at multistage treadmill test (VO_2max), uphill walking performance at 4100 m and maximal reached altitude.

Methods: Before the expedition fifteen (36 ± 11 years, 68 ± 10 kg) members of Peak Lenin 7134m Slovene expedition performed a multistage treadmill test (walking with15 kg aditional weight) to assess VO_2max and »all effort« uphill walking test with 70 m altitude difference at altitude of 4100 m. All members also recorded their highest reached altitude.

Results: Correlation between VO_2max reached at sea level and speed of ascent at uphill walking test at 4100 m was positive (R^2=0,64; P<0.01), as it was also between speed of ascent at 4100 m and reached altitude (R^2=0,74; P<0.001). But there was no correlation between sea level performance (VO_2max, duration of treadmill test) and highest reached altitude.

Discussion and Conclusion: The results of this study demonstrate correlation between treadmill walking performance (VO_2max) at sea level and speed of uphill walking at altitude of 4100 m. Speed of walking at high altitude is in higher correlation with highest reached altitude than with the endurance variables (VO_2max, duration of treadmill test) measured at sea level. Further researches should include other variables which are believed to be important for individual success at high altitude expeditions, e.g. weather and snow conditions, nutrition, psychological aspect, previous high altitude experiences and others.

PERIPHERAL VERSUS TRANSTHORACIC MEASUREMENT OF BIOELECTRIC IMPEDANCE FOR EARLY DETECTION OF HIGH ALTITUDE PULMONARY EDEMA (HAPE) AND ACUTE MOUNTAIN SICKNESS (AMS)

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Objective: AMS and HAPE are characterized by changes in body fluid homeostasis. Bioelectrical impedance analysis (BIA) is a clinical tool to measure body composition and hydration. As other authors, we showed in our former study under real mountain conditions and in a hypoxic chamber significantly, that people, who suffered from AMS, gained fluid, what we measured as a decrease of the Resistance R. For an early detection of the fluid shift a continuous measurement of impedance is necessary, but not available. So, we developed a new device, for which is taken out a patent. The actual study will show the difference between peripheral and transthoracic measurement of impedance.

Methods: Until now, we investigated 10 persons in a control group in normoxia and 2 under hypoxic conditions for 6-8 hours by continuous peripheral or transthoracic measurement of bioelectrical impedance. More investigations will follow in summer 2011.

Results: In single case analysis the peripherally measured resistance shows alterations about 40-60 Ohms after changing of the sleeping position, but the tranthoracic resistance only about 3 Ohms.

Conclusion: As it is known, that the occurrence of HAPE leads to a decrease of Resistance about 6-15 Ohms during transthoracic measuring and 40-150 Ohms during peripheral measuring, transthoracic impedance measurement is the more exact method for early detection of the fluid shift under hypoxic conditions. More detailed results can be presented only at the symposium because of the patent.

INTERMITTENT HYPOXIA DOES NOT AFFECT ARTERIAL OXYGEN SATURATION AT REST DURING SHORT-TERM EXPOSURE TO SIMULATED ALTITUDES UP TO 4000 M

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Objective: Intermittent hypoxia (IH) is assumed to prevent acute mountain sickness (AMS) by inducing aspects of acclimatisation [1]. Although several studies dealt with the AMS prophylaxis by IH no systematic results on IH effects are available [2,3]. The goal of the present study was to test the effects of IH on resting arterial oxygen saturation (S_pO_2) during short-term exposure to different altitudes up to 4000 m.

Methods: Nine healthy male volunteers (26±4 years) were exposed to different degrees of normobaric hypoxia corresponding to 1000 m, 2000 m, 3000 m, and 4000 m (random order, single blinded). After 20-minute at rest S_pO_2, heart rate, and blood lactate concentration were measured. After a pre-acclimatization program (IH: 7 x 1 hour at rest, corresponding altitude 4500 m) the identical test procedure was repeated. A two-way ANOVA with repeated measures was used to detect effects of IH and altitude. P-values <0.05 (two-tailed) were considered to indicate statistical significance.

Results: The results are shown in table 1. S_pO_2 decreased with altitude, but there was no effect of IH on S_pO_2. Blood lactate concentration tended to be lower after IH irrespective of altitude.The present results do not indicate that the applied IH protocol improves S_pO_2 during subsequent exposures to altitudes up to 4000 m, but autonomic adaptations by IH might play a role during subsequent high-altitude exposures.

Table 1. *Selected cardiorespiratory and metabolic parameters during short-term exposure to different simulated altitudes before (pre) and after (post) intermittent hypoxia. P values refer to effects of intermittent hypoxia.*

Simulated altitude		1000 m	2000 m	3000 m	4000 m	*P*-value
Arterial oxygen saturation (%)	pre	98±1	94±2	92±2	85±4	ns
	post	98±1	93±2	91±3	86±3	
Blood lactate (mmol/l)	pre	1.0±0.3	1.1±0.3	1.3±0.5	1.3±0.5	0.066
	post	0.9±0.2	1.0±0.3	0.8±0.4	1.0±0.3	
Heart rate (bpm)	pre	67±5	69±9	72±8	73±10	ns

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ENERGY CONSUMPTION DURING THERAPEUTIC HIKING AS PART OF THERAPY FOR OBESE CHILDREN IN THE SCHÖNSICHT HOSPITAL BERCHTESGADEN

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Objective: In the clinic Schönsicht Berchtesgaden mountain hiking is a main part of the therapy of obese children (and adolescents). Together with diet (1600 kcal/d), behavioral training and psychotherapy, activities like therapeutic hiking should help to reduce body weight by increasing the total energy consumption. The mountains in Berchtesgaden offer excellent opportunities for this, but at least it is not consistently assured which additional amount of energy is expended. Reference values for obese children are rare in literature.

Methods: In a previous study, Gross-Bölting (2010) measured the oxygen consumption during mountain hiking of 9 obese children by using the mobile spirometry system MetaMax 3B. The sample was separated in 5 subjects on a short hike track (3.0 km) and 4 subjects on a long therapeutic hike track (11.3 km) of the clinic (table 1). The clinic was interested in more subjects and by this of more representative values. Therefore 7 subjects were measured under the same conditions on the same short and 6 subjects on the long hike track during august & sept. 2010.

Results: The "rest" rate was (n= 22) 1.59 $J \cdot s^{-1} \cdot kg^{-1}$. Furthermore table 1 shows similar values as before from Gross-Bölting (Addition. en. cons. = metabolism above "rest" rate *during distance* [$J \cdot kg^{-1}$] ± $s_{D.}$. Related to the distances (3.0/11.3 km), the additional energy consumption was 4.57 (3.50) $kJ \cdot km^{-1} \cdot kg^{-1}$.

Table 1. *Previous results of Gross-Bölting (2010) and new results of Gebhardt (2011)*

Author	track	*n*	Body weight	Time [h:min]	V [km/h]	Addition. en. cons.
Groß-Bölting (2010)	short	5	118±17 kg	00:57±00:06	3.2±0.5	13.85±2.05 kJ/kg
Groß- Bölting (2010)	long	4	115±18 kg	2.42±00:17	4.2±0.5	39.09±5.31 kJ/kg
Gebhardt 2011	short	7	99±16 kg	00:48 ±00:06	3.8±0.4	13.82±2.63 kJ/kg
Gebhardt 2011	long	6	104±34 kg	2:03±00:13	5.5±0.6	40.95±8.73 kJ/kg
Total group	short	12	107±20 kg	0:52±0:08	3.5±0.5	13.7±1.0 kJ/kg
Total group	long	10	107±31 kg	2:19±0:25	5.0±0.9	39.6±3.7 kJ/kg

If daily performed by a 100 kg person, these values show a daily increase of metabolism of about 1370 kJ (327 kcal – short track) or 3960 kJ (945 kcal, long track), whereas the reduction of daily energy intake amounts in our group are about 7040 kJ (1680 kcal).

Conclusions: This comparison demonstrates an effective contribution of hiking for reduction of body weight, but underlines the high importance of diet.

References: two Diploma-theses (Inst. of sports science, University D Mainz)

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Acknowledgment: We thank to the Mittendorff-Institut (Berchtesgaden) for generous support.

CHROMOGLYCATE, REPROTEROL, OR BOTH – WHAT'S BEST FOR EXERCISE-INDUCED ASTHMA?

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Objective: The study evaluates exposure to the cold of persons involved in 1082 helicopter rescue operations We investigated the optimal dosage of common drugs and their combination for the prevention of exercise-induced asthma (EIA) or bronchoconstriction (EIB). Asthma is a common chronic disease with world-wide rising prevalence. Most of the patients show also an exercise-induced aberration of the pulmonary function. Therefore preventive strategies are especially important.

This study aims to prove the preventive effect of a combination of 1 mg reproterol and 2 mg disodium chromoglycate (DSCG) and its single components vs. placebo measuring the decrease of FEV_1 after a standardized treadmill test in eleven patients with recorded EIA. The study medication was twice as high as those of drugs which are commercially available (e.g. Allergospasmin®, Aarane®).

In this study could be demonstrated that the combination of reproterol and DSCG as well as the single component reproterol offer protection against a decrease of FEV1 after a standardized exercise challenge test (ECT) without significant difference. DNCG did not show significant effect compared to placebo.

Conclusions: A prevention of EIA with the combination of reproterol and DSCG or with reproterol only is effective. An exclusive recommendation in favor of the combination cannot be given. Due to the limited number of subjects and some probands showing protection under DSCG, it cannot be completely excluded that there is some preventive power of DSCG in individual cases. This should be proven in further studies.

COLD INDUCED VASODILATATION AS PREDICTING FACTOR FOR FREEZING COLD INJURY

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Objective: The study evaluated the hypothesis that the cold induced vasodilatation response of the fingers and toes may provide an index of risk for freezing cold injury. We further hypothesized that mountaineers after freezing cold injuries (FCI) are at greater risk for these injuries.

Methods: Cold induced vasodilatation (CIVD) was measured in fingers and toes of all subjects in three groups. Group I consisted of mountaineers after FCI (amputated digits and/or toes), group II of mountaineers without FCI and group III (control group) of subjects who were not alpinists, but who performed regular aerobic activity. During the test, the subjects successively immersed their left hand and foot in a bath of water maintained at 8 °C. Each immersion lasted 30 minutes. Digit skin temperature was measured at the nail beds. At regular intervals during the immersion we measured blood pressure and heart rate. Tympanic temperature was measured before and immediately after each immersion. We also obtained subjects' weight, height and the volumes of the immersed hand and foot. Using visual analogue scales, the subjects provided subjective ratings of their perception of temperature and thermal comfort during the test. Digit skin temperature responses during immersion were analysed for: number of CIVD cycles (N), time to the apex of the first CIVD wave (tmax), maximal and minimal temperature of the single wave (Tmin, Tmax), average digit skin temperature (Tavg) and final digit skin temperature (Tpost).

Results: In group I, there were fewer waves (N) in fingers compared to group II (1.1 vs. 1.9, $P<0.01$). Compared to group II, the toes of group I had significantly lower Tavg (11.3 vs. 12.9°C, $P<0.01$), Tmin, (8.0 vs. 9.3°C, $P<0.01$) and Tmax (8.7 vs. 10.7°C, $P<0.01$). In group I tmax was significantly shorter than in group II. (14.4 vs. 16.8 min in fingers and 12.3 vs. 20.0 min in toes, both $P<0.01$). With the exception of Tmax, Tavg and Tpost in hands, all group I CIVD indices for fingers and toes were similar to the parameters of group III. Parameters such as body weight, body height, blood pressure, heart rate, tympanic temperature and hand /foot volumes were not significantly different among groups.

Conclusions: On the basis of the digit CIVD response we conclude that alpinists that have suffered FCI are at greater risk for cold injury. Whether this susceptibility is a cause or consequence of their injury cannot be discerned from the present study. Subjects' digit CIVD response may be a good predictor of susceptibility to FCI.

THE DOUBLE SENSOR – A NEW HEAT FLUX MEASUREMENT DEVICE TO MONITOR CONTINUOUSLY CORE TEMPERATURE IN HUMANS UNDER DIFFERENT ENVIRONMENTAL AND CLINICAL SETTINGS

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Introduction: Accurate measurement of the core body temperature (cbt) is fundamental to the study of human temperature regulation and usually as standard sites are used rectum, esophagus, vesical, nasopharynx or acoustic meatus [1, 2]. Recently, a new non-invasive cbt sensor (Double Sensor)(*) has been developed [3, 4]. It was the aim to evaluate the applicability of this Double Sensor in humans under different settings including deep hypothermia (14-16°C).

Methods: In the first study (study 1) 20 male subjects (39.5 ± 10.2 years, height 1.80 ± 0.06 m, weight 83.8 ± 11.0 kg) participated. Thermal and cardiovascular data were collected continuously before, during and after the different experimental set-ups from 25-55% maximal intensity work load at 10, 25, and 40°C environmental temperatures. In the second (study 2) the double sensor was used during a regular VO2 ergometer testing before, several times in space on the ISS, and after spaceflight in one male long-term astronaut. In the third setting (study 3) we determined the core body temperature of 24 patients during cardiac operations in deep hypothermia (14-16°C).

Results: Study 1 revealed that i) the device under test differed between -0.16 to 0.1°C from the average of the rectal temperature and the Double Sensor, ii) showed with increasing ambient temperatures increasing concordance correlation coefficients (CCC) (10°C: 0.49; 25°C: 0.69; 40°C: 0.75), and iii) exhibited a faster temperature decrease at all resting periods at all ambient conditions as compared to rectal temperature ($P<0.01$). Study 2 in space showed marked increases during exercise in core temperature, sometimes >40 °C. Study 3 during the operations under hypothermia depicted that the sensor showed great accuracy (Lin's CCC=95%) and it reflects in a dense temporal pattern the reperfusion rate of a body part after occlusion of the great vessels.

Conclusions: The device under test seems to be a reliable method of assessing core temperature under different environmental and clinical conditions.

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Acknowledgements: Several EU and US patents applied. This research was partly supported by the Draegerwerke AG and the DLR/BMWi Projects 50WB0223, 50WB0724, and 50WB1030.

MILITARY OPERATIONS AND PREPARATIONS FOR HIGH ALTITUDE DEPLOYMENTS

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Military operations at high altitude can be significantly different from civilian ascents. The requirements of military missions magnify the impact of high altitude and have resulted in adverse consequences to both the mission and military personnel. The optimal physiologic mitigation through acclimatization is rarely possible. Military deployments to high altitude routinely require sudden ascents of 3000-4000 meters and involve immediate strenuous physical stress. Military planners frequently are unaware of the limitations imposed by rapid unacclimatized ascent and do not take advantage of the current knowledge of altitude effects mitigation strategies and especially the use of medication. Example will be a review of Operation Anaconda in Afghanistan.

Military preparation and training for high altitude missions focuses on acclimatization and physical stamina training. Mountain warfare units train extensively in mountain terrain, tactics, and in selecting ideal equipment. However, few programs train at high altitude and few military leaders or planners are aware of modern altitude mitigation options available. Significant efforts in research on altitude effects and treatments have been undertaken by military forces including the British Military Everest Expedition and studies of genetic differences in altitude response. Aggressive protocols and training to optimize performance at high altitude are therefore available such as the Mission Performance at High Altitude program from Deployment Medicine International.

These strategies reflect the full use of altitude physiologic science but are rarely seen at this scale in civilian settings. Mitigation strategies include the use of pre-ascent physiologic preparations, tactical strategies at altitude, use of multiple Acute Mountain Sickness prevention medications, and early identification and treatment of severe mountain disease. Medications considered for military operations include acetazolamide, steroids, sildenafil, stimulants, and symptomatic treatments. Clinical observations during the Mission Performance at High Altitude program reveal possible significant difference in effectiveness among medication formulations suggesting the use of sustained release acetozolamide and short acting phosphodiesterase inhibitors. Current efforts now must focus on the education of leaders and planners in the full range of high altitude mission impacts and mitigation strategies.

DISINFECTION OF HANDS AT A HIGH MOUNTAINS EXPEDITION (CHO OYU) – AN EXPERIENCE REPORT

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Objective: While touring in the high mountains, one can only gain drinking water by melting snow. Snow can be contaminated by intestinal bacteria, eliciting enteritis. To avoid this, meltwater usually is boiled. However, an enteritis can also be caused by intestinal bacteria located and transfered on hands. Thats's why we should take care of hand hygiene (proposal: M. Pietsch, Mainz).

Methods: First tests with alcohol cloths showed that these were not practical, so a test of a commercial hand disinfection gel (Stokosept-Gel, http://www.mzgroup.com.my/doc/Stokosept%20Gel.pdf) was commenced during a high mountain expedition (8000 m) of the DAV (section Mainz) in the autumn of 2010.

All 8 participants (see table 1) of the expedition were given several 100 ml plastic bottles of hand disinfectant gel and a skin-care creme. All participants were instructed into the professional hand disinfection.

Table 1. *No, sex and age of the 8 participants*

1, f, 45	2, m 37	3, m, 56	4, m, 47	5, m, 52	6, f, 48	7, m, 57	8, f, 52

Results: As a fist outcome we note that all participants used the gel (see table 2), but only 2 of them the skin-care cream against "sick hands".

Table 2: *Use of the disinfection gel , 7 categories*

Category	answer	always	sometimes	seldom	whole, *n*=
1	Before meal	7,8,5 (*n*=3)	1,2,3,6 (*n*=4)	4 (*n*=1)	8
2	Meal	5 (*n*=1)			1
3	After going to the toilet	2,3,5,1,8 (*n*=5)	6,7 (*n*=2)	4 (*n*=1)	8
4	In between		3,6 (*n*=2)		2
5	Personal hygiene inside tent	2 (*n*=1)			1
6	After putting on shoes	Ohne Angabe			1
7	Zip	5 (*n*=1)			1

One participants (male) suffered from diarrhoea throughout 40 days. One participant (female) suffered from diarrhoea on one day.

Conclusions: The use of the gel turned out very practical, the expedition guide will therefore use the gel on all forthcoming expeditions. The easy application of this licensed product leads us to believe that it may also have disinfecting effect in the mountains, this has yet to be verified. During a next excursion the practicability of a glove-disinfection will be tested.

Acknowledgement: We thank to *Evonik Stockhausen GmbH* for supplying gels and creams.

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EDUCATION IN HIGH-ALTITUDE-MEDICINE IN THE GERMAN ARMED FORCES

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The broader employment of the German Armed Forces exposes German troops to countries with mountain ranges well above the critical altitude of 2500 m. The experience of allied troops has shown that in military operations above 3200 m up 14 % of the employed soldiers fall sick due to mountain sickness (1). However, specialist knowledge in that topic is limited to a few individuals, which are rarely involved in operational planning of this kind.

As fixed content of military training, altitude medicine is represented in the mountain guide course and to a far lesser extend in a short alpine rescue training for physician and paramedics. A 3-day course for physicians is held once a year at the Air Force Medical Research Centre near Dresden. Starting in November 2011, an altitude medicine lecture will be part of the curriculum of the basic course in tropical and travel medicine for military physicians at the Bernhard-Nocht-Institute in Hamburg.

Future activities shall be aimed to military leaders in order to get them acquainted with practical high altitude skills in field conditions. This may lead to an increased sensitive approach to high altitude and allow prevention measures when military operations in regions above 2300 m are being planned.

References:

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ECG, EEG AND CHANGES IN THE LAKE LOUISE SCORE (LLS) FROM SEA LEVEL TO A SIMULATED ALTITUDE OF 4000 M AND BACK TO SEA LEVELING COMPARISON TO A FORMER STUDY AT THE DACHSTEIN MASSIF 2005

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Objective: We performed a reaction time task-test in a simulated height of 4,000 m over the time of 11 hours in comparison to the test before and 1 h after the exposition. The concentration of oxygen in the air remains constant but its partial pressure drops with increasing altitude.

Methods: To describe how this affects the body experiments were performed in a hypobaric chamber for 11 hours (4,000 m) and were compared to a study on Dachstein (2,700 m) of Guger 2005. We recorded EEG, ECG simultaneously. Additionally, the subjects filled out a Lake Louise questionnaire that describes the degree of altitude mountain sickness (AMS).

Results: The heart rate increased from the first test-point up to the last test point in height. Then it decreased.

The HRV parameters RMSSD, SDANN and SDNNindex showed the same, LF-norm parameters increased at the first three measure points (2+ 4 in 4000 m, 4 after 11 hours) an decreased then after decompression to the sea level. The LF/HF components results were like described before.

So we showed clearly that the sympathic reaction of the body with increase and the long time of exposure of the height. This was also shown in some other studies.

The LLS starts with a 0 on the scale at the measure point 1 (MP1), and it increases with each MP to 3.4 at MP4. Therefore only MP3 and 4 are significantly different to MP1. Mp4 is additionally significant different from MP2.

EEG beta activity in the frequency range of 14 to 18 Hz was attenuated at 4000 m within the hypobaric chamber. Even after one hour after return to sea level/134 m (the Chamber is on 134 m) all parameters are still affected from the time on 4000 m altitude.

Conclusions: All results were in line with the results obtained at the Dachstein study.

ALTITUDE RESCUE – THE USE OF ALPINE TECHNIQUES IN AN URBAN ENVIRONMENT (CATHEDRAL OF ULM)

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With modern advanced techniques there are only a few situations where it is difficult to approach, rescue and to transport the patient. Normally all patients can be approached more or less directly, there are only some cases where a crane or a turntable ladder is necessary.

But there are situations in our technical world, where it is impossible to use standard rescue procedures. Examples are wind energy plants, construction workers at facades or on frames, cranes, or buildings which were constructed before elevators were common. But in all these situations the modern population expects a quick and professional rescue.

In contrast to alpine environment urban people do not realize that rescue may be technically very difficult or even impossible.

The tower of the Cathedral of Ulm is the highest one of any church worldwide. The main tower with its height of 168m is climbed by more than 1000 persons per day when the weather is fine to enjoy the look-out. But the Gothic monument is such a complex and fragile architecture that any rescue at the tower cannot be performed from outside via helicopter.

Therefore the altitude rescue group of the town's fire department has developed a concept which enables the team to provide a efficient and patient oriented rescue. The concept includes an emergency physician, who may provide an all-over monitoring and treatment of the patient.

SAFETY IN CAVE DIVING – INSIGHT INTO A DISCIPLINE WHICH IS LESS EXTREME THAN MOST PEOPLE MIGHT EXPECT

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With increasing technical development cave diving has changed from a discipline, which previously was performed by a few freaks undaunted by death to a well accepted sub-discipline of technical diving. Apart from wreck and deep diving a special training has been established which follows worldwide standards for training and diving in caves.

But there was already a structured training in the early 80's which was established by well-known cave divers like Sheck Exley and which was based on accident statistics and risks.

Any training for cave diving should focus three life saving aspects: light, air, and leash. Taking these three topics into account reduced drastically the high number of fatal incidences of cave diving.

Today three topics provide safety in modern cave diving: i. a good and structured training by an approved organization, ii. an equipment which takes into account the specific demands of cave diving and which is redundant, and iii. the diver himself, who was trained to cheat Murphy by a high portion of discipline and calmness.

CLIMBING CAPABILITIES AND ALPINE EMERGENCIES – MINIMAL REQUIREMENTS FOR PERSONNEL OF ALPINE RESCUE ORGANIZATIONS

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Objective: Effective and safe work during alpine rescue operations need some capabilities in rock and ice climbing, but the minimal requirements were not yet investigated.

Methods: 2,731 alpine rescue operations of two regions (Oberwallis, Switzerland, *n* = 1,082; Tirol, Austria, *n* = 1,649) were analyzed with special regard to the type of terrain at the site of the accident (easy walking, "off-route hiking", "real alpine climbing"), climbing difficulties (rated by UIAA Scale for rocky terrain and steepness for ice / glacier), and other factors indicating the necessity of so-called "alpine experience" for rescue personnel involved. The data were grouped according to NACA classification (terrain index).

Results: 99.7% of the accidents could be analyzed. 62.2% of rescue operations were performed in alpine terrain of moderate difficulty (NACA d,e). 5.9% took place in difficult or extreme terrain (NACA f, g). Compared to the Western Alps there were more difficult operations in the Eastern Alps (78.2% NACA d, e and 2.2% NACA f, g in the west vs. 51.8% / 8.4% in the east). During summertime there were significant more operations in hard terrain than in winter.

The NACA d – g classes correlate to 7.1% of accidents on steep glaciers, 9.1% high-alpine tours (ridges, walls), 4.6% rock terrain up to III° UIAA, 6,0% rock terrain UIAA III-IV°, 2.4% >IV UIAA, and 1.5% in ice steeper than 50°.

Conclusions: Advanced "alpine experience" is a "must" for any person involved in alpine rescue operations – physicians, too. In absolute extreme terrain there is no need for medical help. Here technical rescue is dominating. Therefore a compromise for minimal climbing requirements of medical personnel is as follows: Capability of absolute control of rock climbing UIAA III°, safe climbing (as second) IV° UIAA, absolute control of 50° in ice, safe climbing (as second) of 60°. Special alpine knowledge is a "must" for situations like avalanche rescue.

Acknowledgements: The study is part of the project "Demands and Safety in Alpine Rescue". The project was sponsored by the Austrian Society of Alpine and High Altitude Medicine (ÖGAHM).

COLD EXPOSURE DURING ALPINE RESCUE OPERATIONS – CONSEQUENCES FOR THE RESCUER'S AND PATIENT'S SAFETY

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Objective: The study evaluates exposure to the cold of persons involved in 1082 helicopter rescue operations over a period of 15 months in the Oberwallis Region (Switzerland).

Methods: Rescue operations were analysed with special regard to the weather conditions, the locality and its altitude, and the duration. The equivalent chill temperature was estimated with two independent models. 'Mean exposure' as well as the 'worst-case situation' (based on maximum wind speed) were calculated. The results were evaluated according to the 'classic' Siple–Passel model, the more recent model of Danielsson, ISO 11079, ISO 9920, the German industrial standard DIN 33403.5, and the German government regulations for work in cold environments ('G21').

Results: The temperature models showed only marginal differences in chill temperature. Assuming 'worst-case conditions', the Siple–Passel model showed that 87.1% of the operations occurred at chill temperatures > –30°C, 12.1% in the range of –30 to –45°C, and 0.8% at < –45°C. The lowest temperature was –54.6°C. The Danielson model resulted in 77.6% without the risk of frostbite, 20.1% with >5% risk, 6% with >50% risk and 1.8% with >95% risk. According to DIN 33403.5, 1.5% of the operations were performed at chill temperatures higher than cold class 1: 2.3% are class 1, 13.3% class 2, 34.7% class 3, 34.6% class 4 and 13.7% class 5. The maximum exposure times of DIN 33404.5 are exceeded in at least 0.5% of the missions. According to ISO 11079, in summer clothing with 2.0 clo is sufficient in 40.2% and 23.9% of the operations [required clothing insulation (IREQ) min. and IREQ neutr., respectively]. In winter the corresponding results are 0.3% and 0.0%. Duration of limited exposure is exceeded in 9.1% (IREQ min.) and 19.8% (IREQ neutr.) of the operations in summer and in 10.3 and 19.8% in winter. According to ISO 9920, ICL min. as well as ICL neutr. are exceeded in 100% in summer and winter operations.

Conclusions: Alpine rescue operations are typical of a place of work in a cold-sometimes extremely cold-environment. Because of the limited time of exposure during the majority of the operations, the most important danger for rescue personnel is frostbite. Special advice to avoid the specific risks must be given to the crews and an examination by occupational medicine, e.g. according to 'Working in cold environments, G21' of the German Berufsgenossenschaften, is recommended. Beside of basic provisions for cold protection a mobile phone is best to avoid hypothermia of alpine patients because immediate emergency call.

Acknowledgements: The study is part of the project "Demands and Safety in Alpine Rescue". The project was granted by the Austrian Society of Alpine and High Altitude Medicine (ÖGAHM).

DIFFERENTIAL DIAGNOSIS OF DYSPNOEA AT HIGH ALTITUDE IS NOT THAT EASY

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Some of the most common disorders observed in mountain medicine are AMS (Acute Mountain Sickness) and HAPE (high altitude pulmonary oedema) with respective prevalence rates of 8-84% and 5-15%. Both AMS and HAPE are related directly to exposure to high altitude. Bronchitis and/or pharyngitis are experienced in approximately 12% of all trekkers climbing for a short time period at altitudes higher than 4000 m. Access to appropriate medical diagnostic equipment and treatment during trekking tours will be limited, even if a medically qualified trekker accompanies the group. It is, therefore, important to be able to differentiate among the most common diagnoses using basic equipment and a sound knowledge base. The diagnosis is often unclear and the differentiation from disorders with similar symptoms causes regularly major problems for the travellers.

We discuss the differential diagnosis that should be taken into account in such situations where a mountaineer or trekker may also be suffering from potentially life threatening HAPE and present procedures how to make the differential diagnosis as precise as possible, when the special circumstances of the situation in a wilderness environment is taken into account.

PRE-ACCLIMATIZATION IN HYPOXIC CHAMBERS FOR HIGH ALTITUDE SOJOURNS

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Since hypoxic chambers are more and more available, they are used for pre-acclimatization to prepare for sojourns at high altitude. Since there are different protocols and the data differ, there is no general consensus about the standard how to perform pre-acclimatization by simulated altitude. We review the different types of exposure and focus the target groups which may get benefit form pre-acclimatization. Since data about intermittent hypoxia for some hours per day to reduce the incidence of acute mountain sickness differ, it is suggested to perform pre-acclimatization by sleeping some nights at a simulated altitude which follows the altitude profile of the "Gold Standard" for high altitude acclimatization.

The most important groups were pre-acclimatization should be taken into account are as follows: In some situations an ideal acclimatization profile cannot be realized. It may be impossible if the person has to fly to airports at high altitude (e.g. in the Andes or Tibet), if urgent and unexpected work has to be done at high altitude (e.g. for industrial maintenance and services at high altitude facilities or for some special rescue purposes) or "critical" mountains where a good altitude profile is difficult to be realized (e.g. Ruwenzori Mountains). While a pre-acclimatization for 24-48 hours should be possible for most industrial or business tasks, the setting for most rescue operations is different. For normal alpine (helicopter) rescue pre-acclimatization is not necessary, mainly because the crews stay too short at altitude and most of them are partially acclimatized. But if international operations should be assisted by a back-up team of unacclimatized low-landers, the time necessary to organize such operations should be used to pre-acclimatize the team members.

But there are even more people who may benefit from pre-acclimatization: persons with known problems of acclimatization, although the altitude profile was perfect ("slow acclimatizers"), or elite sport teams who are facing competitions at high altitude. The latter was first discussed for the Olympic Games at Mexico City in 1968.

TREKKERS DON'T HAVE TEETH? – THE NEED FOR DENTAL FIRST AID KNOWLEDGE WHEN TRAVELLING ABROAD. DATA FROM THE 1ST ADEMED EXPEDITION 2008

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Objective: We evaluated the epidemiology of dental problems of trekkers in Nepal to develop strategies for preventive care during and before travelling and a curriculum for dental First Aid training for travellers and physicians.

Methods: 309 Trekkers were included in a prospective cohort study at Manang (3550m, Annapurna Circuit / Nepal). A questionnaire about dental care before and during trekking had to be completed. It also included questions about dental first aid kits carried along, dental problems en route, and nutritional behaviour. A dental check included dental status, papillary bleeding index (PBI) and plaque index according to Quigley and Hein (QH).

Results: 50/309 persons complained about dental problems (16,5%), which might have been sufficiently treated with a dental First Aid kit – if such an equipment would have been carried along. Oral hygiene decreased during the trip significantly and most participants showed increased plaque indices (Median QH: 2.25 (women; 2.36 (men)). Trekkers, who were checked by a dentist ≤6 months before departure suffered from significantly less problems, especially there was less dental bleeding.

If the reported problems are combined with the data from the Nature Park Authorities about the number of trekkers and the duration of their stay, the total amount of dental problems of trekkers in the region is as follows (based on the visitor data of 2007): 30,000x dental problems; 24,000x gingival bleeding; 6,200x dental pain; 1,700 fractured teeth; 2,600x lost fillings. The risk of dental problems is as follows: any dental problem 1:23.7 trekking days; gingival bleeding 1:37.7 trekking days; dental pain 1:145.2 trekking days; fractured teeth 1:509 trekking days; lost fillings 1:339 trekking days.

Conclusions: Dental problems are significant incidences during travelling and trekking. Since it may need several days to reach professional dental treatment sufficient knowledge and equipment in dental First Aid is essential. Dental First Aid and emergency treatment in the field should be included in the curricula of trainings in travel medicine for physicians.

EMERGENCIES WHILE TRAVELLING: RISK MANAGEMENT WHEN TREKKING

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Although the situation may have improved since Shlim and Galle published their data with a risk of organized trekkers for fatal outcomes increased by 5x compared to individual trekkers, risk assessment and risk management is still an important part of responsible trekking. Unfortunately there is a widespread lack of proper risk management, e.g. sown by an incidence of acute mountain sickness of 50 – 84%, caused by too fast ascents.

Based on previous pilot studies at the Khumbu region (Nepal) and on the risk management preached by the leading German trekking operators a survey was performed by two partial standardised questionnaires, one for organized or individual trekkers each, by the ADEMED Expedition 2008 (Aachen Dental and Medical Expedition). The study site was Manang (about 3,500m; Annapurna region, Nepal). All trekkers passing the study site and willing to join the study were included. The design was proved by the ethical commission of Salzburg University (Austria). For evaluation descriptive statistical methods were used.

We report the results of 442 evaluated datasets with special regard to those topics of risk management, which can be easily realized either by the organizations or by the individuals.

The trekking collective is characterized by facts such as gender, age, type of trekking tour etc. and represents the expected target group.

As the data concerning organized Trekking were already presented, the data concerning individual Trekking are following now.

287 individual trekkers took part. 90.6% looked for health advices in advance. They used about 2.5 sources which were mentioned equally. 25.5% had self- medication against AMS including a variety of 11 substances. Most of the trekkers took recommendations on acclimatization into account (92.7%) and checked whether they were adequate acclimatized (58.1%). As a general result of RIMAT one can say that although there is an adequate preparation for the trekking tour, there is still lack of education concerning self- medication.

MEDICAL ASPECTS OF SPACE MEDICINE

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This paper presents simulations modalities of weightlessness by head out water immersion, head-down tilting and parabolic flights.

The results clearly point to the headward shift of blood during space flight with some hemodynamic changes with a compensation during long lasting flights on the ISS. Some more problems will be shown as to bone densitiy and blood composition. Problems and task for a flight surgeon will be discussed with special reference to the D1 and D2 mission and to the situation of man in space. Informations will be given on countermeasures during short- and longlasting space flights.

In addition, weekly informations from the ISS give medical relevant and actual informations on the astronauts' health situation and the ambient conditons within the ISS.

ATHLETIC PROFILE OF HIGH ALTITUDE CLIMBERS AND INFLUENCE OF AN EXPEDITION ON ANTHROPOMETRIC VARIABLES

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Objective: Physiological variables registered before an expedition could hardly serve to predict performance at high mountains as acclimatization ability is a major factor. The purpose of this study was to identify parameters that distinguish climbers with more chances to reach a summit and to examine the changes in some anthropometric parameters under the influence of physical exertion at high altitudes.

Methods: Eleven male Bulgarian alpinists aged 32±8.9 years participating in an expedition on Peak Lenin (7134 m) in Pamir were examined three times: 1) before departure; 2) after descending to base camp; 3) after returning to Sofia. Anthropometric variables were gathered during the three examinations. In the first trial cycling maximal oxygen uptake ($\dot{V}O_2$max) was measured and a speed mountain ascend was performed.

Results: The initial values of the anthropometric variables were: height 174.8 ± 7.6, body mass 72.7 ± 7.6 kg, body mass index (BMI) 23.8 ± 1.6, % body fat (% BF) 12.9 ± 5.3, % muscle mass (% MM) 44.2 ± 3.4. $\dot{V}O_2$max was 51.5 ± 4.6 ml/kg/min. Non-summiters (n = 5) differed from summiters (n = 6) by higher BMI (P < 0.05) and% BF (P < 0.01) and by smaller % MM (P < 0.05). The summiters had by 8% higher $\dot{V}O_2$max and by 11.5% better score in the mountain ascend test, but these results were statistically not significant. After descending to base camp, it was established that the subjects had lost significant portion of BF (2.8 ± 2.3 kg, P <0.05) and 1.1 ± 1.6 kg MM. These changes were more noticeable in non-summiters. After returning to homeland the subjects had recovered their MM but their BF remained low (body mass was still smaller than the initial one, P < 0.05).

Conclusion: The athletic type of alpinists is more likely able to reach a high summit. High levels of aerobic power and sport-specific endurance are conditions for a safer ascend. Nevertheless these abilities do not guarantee success. Psychological factors, experience and tactics are very important. The expedition provoked significant loss of tissues, which effect was stronger in the less prepared participants. The magnitude of these negative changes appears also to be an acclimatization indicator.

SPORT-SPECIFIC STRENGTH ENDURANCE AND PHYSIOLOGICAL RESPONSES DURING TWO CLIMBING TRIALS WITH DIFFERENT DURATION AND HOLDS' SIZES

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Objective: In regards to performance diagnosis in sport climbing the main objectives of the study was to verify some sport-specific tests, to identify suitable physiological indicators as well as to broaden the existing knowledge on physiological responses to sport climbing.

Methods: Eight elite sport rock climbers (best redpoint achievement: 8a – 9a French grading system) performed two sport-specific strength endurance tests until exhaustion. Climbing pace was steady (2 hand moves per 5 sec) in order to allow comparison between subjects. The technical difficulty was decreased to minimum to ensure greater tests' validity. The subjects traversed near the ground (changing left and right direction) on a slightly overhanging indoor climbing wall (inclination: 12 degrees from the vertical). Test 1 was shorter in duration and more intensive than test 2. This was achieved through a single difference in conditions: smaller hand holds in test 1. Oxygen uptake ($\dot{V}O_2$), ventilation (VE) and heart rate (HR) were continuously measured. Respiratory exchange ratio (RER) was also calculated. Data were expressed as peak values (HR_{peak}, $\dot{V}O_{2peak}$) and as averages (HR_{avg}, $\dot{V}O_{2avg}$). Pre climbing and three min post climbing blood lactate (La) samples were taken. After test 2 La clearance was followed at the 10th and 20th min after the exercise. Additionally the maximal strength during "crimp" and "open" finger grip position and anthropometric parameters were registered.

Results: The climbers who possessed 8c level and above climbed longer, had higher $\dot{V}O_2$ values and slightly better La clearance in both climbing trials. Their maximal strength (crimp grip position) and relative strength (crimp and open hand grip position) were also higher. $\dot{V}O_{2peak}$ significantly correlated with test performance in the shorter climb (r = 0.80) and $\dot{V}O_{2avg}$ significantly correlated with test performance in the longer bout (r = 0.85). The exercise duration of test 1 correlated stronger and significantly with outdoor performance (r = 0.95). Despite HR_{peak} and $\dot{V}O_{2peak}$ values were higher and VE and RERpeak values were significantly higher during the longer climb, the HR_{avg} and $\dot{V}O_{2avg}$ values were similar.

Conclusion: Non-standardly during maximal workloads of different intensity $\dot{V}O_{2avg}$ and HR_{avg} may not differ. Sport-specific strength endurance is a major factor of performance in sport climbing. A new finding is that specific aerobic abilities highly determine climbing duration. Nevertheless, most likely the short-term endurance is more important than the ability to sustain on longer routes with easier moves. The climbing tests used in this study proved to be applicable for strength endurance diagnosis.

HYPOXIA DOES AFFECT LEFT VENTRICULAR DIASTOLIC FUNCTION TOGETHER WITH SIGNIFICANT PULMONARY HYPERTENSION IN ACUTE MOUNTAIN SICKNESS SYNDROME (AMSS)

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Objective: Hypobaric hypoxic circumstances in high altitude has been suggested to cause pulmonary vasoconstriction and right ventricular(RV) pressure overload, which may lead to left ventricular(LV) diastolic dysfunction.

Method: We examined cardiopulmonary performance of AMSS subjects by Echo, who visited the mountain clinic at the height of 3100m. Also at the summit of Mt. Fuji (3776m) we investigated cardiopulmonary change of healthy mountaineers during exercise using double master steps. The echo specialists performed the whole recording of LV and RV systolic and diastolic function using GE Vivid-I. Hypoxemia was also assessed by blood gas analysis, together with pulseoximetry in room air after 20 minutes' rest.

Results: Echo evaluation was performed in 49 volunteers in total (31males/18females, aged 40.3+/-13) at the height of 3100m (*n*=8) and the summit of 3776m (*n*=41) altitude. SpO_2 level, pulse rate, and systolic pressure gradient across tricuspid valve (TRPG) of those were 81.4+/-5.6%, 95+/-13bpm, 35.0+/-9.5mmHg, respectively. At the height of 3100m, TRPG in AMSS subjects(*n*=6) was significantly higher than that of healthy subjects (*n*=8) (43.0+/-3.6 vs 26.9+/-5.2mmHg; *P*=0.001). Prolonged annular relaxation velocity (e'), shortening of LV and RV deceleration time (DCT) were also significantly different between AMSS and healthy subjects (14.0+/-28.9 vs 10.0+/-3.22msec; *P*=0.05, 187.5+/-57.8 vs 117.8+/-56.9msec; *P*=0.057, 160.0+/-54.5 vs 88.9+/-40.2mmHg; *P*=0.02). In healthy subjects, TRPG at the summit of 3776m were significantly higher than that at the height of 3100m (28.4+/-6.0 vs 38.1+/-6.0mmHg; *P*=0.03), no remarkable change of diastolic dysfunction was shown in echocardiography.

Conclusion: The mountaineers of acute mountain sickness syndrome showed the obvious LV diastolic dysfunction, which is considered closely related to the mechanism of acute mountain sickness syndrome.

FIVE YEAR EXPERIENCE WITH THE UPGRADED DYNAMIC FLIGHT SIMULATOR (HUMAN CENTRIFUGE) FOR EUROFIGHTER /TYPHOON PILOT TRAINING IN THE GERMAN AIR FORCE

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Objective: In 2006 the GAF Human Centrifuge (HC) was upgraded to support the introduction of the Eurofighter / Typhoon in the GAF, a modern fighter aircraft 4th Generation. This modernisation provided a more realistic centrifuge training that covered international requirements. Importantly the G-onset was increased up to 6g/sec. Germany is the only EF-Nation, which has a high Performance HC available. GAF provides centrifuge training for many other countries.

Methods: 135 EF-pilots (all men, age 33 ± 6 yr) were trained in this five year period. German EF pilots have to take part in basic training and refresher training courses. In the first four years of their carrier EF-Pilot have to perform this training yearly and then every four years. The goal is to familiarise them with the new Anti- G-Protection and to achieve a 9 g run for 15 sec with a G-onset of 6g/sec. In total 286 qualification runs were completed.

A Dynamic Flight Simulation with target chasing in the HC completed the program.

Anti-G-Protection was either a pneumatic system (which consists of a Full Coverage Anti-g-Trouser and Positive Pressure Breathing for G-protection (PBG) (*n*=89) or a hydraulic self regulated suit without PBG (*n*=46)

Results: All pilots successfully achieved 9g for 15sec, with 6g/sec onset. One pilot equipped with the self regulated hydraulic suit had G-Loc but ultimately he passed the test.

The resting heart rate one minute prior to the 9g run was 103 ± 17 bpm. The maximum heart rate under 9g was 161 ± 20 bpm.

Pilots equipped with the pneumatic system complained about arm pain in 12% of all runs. Arm pain was not reported when using the self regulated hydraulic suit. Complaints about foot pain were very uncommon for both systems.

Conclusion: High-G-Training in the upgraded HC is now well established in the GAF and has shown to be medically safe. Our goal is to improve flight safety and mission efficiency by avoiding G-related health problems during operational flying duty. The Full Coverage Anti-G-Trousers in combination with PBG used by the most EF-Nations has proven to be a very effective Anti-G-protection.

ALTITUDE TRAINING – FACTS AND MYTHS

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Objective: High altitude training has become a mainstay in endurance sports, with live high–train low as the current protocol of choice. Athletes either live or sleep in artificial or natural hypoxic conditions with the aim to increase serum erythropoietin concentrations, which are thought to improve maximum oxygen uptake and thus exercise performance.

Changes, however, are not very striking and only apparent in so-called responders, who are not a well-defined group and may be as little as 50% of the trained study population. Whereas some studies show minor improvement, others report no change or even worsening. Furthermore, the mechanisms behind the proposed beneficial changes remain obscure and are far from being proven. There is an evident lack of sufficiently powered randomized, double-blinded studies, with training protocols that are identical for all groups and groups that are indeed comparable. Several studies discriminate between responders and non-responders, without clearly assessing the characteristics of the so-called responders. Until this has been done, it remains unclear if such a group really exists and how these subjects are characterized. This, however, would be of immense value, so protocols could be tailored to athletes' needs.

Conclusion: Taken together, the current literature on natural or artificial hypoxia somewhat documents improved performance at high but not low altitude.

CONTRAST-ENHANCED ULTRASOUND (CEUS): TREATMENT OF DEEP FROSTBITE INJURIES AND EARLY PROGNOSIS IN AMPUTATION LEVEL

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Objective: The extent of tissue loss caused by local cold injuries is difficult to estimate in the very beginning of treatment. In the past clinical classifications of frostbite severity were amended by technical diagnostics like e.g. technetium^{99}-scintigraphy. We use contrast-enhanced ultrasound (CEUS) to detect microperfusion in the ischemic border-line zone. We present our protocol of diagnostic tools including CEUS to establish early prognosis of amputation and stage-adjusted early and late treatment.

Methods: We present two cases of deep frostbite injuries using the modified clinical classification of frostbite severity by Cauchy (2001), technetium^{99}-scintigraphy, and CEUS additionally to establish an early prognosis of amputation. CEUS was performed by low mechanical index technique (ultrasound system: iu22, Philips) with intravenous injection of up to 2,4ml SonoVue (Bracco, Italy).

Results: In both patients repeated examination with CEUS showed similar localisation of the border-line zone between frozen and viable tissue compared to technetium^{99}-scintigraphy. Final levels of finger amputation concurred well with findings of CEUS examinations.

Conclusion: CEUS proved to be a helpful diagnostic tool to establish early prognosis of amputation and outcome in severe deep frostbite injuries. CEUS allows a dynamic examination of micro- and macroperfusion with high resolution and is a new promising method in the diagnosis of local cold injuries without the disadvantages of nephrotoxicity, contrast-agent allergy and radiation in critically ill patients suffering from hypothermia. Furthermore, the procedure can be performed easily at bedside.

STATISTICAL ANALYSES OF METEORLOGICAL DATA OF GERMAN ALPS AND LOWER MOUNTAIN RANGES

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This contribution presents the results of the statistical analyses of data of the meterological observatories Hoher Peissenberg (987 m), Wasserkuppe (950 m) and Zugspitze (2962 m). Time series of temperature, condensation, wind and other meterological parameters were partially retraced to January 1781. This review gives impressions of the climatic changes of the alps in the last 230 years and of the current climatic situation.

HYPOXIA AND HEARING - WHAT DO WE REALLY KNOW?

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There are several theories, which propose, ATP may be the link between sound and hypobaric hypoxia to the damage of the ears. During sound exposure there is an active secretion of ATP into the perilymphe of the stria cochlearis located in the inner ear. Since the cochlear cells are supplied with oxygen by diffusion, this may lead to an "energetic exhaustion" as a reason for the hearing threshold shift. The effect may be enhanced by hypoxia.

Hypoxia is an independent risk for threshold shifts, because an exposure to 5% oxygen partial pressure induces a reversible shift. Hypobaric hypoxia may increase the risk of hearing loss by noise. Additional risk of hypoxia may be caused by a reduced cochlear capillary perfusion and a resulting decrease of perilymphatic oxygen partial pressure induced by e.g. airborne sound.

Both effects last for several hours even after the noise exposure has finished.

Based on literature study, some parts of the questions concerning hearing and hypoxia should be discussed in a new research project.

Latest literature research results will be given and a proposal of this new project, taking place during the ADEMED Expedition in fall 2011, will be presented.

ANTHROPOMOTORIC PROFILES OF ELITE MALE ICE CLIMBERS

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Objective: Ice climbing as competitive sport exists in some countries for many years, but as Word Cup is organized in the last ten. There is a little data about anthropomotoric measures of ice climbers (IC). Mostly used sport profile for this group of athletes were taken from sport climbers (SC). The aim of this study was to determine anthropomotoric profile of IC, its influence on competitive ranking and to compare IC with group of SC and non climbing (NC) athletes.

Methods: The 23 male participants of the Ice climbing World Cup (age 26.7±5.9) were measured day before competition. Comparison and control groups were made of 23 SC age (27.9±3.9) who reported on site climbing grade over VII+/6c (UIAA/French) (Watts PB., 2004) and the same number of NC athletes age (23.8±2.6) (soccer, basketball, rowing, volleyball, water polo, fitness, karate, hockey, cycling) which were measured during the summer season. The variables measured included age , height, weight, body mass index, % body fat by bioimpedance, % segmental body fat (trunk, left and right arms, -legs), fat mass, fat-free mass (FFM), total body water (TBW), basal metabolic rate (BMR), leg length, arm span, ratio of arm span to height (Ape index), right and left handgrip strength, handgrip strength to body mass ratio (SMR), pincer strength (dominant hand, i.e. thumb and forefinger), handgrip endurance (dominant hand), endurance of shoulder's muscles, foot raise, hip flexion, hip abduction, climbing ability trough standing position or the most difficult on site lead climbing (Grant S., 1996; Giles LV., 2006).

Results: Despite similarity in age between three groups, significant differences (P<0.05) have been shown in body fat %, fat mass, trunk fat %, handgrip strength for both hands, SMR and foot raise. IC had higher mean values for all variables except grip strength and foot raise. Also, only IC versus NC (P<0.05) had lower height, weight, BMI, BMR, FFM, TBW, fat % in extremities but higher ape index, hip abduction and lower endurance of shoulder's muscles. No differences between groups have been found for pincer strength, grip endurance, hip flexion, arm span and leg length. Influence on ice climbing competitive ranking (P<0.05) had age (older had better ranking), handgrip endurance, SMR, foot raise and hip abduction while handgrip strength (left and right) shown significance of (P<0.01).

Conclusions: Elite IC are moderate stature with moderate fat % and SMR but like SC with lower weight, BMI, BMR, FFM, TBW and good hip abduction. Success on competition beside experience probably comes with age have IC with better handgrip, arm endurance and hip flexibility.

Key words: *Anthropometry, strength, elite athletes, ice climbing, sport climbing*

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THE RELATIONSHIP BETWEEN CLIMBERS' LEVEL OF SPORT AND SELECTED BIOMECHANICAL PARAMETERS OF THE MUSCLES

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Objective: The main purpose of the undertaken research was to determine the relationships of sport level performed by the best climbers with selected biomechanical parameters of the muscles. In order to do that, in static conditions, measurements of the maximum torques of flexors and extensors of the knee, hip, shoulder and elbow as well as the trunk were done. The values were expressed in absolute (Nm) and relative units (Nm/kg). Additionally, there were determined maximal values of grip strength in two hand positions: typical (handgrip strength) and specific – similar to climbing conditions. In the first test we used the ball of the thumb, and the resistance of dynamometer fell on the middle phalanges. In the second test we used only nail phalanges (first) and we did not use oppose movement of the thumb.

The measurement set allowed to identify the indicators describing the speed of muscle contraction mobilization. In terms of rapid isometric muscle contraction we determined time needed to obtain the maximum value of the force and its half (t_{Fmax} and $t_{0,5Fmax}$), and the largest rate of force increase (F'_{max}). The variables mentioned were identified for fingers flexors as well as knee and elbow flexors and extensors.

The last aspect of the study was to assess the endurance potential of the forearm muscles. We applied two tests performed to the point when the subjects fail to continue exercising. The first one was a continuous test where the subjects' task was to develop and sustain a force in specific crimp grip position equal to 60% of their maximum voluntary contraction. The results were registered by the effort time ($t_{60\%Fmax}$). In the second test the same grip position and resistance were used but in this case the contractions were intermittent (7 seconds static work and 3 seconds relief phases). In both tests the contact area between the fingers and the support was only for the distal phalanges. In total, more than 60 indicators were developed for the description of possible strength of studied athletes, less than 40 to describe the possibility of speed and 5 to describe their endurance.

Methods: The study was carried out in 2 groups of climbers. The first one (elite), n=3, were characterised by sport level described by rotpunkt (RP) of 8c to 9a. In the second group (n=6) were the athletes performing climbing routes evaluated on (RP) 8a+ do 8b+.

Results: The results achieved indicated that both groups do not differ significantly with the level of muscle speed and endurance. In turn, the climbers from the second group dominated the elite climbers in the level of absolute strength of the measured muscle groups. At the same time, when in the muscle strength description were adopted indicators of relative muscle strength, the differences not only decreased but in some cases there was an advantage of the athletes group I. One of the reasons of that situation was significantly lower body weight. In the study of elite athletes, in the shoulder joint were found higher values of the extensor than flexor torque. Observations like that were not noted in the comparison group.

In both groups of climbers within strength, speed and endurance parameters obtained for the left and right side of the body were found similar minor variations.

Conclusions: It seems that typically used in biomechanics standard motor tests do not take into account the specificity of climbing activity, so their usefulness is limited. Precise measurement is possible, but it is necessary to construct climbing-specific trials, using all available measurement tools used in biomechanics.

A COMPARISON OF PHYSIOLOGICAL RESPONSES TO NORMOXIC AND HYPOXIC EXERCISE IN INTERNATIONAL FOOTBALLERS

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Objective: Acute exposure to medium altitude (2000-3500 m) has deleterious effects on physiological and psychological performance, but the magnitude of this effect has not been quantified in high-intensity intermittent sports such as football, or in elite international players.

Methods: Twenty eight international male football players (Age, 28±4 yr; Height, 1.84±0.08 m; Weight, 78.2±8.9 kg) were tested in preparation for the South Africa World Cup. Players were tested over 2 days, half on day 1 and the remainder on day 2. Each player was fitted with a heart rate (HR) monitor, finger and ear pulse oximeter (Nonin Medical, NoninGo finger pulse oximeter and Nonin Medical Avant 2121 with PureLite 8000Q2 ear clip sensor) and a face mask providing either normoxic (FIO_2: 20.9%) or hypoxic (FIO_2: 15%) gas depending upon the exercise condition.

Players performed a ramp test (+25 W/min) to identify the workload necessary to elicit 85% of age predicted maximum HR and then spent 20 minutes familiarising to the psychological tasks (Simple reaction time, SRT; complex reaction time, CRT, response to different colours; and sustained attention reaction time, SART, go/no go task based on the number that appears; All tasks were programmed in E-Prime (Psychology Software Tools, Pittsburg, PA).

Subsequently, the players performed 10 minutes of cycling exercise at 85% of maximum HR in normoxia repeated in hypoxia and separated by a 20 minute rest period. During the last 5 minutes of each exercise period the players completed the psychological tasks whilst trying to maintain cycling power and cadence. All data were compared with Student's paired t-tests Normoxic vs Hypoxic, with significance accepted at the $P<0.05$ level.

Results: SaO_2 was significantly lower during the hypoxic than the normoxic exercise (86±1vs94±6 %). Heart rate was significantly higher (Figure 1) and power (211.2±29.6vs225.5±26.8 W) significantly lower during hypoxia than normoxia. Hypoxia also altered cognitive function. Simple reaction time was significantly slower in Hypoxia than Normoxia (292±76vs 263±44 ms). There was no effect of hypoxia on complex reaction time or sustained attention reaction time.

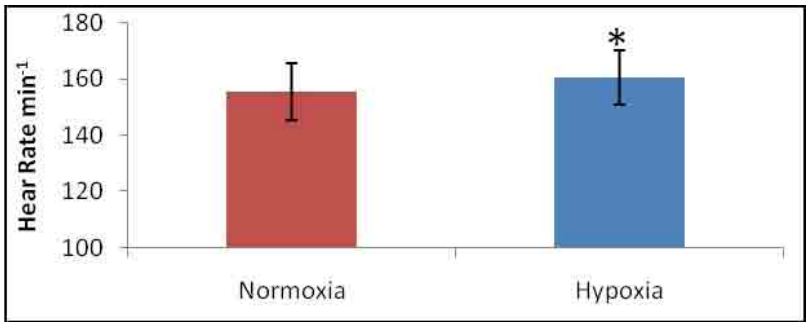

Fig. 1. *Heart rate during hypoxia and normoxia. *indicates significant difference, P<0.05*

Discussion: The results are not unexpected given the recent anecdotal evidence of Bolivia beating Argentina convincingly when playing at altitude of ~3500m in La Paz. The players in this study generally fell into 2 groups, those that maintained their work output and had higher HR, and those that dropped their work output and had similar HR to normoxic exercise. Additionally factors affecting cognitive performance must be considered when competing at altitude as reaction time may be negatively affected. Further work is required to assess the effects of acclimatisation and simulated altitude exposure on altitude performance in both physiological and psychological tasks.

Conclusion: Exposure to moderate hypoxic conditions (equivalent to 2000m) either compromised the ability of international football players to sustain work output during moderate intensity exercise or augmented the physiological demands of the exercise. Cognitive function was also impaired.

QUANTIFYING ALTITUDE RELATED HYPOXIC STRESS BY PROTEIN CARBONYLATION

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Objective: In quantifying altitude related hypoxic stress on a molecular level carbonylated proteins show great promise. They have been used as a biological marker to determine hypoxic stress in newborns so far. In contrast to other markers this substance group is very stable and early detectable. Therefore, their use in a high altitude environment should be with good prospects.

Methods: Twelve subjects spent a night in a hypobaric chamber at a simulated altitude of 4000m. 1 hour before altitude exposure and 2 hours after arrival at 4000 m a blood sample was taken and protein carbonylation was analyzed by special ELISA. Results were compared with severity of acute mountain sickness (AMS) after spending 11 hours at 4000 m quantified by the Lake Louise Score.

Results and Discussion: The fast ascent to 4000 m generates a measurable hypoxic stress to the body with a wide range in individual susceptibility. This appears at altitude expressed by a significant change of carbonyl proteins (P= 0,01) as well as for the severity of AMS. Three of the subjects having no or least AMS showed a decrease in carbonyl proteins. All other subjects had an increase in carbonyl proteins. The participant with the highest increase in carbonyl proteins was the most severely ill person. Regression analysis showed a linear regression; r^2 = 0.43.

Conclusion: This is the first time a correlation between protein carbonylation and high altitude symptomatology has been detected, making these highly interesting for further investigations at high altitude.

IMPROVEMENT OF ALTITUDE PERFORMANCE TEST AFTER ACCLIMATIZATION

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Objective: The Altitude Performance Test is used at a “safe” altitude to assess the individual’s degree of acclimatization and subsequently to make an objective decision whether that individual may continue the ascent. The aim of this study was to investigate if the test result improves after several days of further acclimatization.

Methods: The Altitude Performance Test is based on the lowest oxygen saturation (SaO_2) found during an uphill run at high altitude, combined with the time needed to complete the run. The test was performed on the first day of arriving at Turin Hut (Area of Mt. Blanc) and after 9 days at the same location. The 37 male participants of the German Army mountain guide course were all pre-acclimatized. The sleeping altitude always remained at 3371 m, during daytimes altitudes up to 4808 m (Mt Blanc) were reached. The results of the first and the second test procedure were compared using the Wilcoxon Signed Rank Test.

Results and Conclusion: Test results improved significantly after a further 9 days of acclimatization (SaO_2: +5%-points, $P \geq 0.001$; time: -11 sec, $P \leq 0.001$). This is remarkable because all soldiers were pre-acclimatized and showed in general only minor high altitude symptoms during the whole stay even at the summit of the Mt. Blanc. This underlines that the acclimatization process is not finished after amelioration of altitude symptoms. Especially in case of military missions at high altitude complete regained physical performance is of outstanding importance and the additional time required for that must be scheduled.

ENERGY CONSUMPTION DURING THERAPEUTIC CROSS-COUNTRY SKIING AS PART OF THE THERAPY FOR OBESE CHILDREN IN THE SCHÖNSICHT HOSPITAL BERCHTESGADEN

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Objective: The clinic Schönsicht in Berchtesgaden uses during winter time cross-country skiing as therapy for obese children (and adolescents). Activities as this therapeutic skiing are one part of the therapy, together with diet and behavioral training respectively psychotherapy. The surrounding region offers excellent and attractiv opportunities for skiing and by this for increasing energy consumption to support body weight reduction. Data about energy consumption during cross-country skiing – especially for children in leisure sport – are rare, however. So the clinic was interestes on such values.

Methods: Based on good experience with the mobile spirometry unit MetaMax 3B system in lab and field experiments we tried to measure oxygen consumption of 11 children (13 -18 y, BMI 34.6 ± 3.6; 6 m, 5 f, not very experienced in skiing) during skiing on the typical therapeutic circle (1. – 11. Feb. 2010). Methodical problems were evident, caused by water of condensation in the system, but they could be solved.

Results: We found for the 5-min rest before start a reference value of 6.1 $kJ \cdot kg^{-1} \cdot h^{-1}$. Table 1 shows for a circle of 587 m the additional energy consumption above measured "rest" values. A 100-kg child needs for one circle an additional energy consumption of about 1000 kJ (~ *240* kcal). The reproducibility for metabolic rate of the retest design was: "Rest" (*r* = 0.79), additional energy consumption *(r* = 0.86).

Table 1. *Additional energy consumption*

	Mean bodyweight [kg]	Neededtime [min:s]	Meanvelocity	Additional energy consumption /h	Additional ener. consump-tion for the 587 m-track
1st run	98.8 ± 11.7	29:40 ± 5:07	3.7 km/h	21.3 ± 4.4·kJ $\cdot kg^{-1} \cdot h^{-1}$	10.53 $kJ \cdot kg^{-1}$
2nd run		28:29 ± 4:35	3.8 km/h	20.5 ± 3.6 kJ $\cdot kg^{-1} \cdot h^{-1}$	9.73 $kJ \cdot kg^{-1}$

Discussion: Our "rest" values are not seen as true rest-values, but as metabolism plus the rate for everyday activities without special sport programs and for growing up of the younger children. Because they were not very experienced in skiing, we found a training effect in the second experiments. The caloric deficit for a 100-kg child (by diet) amounts at 14640 – 6700 = 7940 kJ/d. By typical 3 circles of our skiing (ca. 3000 kJ) this inreases to about 10940 kJ. This show a part on total caloric deficit of 27% for the daily skiing and 73% for the diet (similar relations only for endurance sport). The effect of our sking is remarkable, but the discipline in diet is very important, obviously.

Acknowledgement: We thank to the Mittendorff-Institut (Berchtesgaden) for generous support

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CALCULATED ENERGY CONSUMPTION DURING WALKING IN A MOUNTAIN REGION, BASED ON GEOGRAPHICAL DATA (DISTANCES AND HEIGHT-DIFFERENCES)

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Objective: To calculate „calorie-consumption" is a liked extra for watch-like calculators, based on heart rate, shoe-sensors or GPS-Data. The mode of calculation is not clear, however. For health oriented tourists it would be of interest, how much energy is consumed by walking in the mountains in addition to the everyday consumption. The Berchtesgadener Land Tourismus GMBH describes the regional marked trails on a special homepage, including a calorie-counter as a gimmick, based on a simple mathematical function. So they where interested on more valid values without the methodical difficulties of respiration-based measurements of the metabolic rate.

Methods: Available were GPS-data for 24 walking trails and table values of Spitzer et al. (1982) for additional energy consumption over rest-values for walking at different raisings/slopes**.** A survey in literature showed 1) that the table-values were acceptable and very practicable and 2) that the walking velocity between 2 -5 km/h is unimportant, if the metabolic rate is used as kJ/m. So we calculated by the available GPS-data interval distances and height-differences between the measured geographical points. The interval-distances showed a great variability; as mean we calculated 25 m (mean of 24 medians). Based on values for interval-distances and according angles the equivalent metabolic rate was calculated for each interval, using the table-values, differentiated in steps of 5°, and than the sum of all interval-values.

Results: As result we obtained plausible values for the 24 walking routes, often with greater differences to the „gimmick"-values. Our calculated values depended distinct on total distances and terrain-profiles of the 24 trails, ranging between 1648 kcal (13.2 km) and 226 kcal (3.5 km).

Discussion: The accuracy of our values depends on the validity of the table values (not in doubt) and on the accuracy of the GPS-data, especially on the height-values. Our calculated values are estimated values, however, but better than the gimmick and they are transparent. Better accuracy might be possible by a more accurate system as e.g. the European Galileo-project (test phase in Berchtesgaden).

Acknowledgement to *Verein alpines Gesundheitsforum Berchtesgaden* for sponsoring and *Berchtesgadener Land Tourismus GMBH* for support.

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THE ENDURANCE TRAINING EFFECTS OF HIGH – ALTITUDE ALPINIST EXPEDITIONS MAY BE OF SMALLER IMPORTANCE THAN ACCLIMATIZATION

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Objective: In contrast to clear evidence that acclimatization is necessary for performance at high – altitude exercise, the endurance performance seems less important. If it is true, then endurance performance should not enhance as acclimatization during such expedition.

Methods: To test this hypothesis, two groups: 4 alpinists (age: 45 ± 8 yrs; BW: 75 ± 5 kg; BH: 171 ± 20 cm) who reached the summit of the Gasherbrum II (GAS) and 5 alpinists (age: 55 ± 11 yrs; BW: 74 ± 9 kg; BH: 177 ± 7 cm) who reached the summit of the Ama Dablam (AMA), were voluntary participated in the study. They repeated incremental test on the cycle ergometer before and after expeditions in normoxic and hypoxic (FiO_2= 0.18) conditions.

Results: Results showed that intensity, determined by Lactate Threshold (146 ± 28 W before and 149 ± 13 W after) and Ventilatory Threshold (VT) (144 ± 36 W before and 134 ± 16 W after) remained unchanged on GAS. Differently, VT increased from 140 ± 14 W before to 164 ± 10 W ($P < 0.05$) after AMA expedition during testing in normoxic conditions and showed clear tendency for increasing in hypoxic conditions. During exercise at the same reference power limit (RPL) intensity alpinists of GAS reached 202 ± 29 W and in AMA expedition 175 ± 12 W. During testing at RPL intensities, before

and after GAS expedition VE increased from 83 ± 9 to 104 ± 16 l/min ($P < 0.01$) during normoxia and from 111 ± 13 to 135 ± 12 l/min during hypoxic testing. This resulted in characteristically decrease of PCO_2 from 5.2 ± 0.5 kPa before to 4.3 ± 0.2 kPa after ($P < 0.05$) during hypoxic testing. Differently neither VE nor other parameters change in AMA. Acclimatization significantly increased in GAS expedition when estimating by arterial oxygen saturation (SaO_2) during RPL (89 ± 1 % before to 92 ± 1 % ($P < 0.01$) after, but not in AMA, where only a clear tendency for increasing SaO_2 was presented.

Conclusion: Results showed a clear acclimatization effect only in expedition GAS, where more dramatic environmental conditions occurred. The increase of endurance was presented only in less endurance subjects in AMA expedition.

SUCCESS AND PAIN AT SUMMITING OF ACONCAGA (6962 M) IN THE AGE OF 71 YEARS

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This contribution reports about the summiting of Aconcagua in January 2011 in the age of 71 years. It is a case report about extremely mountaineering and gives an introduction of planning, preparation and ascent routes of this expedition. Special considerations are ways of acclimatisation, problems about the weather and technical, conditional and health difficulties.

This lecture will be presented in German language.

INDIVIDUAL REACTION TO ACUTE COLD EXPOSURE

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Objective: High altitude parachutists – military special forces - are trained to get out the aircraft in high altitude up to 10 km. Hypoxia and oxygen deficiency are dangerous for life and mission success. Therefore training in a low pressure chamber is a mandatory task for those military persons. The extreme cold environment in high altitude (- 56°C in FL 330 resp. 10.000 m) is as critical for life and mission success as hypoxia. Therefore special equipment has to be developed, tested, and qualified. During one of these equipment tests with military special forces parachutists physiological data were taken for medical safety reasons.

Methods: During oxygen mask testing trials in the normobaric climatic chamber of the BWB Koblenz together with the division Ergonomics of the German Air Force Institute of Aviation Medicine three voluntary parachutists took part in a simulated HAHO (high altitude high opening) glider parachute mission. Simulation circumstances in the chamber were cold temperature (at the start of the test in the chamber: -56°C) and the maximum exposure time of 30 minutes hanging at the parachute. In addition there was a mild wind by a ventilation system to produce an additional chill effect. Physiological data (ECG, breathing activity, oxygen saturation of the blood, rectal and more than 10 skin temperatures) were taken from the subjects who took part in several exposures under these extreme conditions. The subjects were equipped with their typical parachute garment for extreme cold temperatures. After leaving the climatic chamber the recovery period was supervised by the physician to avoid a too fast mixture of the central and peripheral blood volume. Data of the rectal temperature, the skin temperature of one finger and one toe were continuously recorded.

Results: The temperature curves show first no change or a light increase of the rectal temperature during the exposure of the subjects in the cold temperature of -56°C. During this time peripheral skin temperatures decrease for about 10°C. After the exposure in the chamber the subjects were advised to stay more ore less without major movements of their arms and legs, the equipment was taken part after part from the subjects under the advise of the responsible physician. The reaction of the rectal temperature shows a typical relation between movements of the limbs and the decrease of the rectal temperature. This underlined the danger of a possible too fast mixture of the cold peripheral blood with the centralised blood.

Conclusions: The temperature of the peripheral blood of finger and toes of subjects, exposed to very cold temperatures, drops down very quick even good isolation by special clothing is worn. To avoid the famous death after rescue due to a mixture of the peripheral cold blood with the centralised warm blood, also to avoid heart dysrhythmias, the data show the necessity to avoid major movements by arms and legs in the first 20–30 minutes after leaving the cold environment.

Key words: *cold exposure, body core temperature, finger and toe temperature, recovery period*

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HYPOXIA IN HIGH ALTITUDE INDUCES HYPERTHERMIA IN BODY CORE TEMPERATURE MEASURED BY USING THE HEAT FLUX DOUBLESENSOR METHOD

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Objective: Training in flight personal of German Air Force (GAF) usually includes an hypoxia demonstration in the high altitude chamber in the training center of the Aviation Medical Institute every fourth year. During the demonstration trainees often reports the symptom of upcoming heat in the central body and/or in the head. The empirical evaluations of that fact showed that nearly 60% of the trainees have such a sensation. In recent studies we successfully used a non-invasive heat flux DoubleSensor to measure body core temperature (Gunga 2008, 2009, Werner 2010, 2011). To objective the symptom temperature increase this study was conducted and approved by the General Surgeon of the GAF.

Methods: In the high altitude chamber trainees were examined during their demonstration of hypoxia. During their lessons subjects were asked to their voluntary participation in the study. Subjects were instrumented with HealthLab® devices; heat flux DoubleSensors for measuring body core temperature (one on the forehead, second on the chest), O_2-saturation, and ECG electrodes were put to the skin; standard monitoring procedure (ECG, heart frequency, O_2-saturation) was not influenced. The "flight" profile was a standard procedure, including an adaptation period of 4.000ft, followed by a 25.000ft with the first hypoxia demonstration and thereafter by 18.000ft the next hypoxia and darkness demonstration.

Results: 24 healthy subjects (w/m = 4/20), 35.5 ± 10.3 years, weight 79.4 ± 14.0 kg, height 179.4 ± 6.7 cm, and BMI 24.6 ± 3.7 kg/m² were examined. In 60% of subjects the subjective symptom "heat flow" from the extremities to the body or to the head was reported. On the measurements of the DoubleSensor: for the chest it was seen that only 30% of the temperature showed an increase. Moreover, on the head the temperature increased in nearly 60% of the subjects and sometimes more than 1.5°C. During the re-oxygenation and normalization of saturation the body core temperature on the head has decreased and became normal.

Discussion: The continuous measurement of the body core temperature on the head with the DoubleSensor has shown an increase during hypoxia and a decrease after returning to normal saturation, which has objectified the subjective symptom. Increasing brain temperature has an impact in human performance, cognitive function and induces fatigue. Recently, it has been shown that passive hyperthermia has impairment in cognitive function and is task dependent (Gaoua 2011). That implements, if body core temperature increases during hypoxia, it has also an impact in the cognitive function and probably promote fatigue (Nybo 2001). A further question: Does an addition of two environmental conditions (hypoxia and high temperature) will have a potential effect?