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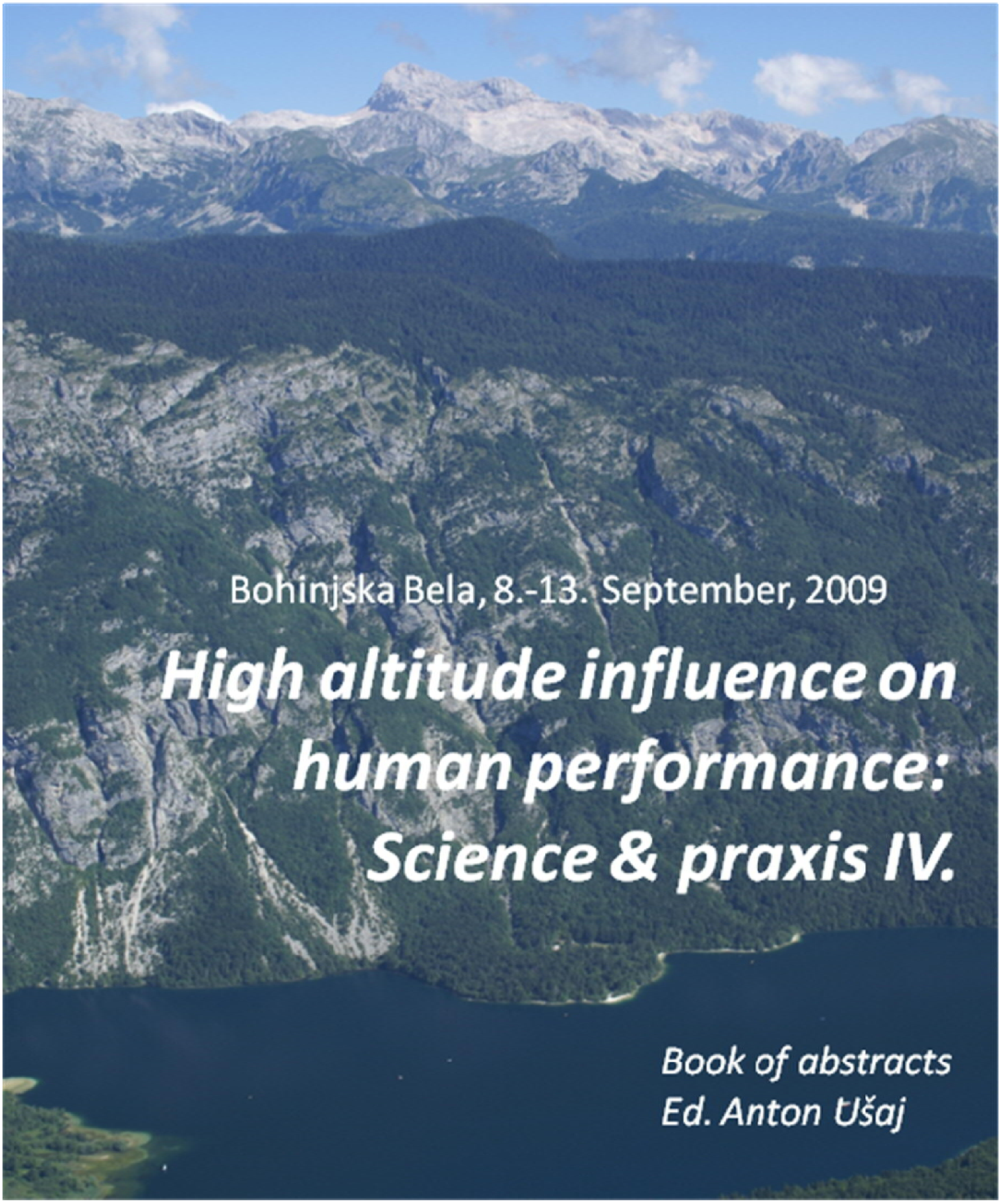

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4th International Symposium

High altitude influence on human performance:Science & praxis IV.

BOOK OF ABSTRACTS

Bohinjska Bela, 8. – 13. September 2009

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- Markus Tannheimer

PROGRAMME

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Mountain School of the Slovenian Armed Forces – SAF

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* Invited speakers

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Friday, 11th September

Basic & Applied Physiology

Sport Physiology

Altitude, Hypoxia, Exercise and Training. How We are Interesting in?

A.Ušaj

Laboratory of Biodynamics, Faculty of Sport, University of Ljubljana, Ljubljana, Slovenia

Key words: endurance, hypoxia, acclimatization, deacclimatization,

According to our basic interest in endurance, the part of our interest is also related to altitude, which we observe from the several points of view.

LOW ALTITUDE (< 1500 m). Usually there are no existing problems related to hypoxia during exercise. However, during maximal exercise performed by large muscle mass, the exercise induced arterial hypoxemia (EIAH) and hyperventilation induced hypocapnia occurs. Both may impair on redistribution of blood flow and regional hypoxia which may accompany fatigue. Does training somehow improved such problems related to "normoxic hypoxia" is one of our interest. What kind of training can improve climber's endurance performance and what metabolic adaptations represent the background for such performance is our interest of observations, too.

MODERATE ALTITUDE (1500 – 3000 m). During resting there is no significant hypoxia occurred probably because of hypoxic ventilatory response, which occurs at the more sensitive subjects. During exercise, the typically changes occurs. We are interesting in intensity of these changes in relation to exercise intensity and endurance performance. We are looking whether blood oxygen arterial saturation changes are matched by brain and exercising muscle deoxygenation. EIAH and hyperventilation induced hypocapnia. The combination of their influence may be important factor, which can reduce performance in such altitude during intense exercise. On the other hand, we are also observing how "altitude training" affects competition results when subjects compete at altitude, or at sea level. Adaptations, that occur during period of several days to weeks of living, training, and especially military activities, are our interest. What kind of preparations (acclimatization and training) are the most effective for such activities is our interest.

HIGH ALTITUDE (3550- 5500 m). Living at such altitudes significantly influenced organism even at rest, which caused acclimatization. Classically competitions in endurance events were not performed at these environmental conditions because they reduced dramatically performance. Therefore, it is not surprised that mountaineering, trekking and alpinist climbing were not developed in "racing" but successful completion of the planed activity. During such activities, the acclimatization is necessary. This phenomenon is not matched by endurance performance and aerobic power of subjects, respectively. Deacclimatization after high-altitude exercising and living is not simple reverse process of acclimatization. Our interest is to follow the deaclimatization process to assess the adequate moment for reacclimatization, which is especially important in high-altitude military and rescue operations.

EXTREME ALTITUDE (5500 – 8848 m). During such environmental conditions, acclimatization is no longer as effective as at high-altitude. Especially at altitudes > 7000 m alpinists cannot live for a more than several hours without danger for their health and even for their lives. Dramatic changes in body structure and functioning were recognized also in a longer period of deacclimatization during returning to sea-level.

High Altitude Adaptation in the Respiratory Control System

A Mathematical Model Study

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Key words: hypoxia, chemoreflex control of breathing, acid-base balance, strong ion difference, 2,3 DPG.

Introduction: Our interactive personal computer based mathematical model for the oxygen transport uses clinical and laboratory data for the purpose of simulation of physiological and pathophysiological states, and is based on the known kinetic principles to describe transport of blood gases in human body from the outer atmosphere to different tissues[1]. Recently, the model was upgraded to include the influence of acid-base balance in the chemoreflex control of breathing[2], as well as the influence of hypoxia on the peripheral blood flow[3]. With such model we simulated adaptation of breathing to the prolonged hypoxia to find which of the known compensatory mechanism is most effective.

Material and methods: The model is composed of four compartments for transport of blood gases (O_2 and CO_2): airways, alveolo - capillary interface, the blood and the blood vessels, and the Krogh cylinder for blood gas exchange in tissues. With the model, it is possible to change interactively in real-time different parameters that are accessible from clinical and laboratory measurements to monitor the arterial oxygen saturation and blood CO_2 levels. Thus, it is possible to vary the gas composition and the barometric pressure, alveolar ventilation, diffusion capacity of the lungs, blood hemoglobin concentration, plasma protein concentration (both affect pH), blood perfusion of different tissues (so far we use 6 different tissues), specific tissue metabolism and the tissue capillary density. In addition, it is possible to vary strong ion difference (SID) in the blood plasma and cerebrospinal liquor, or to change the concentration of 2,3DPG in the erythrocytes.

Results: The most effective adaptation measure to reduce effects of hypoxia were found to be changes of brain SID and acidification of blood due to bicarbonate excretion by kidneys, whereas substantial changes in 2,3 DPG in the blood inexpectedly reduced the efficiency oxygen transport to tissues, particularly after acid-base adaptation has already reached

Conclusions: The model enables understanding of integrative function of respiratory adaptation and suggests direction of the experimental studies connected with hypoxia.

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Coordination During Acute Isobaric Hypoxia without Exercise Corresponding to Altitudes until 4500 m*

M. Schwager[1], S. Claus[2], H. Claus[2] and H.-V. Ulmer[1]

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Key words: coordination, mountaineering,

Introduction: A previous study (expert interviews, 1) underlined the thesis, that not only metabolic, but also motor aspects of hypoxia could be relevant for mountaineering in medium altitudes. Therefore we examined coordination by 2 new tests, orientated on tasks typical for mountaineering with exclusion of metabolic aspects/physical fatigue.

Methods: 9 subjects (5 female, 4 male, students with inconspicuous Hb-values), sitting in a chair, performed after a pretest-training the following tests: 1) Handling snap hooks, 2) handling a rope. Isobaric hypoxia was generated (Hypoxico, USA) for 10 min. each, corresponded to low level, 2500, 3500 and 4500 m in a systematically changing order, with one repetition and a control series (low level). Measurements of needed test-time, inspiratory O_2-concentration, heart rate and Hb-saturation (fingerclip oxymeter).

Preliminary Results: Until simulated 4500 m only small increase of needed test-times could be observed (table 1)

Table 1.
Needed test times (s) for test 1(handling snap hooks) and test 2 (handling a rope), n = 9, means ± s_D

High	ca. 0 m	ca. 2.500 m.	ca. 3.500 m	ca. 4.500 m	ca. 0 m
Test 1	13,1 ± 1,2	14,0 ± 1,7	13,9 ± 1,8	15,2 ± 2,4	12,9 ± 1,5
Test 2	28,6 ± 3,4	29,2 ± 3,7	29,9 ± 3,9	31,8 ± 3,9	27,0 ± 3,4

Conclusions: The results underline, that – by regarding the means of the test-times – the coordination is only lightly affected by acute hypoxia until altitudes typical for European regions. A stronger negative effect on coordination might be possible, if additional intensive physical exercise is performed.

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Acknowledgment: The authors are very obliged to Mrs. Dr. E. Lachtermann (department of sports medicine, institute for sports sciences, Johannes Gutenberg-Universität, Mainz, Germany) for Hb-measurements

*first results of a magister-thesis, Johannes Gutenberg-university Mainz

Correct Measurement of Oxygen Saturation at Altitude

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Key words: pulse oxymetry, measurements, accuracy

Introduction: Oxygen saturation (SaO_2) measured by pulse oximetry is widely used in the assessment of high altitude disease and acclimatization process. Compared to measurements at sea level the measurement at altitude differs fundamentally because of the cyclical course of SaO_2 provoked by Cheyne Stokes breathing. Therefore, the determination of a representative value is difficult and possibly biased.

The key question is: does the visually determined SaO_2 value correlate to the actual average of the measurement interval?

Material and methods: During the expedition to Yasghil Sar (6350m; Pakistan) SaO_2 was measured daily, sometimes several times a day (128 measurements in 16 days), using a pulse-oximeter with memory function. The used device (PalmSat 2500®; Nonin) memorizes the value for SaO_2 and pulse every 4 seconds. The four participants, familiar with pulse oximetry at altitude, wrote down a representative measurement value according to their individual observation. The evaluation and the comparison of these visually determined values with the memorized values was done after finishing the expedition.

Results: The visually determinate values differ only marginally (-0.4 %-points; ± 0.83) compared to the average of the measurement interval memorized by the pulse-oximeter device. The average interval time was 143 ± 48 sec; this is enough to determine a representative value. The spread of the single values within the measurement interval is high (in single cases up to 17%-points) in case of insufficient acclimatization. With increasing acclimatization, the values converge, especially after summiting.

Discussion. Because of the typical fluctuations at altitude pulseoximetrical measurements requires an experienced investigator. Anyway the measurements have to be done in the continuous mode of the used pulse-oximeter to ensure a sufficient timeframe over 3-4 cycles, meaning a single measurement of SaO_2 at rest takes round about two minutes. Ideally a pulse-oximeter device with memory function should be used to allow a reevaluation later. To counteract a too “optimistic” visual~~ly~~ determination of the representative value we recommend to record the maximum and the minimum value of the prevailing interval. If proceeding acclimatization leads to a (almost) stable SaO_2-value the measurements can be performed identically to measurements at sea level with shorter measuring time respectively.

Oxidative Stress at High Altitude

B. Haditsch, A. Rössler, H. Frisch, H. Hinghofer-Szalkay, J. Greilberger, K. Oettl

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Key words: carbonyl groups, malonedialdehyde, antioxidative status.

Introduction: Oxidative stress, an imbalance between pro- and antioxidative mechanisms, is involved in the developement of different diseases and metabolic disorders. In addition physical activity as well as exposition to hypoxic conditions cause oxidative stress.
Aim of this study was to determine parameters for oxidative stress during a high altitude (HA) sojourn.
Material and methods: After a baseline examination at low altitude (LA, Herxheim, 150m) 33 subjects (16 female, aged 19 –65 yrs) were examined on the 3rd day (HA-1, Namche Bazar, 3440m) and on the 14th day (HA-2, Lobuche, 5050m) of HA sojourn. Moreover, the same parameters of 7 HA natives were investigated. We determined malonedialdehyde (MDA) which reflects the lipid peroxidation and the content of carbonyl groups (CP) of the serum proteins as an indicator of protein damage. Furthermore the total antioxidative status (TAS), uric acid and C-reaktive protein (CRP) were measured.
Results: During acclimatisation CP was increased (HA-1 vs. LA) but decreased significantly below baseline level at HA-2. Similarily CRP was increased at HA-1 and reached baseline levels at HA-2. In contrast, MDA did not change significantly at HA-1 but was decreased below baseline at HA-2. Both, TAS and uric acid did not change at HA-1 but increased significantly at HA-2. CP, MDA, TAS and uric acid were different at baseline compared to native persons and were no more different at HA-2.
Conclusions: Oxidative stress in high altitude is found during acclimatisation. However, different oxidative stress parameters may respond differently. The found protein modification may have an inflammatory background. After acclimatisation parameters converged the values of native persons. Our data underline the necessity of measuring several paramters to get a correct idea of oxidative stress.

Acknowledgement: This study was supported by the government of Styria and the government of Graz, by a grant of the Friedrich Schmiedl Foundation and a grant of the Lanyar Foundation, by GlaxoSmithKline Austria and by the TravelMedCenter Leonding/Austria.

Borg Scale at High Altitude

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Introduction: The Borg Scale for perceived exertion is well established for athletes and also patients during their recovery training. It assists them to estimate their rating of perceived exertion during their training and therefore to keep an appropriate level of intensity. Although the Borg-Scale is also commonly used for altitude training, it has never been evaluated before, whether it is valid at the very different conditions of high altitude. Furthermore it was never investigated, which factor(s) is / are most important for the individual to rate the exertion.
Material and Methods: 16 mountaineers were included In a randomised cross-over design. The individuals were measured at sea level, at 3000m and at 4559m. At each altitude the following procedure was performed: spiro-ergometry with a modified Hollmann scheme (starting at 40W, +40W every 3 min. until exhaustion). At the end of each section the subjects were asked to rate their perceived exertion with the Borg-Scale and several cardio-respiratory parameters such as blood pressure, heart-rate, lactate etc. were recorded. The validation of the scale at the different altitudes was done by Bland-Altmann-Plots: the Borg ratings of two altitudes were compared for each intensity level. For the analysis of the factors responsible for the rating a model of covariance analysis between each parameter and the Borg rating was used. $P<0.05$ was defined as significant.
Results: More than 95% of all Borg ratings were within the interval of 1.96x standard deviation. The covariance model showed the blood pressure with $P=0.0356$ as the parameter with the highest influence on the rating of exertion.
Conclusions: 1. Borg-Scale is valid at high altitude and therefore can be used during physical exercise at any altitude. 2. The most important factor for the rating is the (increase of blood) pressure.

The Influence of Hypoxia on Arterial, Muscle & Brain Oxygenation before ond after 2008 Peak Lenin Expedition

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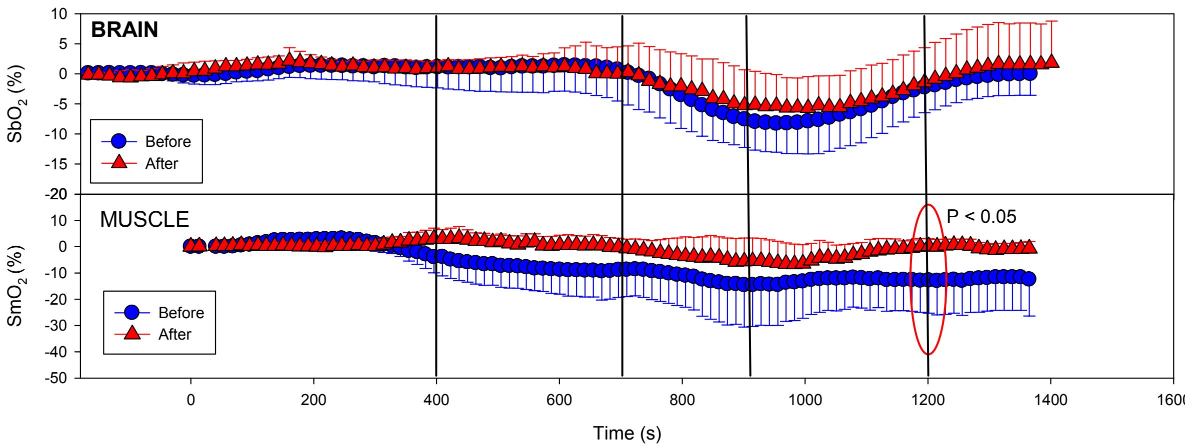
Key words: pulse oxymetry, NIRS,

Introduction: High-altitude alpinist expedition influences on several characteristics of structure and functioning of organism, which persists for a certain time interval also after returning to normoxic conditions. Our previous experience have shown that oxygen saturation remain elevated during hypoxic condition exercise as that before expedition to 8000m. Therefore, the aim of the study was to ascertain, whether the blood, brain and/or leg oxygenation were somehow differently oxygenated after Peak Lenin alpinist expedition compared to pre-expedition values.

Material and methods: Six males 35±5 yrs, 173±6 cm, 72±5 kg, participated in the study before and after high-altitude alpinist expedition. They performed continuous exercise on electrically braked cycle ergometer (Ergoline 960, Sensor Medics, USA) for 5 min at W/kg, followed by 3 min at the same exercise intensity but with additional hypoxia (FiO_2= 0.15), and final time interval (5-6 min) of the same intensity, but normoxic conditions as during first 5 min. Arterial oxygenation was measured by using pulse oxymeter (Ohmeda, Switzerland). The muscle and brain oxygenation was measured by near infrared spectroscope (ISS, USA). Data were compared by using ANOVA for repeated measurements.

Results: showed that living and climbing for about a month did not influenced arterial oxygen saturation (SaO_2) differently, when compared results before and after expedition. Saturation decreased from 95±3 % to 82±3 % during hypoxia before expedition, and from 94±3 % to 84±4 % during hypoxia after expedition. Relative brain oxygen saturation (SbO_2) decreased ($P<0.05$) from -0.8±5 to -8.3±5 % before and from -1.2±6 to -5.6±5 % ($P<0.05$) after expedition without any significant acclimatization or training effect. Relative muscle oxygen saturation (SmO_2) did not decrease significantly due to acute hypoxia, neither before nor after expedition. However, a clear tendency of SmO_2 to be higher throughout the test after the expedition resulted in significant difference in post hypoxic interval at 1200 s ($P<0.05$). SmO_2 reached -12.7±13 before and 0.1±2.6 % ($P<=0.05$) after expedition.



Conclusions: The high-altitude alpinist expedition resulted in significantly higher post hypoxic muscle, but not brain oxygen saturation. A clear tendency was presented that only muscles may be more oxygenated throughout the whole test.

The Influence of High Altitude Alpinist Expedition on Organism´s Response during Similar Submaximal Exercise at Normoxic and Hypoxic Conditions

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Key words: deacclimatization, acid-base, lactate, oxygen saturation,

Introduction: The aim of the study was to ascertain alterations reached during testing in normoxic and hypoxic conditions, before and a month after high-altitude alpinist expedition.
Material and methods: Four males 45±8 yrs, 171±9 cm, 75±5 kg, participated in the study before and after high-altitude alpinist expedition. They performed four incremental exercise testing protocols on cycle ergometer (Monark, Sweden): two before expedition and two after it. They were similar according to increase of exercise intensity (40W/4 min) but two were performed in normoxic and two in hypoxic (FiO_2= 0.15) conditions. Arterial oxygen saturation (SaO_2) was measured by using pulse oxymeter (Ohmeda, Switzerland), acid-base status of capillary blood by using ABL5 (Radiometer, Denmark), lactate concentration ([LA]) by LP 40 Photometer (dr. Lange, Germany). Heart rate (HR) was measured by Vantage NV (Polar, Finland) heart rate meter and ventilation (Ve) by Metamax Plus II (Cortex, Germany). Data were compared at similar absolute exercise intensity of 180 W, by observing individual results and by using paired T-test.
Results: Results showed that living and climbing for about a month decreased body weight, which was by about 8 kg ($P<0.06$) lower than pre-expedition. This increased relative exercise intensity at 180 W. HR was similar pre- (144±17 during normoxic and 146±19 min^{-1} during hypoxic conditions) and post-expedition (145±14 during normoxic and 148±16 min^{-1} during hypoxic conditions) irrespectively of increased relative exercise intensity. Pre-expedition Ve (71±8 during normoxia and 101±13 l/min during hypoxia ($P<0.05$)) increased ($P<0.05$) at 180 W, to 90±15 at normoxic and 111±21 l/min during hypoxic conditions ($P<0.05$) post-expedition. [LA] increased from 1.3±0.3 to 3.1±1.4 mmol/l in normoxic conditions ($P<0.05$) pre-, but remained similar at post-expedition testing (2.4±1.2 during normoxic and 1.7±0.6 mmol/l) during hypoxic testing in spite to clear tendency to be reduced. SaO_2 decreased to 89±2 % pre- and to 92±2 % ($P<0.01$) during post-expedition testing in hypoxia.
Conclusions: The acclimatization, training and nutritional effects reached during high-altitude alpinist expedition have remained detected also a month after returning from expedition. Alterations based on different mechanisms. By using normoxic and hypoxic testing, the clear acclimatization effect has been detected by alterations in SaO_2. Differently, unchanged HR seems to be influenced by increased relative exercise intensity and endurance training effect. It seems that training effect, which reduced HR has been balanced by HR increase caused by increased relatively exercise intensity. Ventilation increased due to increased relative exercise intensity at 180 W, but we have not possibility to estimate if any training effect on respiratory muscles existed. [LA] alterations during exercise in hypoxic conditions showed clear tendency for reduction after expedition, probably due to acclimatization and training effect. This seems to be more powerful than increase of lactate production by increased relative exercise intensity.

High CO_2 Atmosphere Exercise Performance and Ventilation in Coal-Mine Workers

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Keywords: exercise endurance, minute ventilation, hypercapnic ventilation

Introduction: Workers in deep underground coal mines are exposed to different atmosphere conditions at excavation points, that may limit their exercise performance and influence health. CO_2 and dimethy sulphide are the most important gasses that appear in Slovenian Velenje coal mine. We tested the hypothesis, that coal mine atmosphere significantly influences workers' performance at work, gas exchange in their lungs and oxygenation status of the blood.

Material and Methods: 80 healthy coal mine workers, that work al least 20 years at excavation point, were included in the study. Ventilatory parameters, diffusion capacity of the lungs and Masters Endurance step test with additional load was performed outside the mine and during the next week in the mine at excavation point. Results were analyzed as pair of data for the whole group (paired T test).

Results: No differences in ventilation or exercise performance were noted at excavation point if atmosphere CO_2 was below 1.2%. Above that value, ventilation for the same level of exercise increased for 11% and the overall exercise performance decreased for 11%. No chronic acid-base changes in blood were noted, spirometry was identical in both atmospheres.

Conclusion: High CO_2 atmosphere imposes an extra load to ventilation and exercise performance in a coal mine. No long term consequences in ventilatory function or lung gas exchange were noted.

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The Influence of Altitude Training on Selected Blood Parameters and Lactate Curves During Swimming

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Key words: moderate altitude, aerobic threshold, OBLA threshold

Introduction: Moderate altitude training (approximately 1800 to 2600 m) has become popular to improve competition performance in swimming both at altitude and sea level. When swimmers are exposed acutely to moderate altitude, a number of physiological responses occur that can comprise performance at altitude; these include increased ventilation, increased heart rate, decreased stroke volume, reduced plasma volume, and lower maximal aerobic power. The aim of the present study was to examine the influence of moderate altitude training on lactate curve during three weeks and after the exposure to altitude training at 1800 m (La Loma, Mexico). We also examined the effects of altitude training on selected blood parameters before and after the training at altitude.

Material and methods: In the study participated four (1 men, 3 women) high competition-level swimmers (mean ± SD; age 21 ± 1.2 years, height 173 ± 5 cm, weight 66 ± 9 kg). All swimmers trained 6 days per week, 2 training sessions per day, for 3 weeks at altitude 1800 m. All swimmers performed 5 times standardized test 5x3x200m to obtain velocities and heart rates at lactate thresholds and OBLA thresholds (before, three times on altitude and after altitude exposure). Blood samples for hemogram analysis were taken before and after exposure to altitude.

Results: No signifficant differences were found in selected blood parameters before and after exposure to altitude training. No signifficant differences were found in both thresholds (lactate threshold and OBLA threshold). Heart rate values on thresholds velocities were also unchanged.

	Before	1. Altitude	2. Altitude	3. Altitude	After
v_{LT} (m x s^{-1})	1,38±0,09	1,38±0,06	1,37±0,06	1,38±0,06	1,41±0,09
$[LA]_{LT}$	1,6±0,3	1,5±0,5	1,4±0,2	1,4±0,4	1,6±0,3
HR_{LT} (b x min^{-1})	161,5±7	161,7±4	159,5±4	159,5±7	164,2±4
v_{OBLA} (m x s^{-1})	1,43±0,09	1,42±0,06	1,41±0,07	1,42±0,06	1,45±0,09
HR_{OBLA}(b x min^{-1})	171,0±7	172,5±2	172,00±4	172,0±6	173,7±3
K-Erci	4,82±0,27	-	-	-	4,71±0,35
K-Hb	143,50±9,26	-	-	-	143,25±12,45
K-Hat	0,44±0,03	-	-	-	0,43±0,03

Conclusions: Selected training on moderate altitude surprisingly didn't influenced on lactate curves during three weeks of exposure to altitude, neither on the lactate curves after the altitude exposure. Selected blood parameters which influence oxygen transport capacity of blood were also unchanged after altitude exposure in comparision to sea levels before the altitude training.

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Evaluation of Training Protocols for the Improvement of Altitude and Sea Level Performance

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Key words: endurance, intermittent hypoxia, respiratory muscle training, live low-train high

Introduction: Endurance athletes regularly employ different training protocols for improvement of athletic performance. The aim of the present study was to evaluate the effects of three short-duration training protocols on endurance performance in normoxic and hypoxic condition.

Material and methods: Healthy male subjects (N=36) were assigned to either a control (CON), Live Low-Train High (LL-TH), Intermittent Hypoxic Exposure at rest (IHE) or Respiratory Muscle Training (RMT) group. Each subject performed endurance exercise training on a cycle ergometer 1-hour daily (5 times per week). The exercise intensity was maintained such that the heart rate was at a level corresponding to 50% of peak power output determined prior to the onset of the training. Subjects in the CON group trained at ambient (normoxic) conditions, whereas subjects in the LL-TH group performed their training at the same relative intensity in a climatic chamber in which the oxygen content was regulated at 12%. The RMT group performed 30 minutes of endurance respiratory muscle training prior to exercise training, and the IHE group performed 1-h of intervals exposures between hypoxic (5-min) and normoxic (3-min) air breathing. Prior to, during, upon completion and 10 days after of the training program, subjects' aerobic capacity ($\dot{V}O_{2max}$) and endurance performance was determined under normoxic and hypoxic conditions. At the same periods, hematological tests were also performed.

Results: Similar improvements were shown in normoxic endurance performance in all groups. Similarly, all groups showed improvements in normoxic $\dot{V}O_{2max}$, except for the LL-TH group. Only the CON and the IHE group showed improvements in normoxic PPO, whereas the RMT group showed significant increase in hypoxic $\dot{V}O_{2max}$ at the POST testing. There were no changes in selected hematological parameters within or between groups.

Conclusions: In conclusion, our results did not show significant beneficial effects of any of the training modality compared to control group.

The Influence of Endurance Training on Performance at Moderate Altitudes

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Key words: hipoxia, VO_2max, treadmill, O_2 saturation, mountaineering

Introduction: Endurance sport activities on high altitude are because of lower partial oxygen pressure reduced. Reduction depands primarly on altitude and fittnes, and less on process of aclimatization. Maximal oxygen consumption - VO_2max is the most often used factor in valueating endurance performance. VO_2max should also play an important role in conditions of high altitude, eg. lower oxygen partial pressure. The main purpose of this final thesis was to research more closely the influence of endurance training (interval training) on the factors of endurance especially VO_2max at walking on the treadmill and on high altitude (2000 m).

Material and methods: Experimental (N=8, 23±3 years, 76±10 kg, 180±5 cm) and control (N=8, 25±3 years, 80±11 kg, 184±8 cm) group performed initially a multistage walking test on treadmill for assessment of VO_2max and competition in uphill walking in mountains at altitude of 2000 m (additional weight of 15 kg). Experimental group participated in running training lasting 8 weeks (4 times a week), which included training tips of maximal effort: 10x200 m, 8x400 m and 5x1000 m.

Results: Velocity of running was improved in experimental group for 11 % at 1000 m and 400 m training distance, and for 6 % at 200 m. After the training the individuals were able to walk longer periods of time and on the higher slope level on the treadmill at sea-level. Under this conditions VO_2max was raised from 49±6 to 54±7 $ml/min \cdot kg^{-1}$. Also some other observed endurance factors improved at the same time. Individuals participating in this research were able to ascent in natural conditions on moderate altitude faster than before.

Additionally it was proved that those individuals who made progress on VO_{2max} reached higher changes of uphill walking (R = 0,77). A similar thing was found out for the speed of running (1000 m, R = 0,78) and the duration of treadmill (R = 0,87). Similarly individuals who showed better results with above stated factors made bigger changes in uphill walking velocity.

Conclusions: The data suggested that the speed of running, VO_2max, and the speed of uphill walking in natural conditions on nidearte altitude (2000 m) were affected due to 8-weeks long high intensive interval training.

Inhomogeneity of Capacity Requirements and their Risks on Commercially Guided Ski Tours with Leisure Sports-Orientated Ski Tour Participants

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Key words cardial and metabolic variability extent, group-internal effort-inhomogeneity, safety risk

Introduction: With the increase of ski touring´s popularity the number of people taking part in commercial ski touring for leisure rises as well – in europe 20 mills.(Zeitler, 2006). With regard to the state of capacity, organizers strive for a group-composition as homogenous as possible to reduce safety risks. Therefore they announce detailed tour descriptions including special difficulties on their homepages, for example. The decision to be suitable to a ski tour´s requirements is left up to the frequently inexperienced competitioners themselves and therefore to a layperson. Question: Do the tour descriptions announced by the organizer present sufficient information in order to reduce the individual´s and the group´s safety risks by a selfreliant assessment of capacity? Assessment of the group-internal degree of inhomogeneity concerning the physical capacity during ascents of commercially guided ski tours.

Materials and methods: During three commercial ski tours (T_1: n= 6, T_2: n=5, T_3: n=10) arbitrarily chosen participants by fours (total n=12) were surveyed while their ascents from 1680m up to 3180m above sea-level to judge the capacity of leisure sport-orientated ski tour participants. Regarding the physical strain, both average heart rate and lactate values were surveyed . Subjectively perceived exertion levels were rated on an modified RPE-scale (1-15). As degree of inhomogeneity the coefficient of variation V was calculated.

Results: The average cardial strain inhomogeneity during the ascents is relatively low (T_1: $\bar{V}$= 6,1%, T_2: $\bar{V}$ = 4,5%, T_3: $\bar{V}$ = 4,4%), in contrast the metabolic strain inhomogeneity is relatively high (T_1: $\bar{V}$ = 42,6%, T_2: $\bar{V}$ = 35,7%, T_3: $\bar{V}$ = 46,7%). 32,2% of all lactate values exceed the 4mmol/l lactate threshold. There is a distinct degree of inhomogeneity of perceived exertion during the ascents as well (T_1: $\bar{V}$= 23,4%, T_2: $\bar{V}$= 12,4%, T_3: $\bar{V}$= 23,0%).

Conclusions: An explanation for the considerable degree of inhomogeneity in same conditions could probably be that several tour probands made a blatant misjudgement of their capacity requirements reffering to the tour description. Such a self-overestimation implies potential safety risks for individual participants and the collective group. Such a self-overestimation implies potential safety risks for individual participants and the collective group (Pollard et al., 2007). Obviously, a detailed pre-description for ski tour enthousiasts does not last out a satisfactiory homogeneity of capacity within a ski touring group.

Suggested solutions: 1) for the responsible organizers/mountain guides: Performance test under real conditions with all participants in the forefront of a ski tour (f.e. probational ski tour on the 1st day) and an adaption to the group´s current state of capacity afterwards.

2) An appeal to all participants: Truthful self-estimation of one´s state of capacity and aviodance of fake ambition at the interpretation of the tour description.

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Dynamic Loading of Climbers Through the Interaction with the Climbing Rope

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Key words: impulse loading, dynamic rope, rope's durability, climber safety.

Introduction: The quality of climbing ropes is determined by two parameters, i.e. climber safety and durability of the rope [1]. Durability in this case does not mean just failure of the rope, but rather deterioration of its time-dependent response when exposed to an impact force. Both parameters are governed by time-dependent properties of the material from which ropes are manufactured. The experiments prescribed by the UIAA (Union Internationale des Associations d'Alpinisme) standard [2] are not geared to analyze the time-dependent deformation process of the rope, which causes structural changes in the material and consequently affects its durability. This abstract summarizes the basics of the comprehensive dynamic analysis of a simple non-standard falling weight experiment, which allows examination of the time-dependent behavior of ropes exposed to arbitrary falling weight loading conditions.

Material and methods: Dynamic analysis of a simple non-falling weight experiment can be successfully applied for calculation of several important characteristics, such as the impact force on the rope, max. deformation of the rope, derivative of (de)acceleration, dissipated energy, etc. during the loading and unloading of the rope. All those parameters can be determined just from a single dynamic response of the rope exposed to impulse loading [3].

Results: The ropes from three different commercial manufacturers, identified as R1, R2, and R3, were exposed to the same loading conditions. Calculated mechanical properties of all three ropes were then compared using the developed methodology – dynamic analysis [3].

In Fig. 1 it is shown that the rope R2 has 35% bigger maximum derivative of (de)acceleration after the tenth fall in comparison to R1 and R3, so rope R2 may be considered as more dangerous for the climbers then the two others.

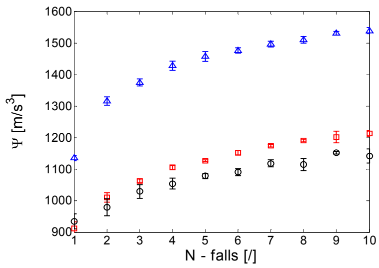

Figure 1. The derivative of (de)acceleration as function of number of falls: □ - rope R1, △ - rope R2, ○ - rope R3.

Conclusions: By using newly developed experimental-analytical methodology we are able to analyze the time-dependent behavior of ropes under impact loading. As the comparison analysis of three different ropes, which according to existing UIAA standard belong to the same quality class and are declared to have the same UIAA standard characteristics, shows, that ropes from three different commercial manufacturers exhibit significantly different behavior when they are exposed to the same impact loading conditions.

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Some Metabolic Responses to Reduced Breathing Frequency During Constant Load Exercise

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Key words: hypoxia, hypercapnia, constant load bicycle exercise, blood lactate.

Introduction: Hypoxia has not been detected only during altitude exercise but also during specific conditions during exercise at sea level, such as exercise with reduced breathing frequency (RBF). Training with RBF is often referred to as "hypoxic training". It was thought that, by limiting inspired air, the reduction of oxygen available for muscular work would result and therefore cause muscle hypoxia, similar to that experienced at altitude (Kedrowski, 1979). Therefore, the purpose of this study was to examine the possible effect of RBF on ventilatory parameters (V_E, V_T), blood gases (Po_2, Pco_2), oxygen saturation (SaO_2) and some metabolic responses (Vo_2 and [LA]) during the constant load exercise to exhaustion.

Material and methods: Eight healthy male subjects (age 25 ± 1 years, height 181 ± 3 cm, weight 80 ± 7 kg and Vo_2peak 44,26 ± 2,93 ml/kg/min) performed an incremental cycling test with RBF at 10 breaths per minute. A constant load test with RBF (B10) was then performed to exhaustion at the peak power output obtained during the incremental test. Finally, the subjects repeated the constant load test with spontaneous breathing (SB) using the same protocol as B10.

Results: Reduced breathing frequency (RBF) during the constant load exercise resulted in a profound reduction in V_E ($p \leq 0.01$), when compared to spontaneous breathing, despite significantly increases in V_T ($p \leq 0.01$). Consequently, there were significantly lower SaO_2 and Po_2 ($p \leq 0.01$) and higher Pco_2 during B10 than during SB ($p \leq 0.01$). However, there were no significant differences in Vo_2 and [LA] between different breathing conditions.

Conclusions: Therefore it may be concluded that RBF during the constant load exercise induced marked hypoventilation and consequently hypoxia and hypercapnia. However, it seemed that this degree of breathing reduction did not influence on aerobic metabolism due to unchanged Vo_2 and [LA].

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Individual Reaction to acute Hypoxia-Symptoms of Jet Fighter Pilots and High Altitude Parachutists

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Key words: high altitude training, reaction time, pulse-oxymetry.

Introduction: High altitude training in a low pressure chamber is a mandatory task in NATO for each military person who takes part in high altitude air traffic. It was presumed that fast jet fighter pilots, all of them full ranked officers, might react more sensitively on hypoxia symptoms than high altitude parachutists, most of them enlisted soldiers with quite a different education in military behaviour. The aim of the study was to compare reaction times from both groups to verify or deny the hypothesis.
Material and methods: A practical part of the physiological training of military aircrew and high altitude parachutists in Koenigsbrueck is the experience of moderate and acute hypoxia in the high altitude chamber. There the trainees should recognise their own typical hypoxia symptoms, when breathing 21% oxygen breathing gas in a pressure altitude of 25.000 ft (7600m) after disconnection from 100% oxygen breathing gas. Aim of the training is, that they should realise their subjective oxygen deficiency symptoms early enough, to avoid acute hypoxia and avoid incapacitation to act properly in the chamber during training as well in the cockpit or during descend with the parachute. The proper reaction in the chamber should be the announcement of the personal feelings to hypoxia symptoms and the reconnection to 100% oxygen breathing gas. During all the time pulse oxymetry will be measured continuously. The time between disconnection and reaction with the first hypoxia symptoms and the equivalent level of peripheral oxygen saturation of the trainees were recorded and statistically compared.
Results: Hypoxia symptoms of both groups don't differ statistically. But parachutists are used to stay a longer time in hypoxia than jet pilots. Typically jet pilots reconnect themselves to 100% oxygen in an earlier phase of decreasing blood oxygen saturation than parachutists, even first hypoxia symptoms are recognised in the same time. Often the reconnection to 100% of the parachutists must be demanded by the instructor outside the chamber, when the oxygen saturation dropped to 70%. The oxygen saturation level 70%, the medically limit of hypoxia demonstration, was reached between 120 and 270 s after separation from 100% oxygen breathing gas.
Conclusions: Jet pilots are used to procedure training, if oxygen deficiency symptoms may occur: they learned to switch immediately to 100% oxygen in the cockpit. Therefore they would perhaps avoid acute hypoxia even during training in the altitude chamber. High altitude parachutists are more likely curious to realise real hypoxia more or less also in a matter of competition with the other trainees.

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Medical Considerations in the use of Helicopters in Mountain Rescue

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Key words: emergency medicine, wilderness medicine, rescue, mountain

Introduction: Patients in the mountains and wilderness are commonly subject to extended delays before being able to call for care, receiving care on site and being transported. In many cases of severe injury or illness, delay can compromise recovery or survival. Different regions have different rescue systems and also equipment types and availability of helicopters vary widely.
Material and methods: official guidelines of the International Commission for Mountain Emergency Medicine ICAR MEDCOM will be presented. These are suggested minimal requirements for competent and safe response to medical problems in the mountain environment. The goal is to provide the "highest level of care available" of capable helicopter, crew, rescuer and medical provider for that response area, and to simultaneously work towards improving that level of care to meet or exceed ICAR recommendations.
Results: The outcome of patient care can be dramatically improved by bringing rapid rescue-medical care to the mountain rescue scene (bringing medical care to the patient rather than the patient to medical care), and by rapid transport to a medical facility. The use of helicopter for these purposes is common. It is necessary when it has clear advantages for victims in comparison with ground rescue and transport.
Conclusions: Helicopters should work within the existing emergency medical system and must be staffed by appropriate mountain rescue and medically-trained personnel. Activation time should be as short as possible. Activation of a helicopter for a mountain rescue should primarily include indication and assessment of flight and safety conditions. No other mediators or delaying factors should be permitted. The main safety criteria are appropriate mountain rescue and flight training, competence of air and ground crews, radio communication between the air and ground crews, and mission briefing before the rescue. Criteria for a helicopter used for mountain rescue are proper medical and rescue equipment, load capacity, adequate space etc. There are two main groups of indications for use of a helicopter for mountain rescue – the patient's condition and the circumstances at the site of the accident. All persons responsible for the activation of the helicopter rescue operation should be aware of specific problems in the mountains or wilderness.

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Helicopter Mountain Rescue and Emergency Medicine Case Reports

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Key words: mountaineering, accidents

Introduction: growing interest in hiking, mountaineering and in so called »extreme« sports in mountainous areas means growing number of accidents which requires high quality rescue and emergency medical work.

Material and methods: 3 case reports from rescue missions with the help of helicopter in Slovenian mountains will be presented.

Results: First case report: two young, inadequately equipped climbers have been traped on the summit of Mangart in severe weather deterioration during winter. Because of bad weather and great avalanche danger classical terrestrial approach was unsuccessful despite of great effort and risk from ground mountain rescue teams. During the third day a helicopter rescue team finally, with extrem risk (fog, strong winds etc.) was able to reach the mountain and lower the doctor with the winch to the summit…

Second case report: four climbers have been trapped in one of the highest and steepest faces in Julian Alps – Loška stena, in winter. Uninjured, but exhausted and slightly hypothermic, they were not able to climb out of the face. After technically difficult helicopter rescue mission they have been saved successfully.

Third case report: 70 years old woman has fallen 40 m down the rocky gully in Julian Alps near Vršič pass. On duty helicopter rescue team of Mountain rescue association of Slovenia with experienced mountain rescue doctor performed fast rescue mission – on site treatment of severely injured victim, winching and flying her directly to the nearest hospital.

Conclusions: helicopter rescue and emergency medicine in difficult accessible places like mountains is usually much faster and more effective in comparison to ground approach and transport, but it is also dangerous and expensive. Careful balance between risk and safety together with rescue and medical skills of team members are of utmost importance for quality service.

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Human Powered Centrifuges on the Moon or Mars

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Key words. Microgravity, Cycling, Cardiovascular deconditioning

Introduction: Cycling on appropriately constructed tracks may help maintaining physical fitness and cardiovascular conditioning of crews living in permanently manned bases on the Moon or Mars. Indeed, cycling along a curved path induces a centrifugal acceleration vector (a_c): $a_c = s^2/R$ (1), where s is the ground speed and R the radius of curvature of the cyclist's path. Since a_c is applied horizontally outwards, the vectorial sum of ac and the constant acceleration of gravity lies in the plane which includes the centre of mass of the system and the points of contact between wheels and terrain. So, the resulting vector (g') can be calculated by simple geometry as: $g' = \sqrt{(g_M^2 + a_c^2)}$ (2), where g_M (= 1.62 m s^{-2} or 3.72 m s^{-2}) is the acceleration of gravity on the surface of the Moon or Mars. So, a cyclist riding a bicycle on a circular track generates a force acting in the head to feet direction which depends on the radius of the track and on the ground speed, and which can be expected to mimic the effects of gravity.

Results and Discussion: Based on the dimensions of the lunar station proposed by Grandl (2007), we propose to construct a circular "track tunnel" with a radius of 25 m. We show here that when cycling on this track tunnel at speeds between 10 and 15 m· s^{-1}, astronauts will generate a g vector acting along the head to feet axis ranging from 0.44 to 0.99 of the value prevailing on Earth. This state of affairs is presumed to counteract, on the one side muscle atrophy, on the other cardiovascular deconditioning that may result from long duration permanence in low gravity bases.

It goes without saying that, for the above described tracks to be operational on the Moon or on Mars, they must be enclosed in appropriate structures within which the air is maintained at a predetermined pressure and temperature. The speeds necessary to achieve sufficiently large values of the vector simulating gravity (g') can be achieved without surpassing the subjects' maximal O_2 consumption only if the air pressure and temperature in the track tunnel are maintained at about 250 mm Hg (33.3 kPa) and 20° C. Thus, the gas contained in the "track tunnel" should be appropriately enriched in O_2, so as to bring its inspiratory fraction to about 0.50. Finally the angles of g' with the vertical, in the range of speed and radiuses mentioned above will vary from 10° to 78.6°, thus showing that the curved parts of the track should be appropriately constructed to avoid skidding. Alternatively, to avoid complex construction procedures, a circular rail of the appropriate dimensions could be constructed a few metres above the ground. In this case, the bicycle could be suspended to the rail by means of two wheels, one of which connected, and set in motion, by the pedals via a regular transmission system. The overall structure, rail and hanging bicycle should be enclosed in a "tube" wherein the atmospheric conditions are kept as mentioned above. This system will also have the advantage of freeing the upper limbs of the cyclist for providing, if needed, additional propelling power, via a second transmission system.

Conclusions: The above considerations show that the described "track tunnels", may indeed prove to be useful tools to avoid CVD and to maintain the astronauts physical fitness on permanently manned bases on the Moon or on Mars. Future studies should therefore be directed to investigate the "doses" of g' necessary to avoid cardiocirculatory deconditioning during prolonged exposure to the Lunar or Martian acceleration of gravity, both in terms of intensity in respect to the Earth acceleration of gravity, and in terms of duration (per day) and frequency (per week) of the exposure. It goes without saying that further studies on the characteristics of the described system, engineering constraints and manufacturing costs, are neded, in view of its possible installation on the Lunar International Space Station, as well as on space vehicles on their way to Mars.

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Altitude and best Performances in Human Locomotion

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Key words. Running, Speed-skating, Cycling, 1 hour record

Introduction: During locomotion on land, the metabolic power (E') is partly dissipated against air resistance, partly utilised to overcome non-aerodynamic forces. When moving at constant speed on flat terrain, in the absence of wind: $E' = C\,s = a\,s + b\,s^3$ (1), where s is the ground speed, a s the power utilised against non aerodynamic forces (gravity, inertia, internal work) and $b\,s^3$, that dissipated against air resistance. For a given set of conditions (barometric pressure and temperature, area projected on the frontal plane, drag coefficient) b is constant, and in running, speed-skating and cycling a is constant and independent of the speed.

Theory: At a given speed, the fraction of the overall power utilised against the air depends on the absolute values of a and b: at maximal aerobic speed, it ranges from about 97 % in track cycling to about 8 % in track running. At altitude, the energy spent against the air is reduced in direct proportion with the air density, and hence with the barometric pressure (for a given temperature). It follows that the metabolic power at a given speed is less (and conversely, the speed attained with a given power is larger) at altitude, the more so, the greater the fraction of the overall power utilised against the air. However, since altitude leads also to a fall of maximal O2 consumption (V'O2max), its the net effects on maximal aerobic performances are set by the balance between the fall of air density and that of V'O2max; they are briefly discussed below for cycling and running.

Results and Discussion: The present world record for 1 hour unaccompanied cycling (56.375 km) was set by Boardman at sea level. The maximal distance that he could cover at altitude in 1 hour, *ceteris paribus*, is calculated below. The maximal 1 hour speed depends on $V'O_2max$ and on the fraction of it that can be sustained throughout the effort (F). Thus, eq. 1 becomes: $E' = F\,V'O_2max = a\,s_{sl} + b\,s_{sl}^3$ (2), where sl denotes sea level. The decreased barometric pressure affects $V'O_2max$ and b. Therefore, at altitude (a): $A\,F\,V'O_2max = a\,s_a + k\,b\,s_a^3$ (3), where: i) A and k are the fractional decreases of $V'O_2max$ and of b due to altitude. Substituting eq. 2 into eq. 3: $A\,(a\,s_{sl} + b\,s_{sl}^3) = a\,s_a + k\,b\,s_a^3$ (4). Thus, the ratio between maximal speed at sea level and at altitude is set by the magnitude of the two constants a and b. The two limits of this state of affairs show that, for a = 0, eq. 4 reduces to: $s_a/s_{sl} = \sqrt[3]{(A/k)}$ (5), whereas, for b = 0 eq. 4 becomes: $s_a/s_{sl} = A$ (6). In track cycling the metabolic power dissipated against non aerodynamic forces at high speeds is less than 3 % of the total. Hence, as a first approximation the two terms $a\,s_{sl}$ and $a\,s_a$ can be omitted, the ratio s_a/s_{sl} being described by eq. 5. The relative gain in speed at any given altitude can therefore be calculated because the decrease of $V'O_2max$ with altitude is rather well known from the literature. Furthermore, assuming equal air temperature, the constant k reduces to the ratio of the barometric pressures at altitude and at sea level. At Mexico (2.23 km a.s. l.) s_a/s_{sl} amounts to 1.04, which would bring Boardman to cover 58.63 km in 1 hour.

Conclusions: The above approach allows one to calculate the optimum altitude for aerobic performances in human locomotion on land, provided that the two constants a and b are known: for cycling it amounts to about 3.8 km, where $s_a/s_{sl} = 1.046$ and where therefore Boardman could cycle 58.97 km in 1 hour. In running, since a is about 20 times larger than in track cycling, the ratio s_a/s_{sl} is close to that described by equation 6. Therefore, in running the speed at altitude declines very nearly in direct proportion with the fall of V'O2max, a fact that becomes even more apparent in swimming in which case the energy expenditure against the air becomes vanishingly small. In speed skating a is about 5 times larger than in track cycling, and the ideal altitude is on the order of 2.2 km.

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Core Body Temperature during Acceleration

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Key Words: Thermoregulation, Lower Body Negative Pressure, Push-Pull-Effect, Fluid Shift

Introduction: As we are stepping forward to new borders of aeronautics and human space travel there are new problems arising due to to the loss of gravity as well as to extreme accelerations challenging our cardiovascular and vegetative system.
Core temperature of the human body might be one parameter reflecting various changes in the human vegetative system. Though it has always been an unpleasant issue to measure it the rectal way under non clinical conditions, there is a new device available to measure core temperature on an easy non-invasive way via determination of the heat flux. Thus it is possible to record quick temperature changes of the core temperature.
Material and Methods: In collaboration with the Czech Institute of Aviation Medicine the changes of the core body temperature were recorded in 21 healthy volunteers during a test of their vegetative response using a „Lower Body Negative Pressure“ device (LBNP). The subjects were made to tilt head down first and - after a short adaptation period - they were put back to upright position. At the same time the pressure around the lower part of the body was reduced within two seconds to 70 mm Hg below ambient pressure. Hereby a so-called push pull effect was generated, which is comparable to a 4,3G acceleration. Thus the blood volume of the subject was shifted to the lower part of the body provoking a common response of the cardiovascular system resembling hypovolemia and vasomotoric resonse mechanisms. Core temperature was measured using a special Double Sensor at the forehead and at the shin. Skin temperature was taken by sensors at the upper arm, the lower arm, the thigh and the foot. Moreover the temperature and humidity inside and outside the chamber was monitored.
Results: During the measurement the LBNP procedure produced a remarkable effect on the subjects´ circulation system. Nine of the 21 participants were able to finish the measurement within the proposed time parameters. However, twelve subjects in the LBNP experiment had a harsh decline of bloodpressure of more than 70 mm Hg and therefore had to stop. Skin temperature showed a concommitant reaction probably due to vegetative vasomotor responses. The double sensors also noted this vegetative reaction. Nevertheless the range of core temperature change never exceeded 0,5 °C at the upper part of the body.
Further analysis of the data will provide information on how vegetative vascular responses might influence central and peripheral thermoregulation, which anatomic part of the body shows the strongest change in skin perfusion and which measured value might be a good predictor of an imminent blackout during acceleration.

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A Problem of Vertical Maneuver

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Specific features of warfare in the mountain areas are considered to be firstly evaluated by a German military theoretician Carl von Clausewitz (1780 - 1831) in his work Vom Krieg. Clausewitz analyzed geographical (relief, weather) impact on warfare and indirect impact on human body and necessary physiological qualities and skillfulness[1] of soldiers to survive and fight at mountain areas.

Mountain units specialized for warfare at mountain areas and extreme weather conditions are relatively new phenomenon in the military. They began to form at the end of the 18th century first in Italy and soon after in France, Germany, Switzerland and the Austria. A characteristic of mountain units in all countries in the initial period was that mountain units recruited soldiers among the population in mountain areas of individual countries with the innate and acquired psychological skills for life (survival), and warfare at high mountains in the world of extreme winter conditions. The effectiveness and ability of military uplanders was plentifully demonstrated during the World War I, when the front lines led near 4000 m elevation (Ortler, 3902 m).

The basic elements and principles of warfare in the mountain world of Clausewitz to date have not changed: limited maneuver and canalized movements, efficiency of small units at altitude dominant points, effectiveness of weapons to support the high curve of launching missiles, demanding logistical support etc. Newness in warfare in the mountain areas is use of helicopters or - the "vertical maneuver."

Helicopters have been used in warfare since after the World War II. In warfare in mountain areas increased use of helicopters occurred during the Soviet intervention in Afghanistan (1979 - 1989). In the recent time operation "Anaconda" is considered the most extensive military operation in mountain world operation. It was carried out by members of the U.S. 10th Mountain Division in March 2002 at Tora Bora in Afghanistan.

The experience of operation "Anaconda" bring new insights on the necessity of knowledge of physiological capacity of soldiers in the use of "vertical maneuver." Members of the U.S. military in operation "Anaconda" were transported with helicopters from lowland military bases in Afghanistan to the height of 3000 m in a very short time. The critical problem of adaptation to the altitude (acclimatization) already occurs at this height, especially with rapidly increased physical exertion. The most demanding physically phase of the airborne attack on the battlefield appears directly after leaving the helicopter and movement transition to an organized tactical formation.

Knowledge and awareness of physiological particularities of the implementation of military operations at altitudes above 2000 m is particularly topical in modern times for a number of reasons. The former principle of recruiting soldiers of mountain units in mountainous areas because of their high altitude living areas is no longer in use due to the decrase of conscript armies. Modern professional armies recruit soldiers of mountain units without innate physiological abilities to operate at high altitudes of present physiological problems. Engagement of mountain and other units in crisis operations (humanitarian and peacekeeping) is geographically unpredictable. The current and potential future conflict zones of today's world are often located in the mountainous envirnment (Afghanistan, Pakistan, Kosovo, Bosnia, the Caucasus) with present of high altitude influence on human performance. The use of "vertical maneuver" in the principles of modern warfare at mountain areas accentuates the physiological problem of soldiers.

[1]acquired skills for movement in high mountain envirnment (climbing), movement in deep snow and skiing, assessment of (in)security passages of snow avalanche areas, very limited supply of water, etc.

Noise Exposure during Helicopter Rescue Operations at Altitude – Is There an Increased Risk for Hearing Loss Due to Hypoxia?

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Key words: alpine rescue, prevention noise, hearing damage

During helicopter rescue operation the medical personnel is on high risk of hearing damage by noise exposure. There are two important factors to be taken into account: The extreme variability with some days involving no exposure but others with high exposure. Second, the extreme noise levels during work outside the helicopter. We estimate the noise exposure of the personnel for different helicopter types used during rescue operations in the Alps and in other regions of the world.
Additionally, hypoxia is considered as an independent risk for hearing threshold shifts. Since the cochlear cells are supplied with oxygen by diffusion, hypobaric hypoxia as present in an airplane or a helicopter 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 airborne sound. Both effects last for several hours even after the noise exposure has been finished.
Noise and hypobaric hypoxia may be linked to the damage of the ears by ATP. During noise exposure there is an active secretion of ATP into the perilymphe of the stria cochlearis. This may lead to an "energetic exhaustion" as a reason for the threshold shift. This effect may be supported by hypoxia.
Latest results in research will be given and the preventing of the hearing loss induced by noise due to modern helicopters will be shown.

Physiological and Metabolic Changes in Human Organisms during Hibernation in the Antarctic

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Keywords: Isolation, Body composition, hematopoesis, synchronisation, gender differences

Introduction: Living and working in extreme environments like in the Antarctic are connected with physiological and psychological changes. The Neumayer II station was designed as an analog to spaceflight, isolation or other experiments in extreme environments, to determine changes in physiological and metabolic parameters in overwintering persons. An investigation was to characterize possible gender differences. It was a special interest in cold and isolation to monitor changes in parameters due to the darkness period during the Antarctic winter (May-August). Hypothesized was that winter periods and long isolations have an influence on physiologic parameters. The effects on human subjects are analyzed as physiological adaptations of circadian rhythms, temperature and altitude with direct consequences on energy balance and body weight. (4) It has been identified that the synchronization is a very common phenomenon observed in bodies' rhythms and can be found, during relaxation or sleep. (2) Earlier studies showed changes in human endocrine and metabolic physiology in extreme conditions. (1) There are reports of increased food intake, gain in body weight and decrease in plasma leptin during Antarctic expeditions.(3)

Methods: Examined were three overwintering teams from 2005 to 2007 at Antarctic Neumayer II-Station (GE), consisting of polar researchers and workers (cumulated n = 24). Each team had to stay for 15 months and had a complete darkness period in the middle phase. Every two weeks in the morning physiological data: heart frequency (H_f), breathing rate (B_r), heart rate variability (H_{rv}) were recorded in lying position for 12 minutes (HealthLab). Body weight (BW) and body composition (BC) – fat free mass (FFM), fat mass (FM), hydration status – were measured at the same time (BIA). To determine circadian rhythm parameters, nutrition and blood cell regulation hormones blood samples were sampled every two weeks during regular medical check: Leptin (Lp), Adiponektin (Apo), Erythropoietin (EPO), serum-transferrin-receptor (sTfR), and thyroidal stimulating hormone (TSH) by using ELISA.

Results: Compared to the pre- and post period, a synchronization of H_r and B_r during the period of darkness (midwinter) could be shown in all years and a de- (or in-) crease of H_{rv} in 2006 ($p < 0.05$). But gender specific differentiation showed that in men the FFM decreased (n.s.) and the FM increased (n.s.), which differs from the women where the FFM increased (n.s.) in the phase of light and drecreased (n.s.) during darkness. There could also be shown a decrease of BW in men but an increase in women while midwinter ($p<0.05$). The nutrition hormone Lp showed a significant decrease, comparing the hormone levels obtained during midwinter (June) with those obtained during midsummer (January) in all groups of over-wintering and clear homogen results in men. The hormone of circardian rhythm -TSH- showed a significant increase in midwinter in 2007 ($p<0.01$) and a tendence of increase in men, women and in the entire isolation group of the year 2006, but a decrease in 2005 (males). Haematopoetic regulation showed significant decrease in Hb, EPO, sTfR ($p< 0,01$).

Conclusions: The study shows differences in men and women regarding overwintering. In more than half of all overwinters synchronization of H_f and B_r and a decrease of H_{rv} was shown. Darkness periods illustrated a significant influence on the measured hormones in overwinterer. With regard to other applicable fields where isolation, cold environment and darkness relevant, one might deduce an alleviating effect on human performance. This might be especially important under micro-gravity conditions, where these effects are combined with other factors. Further research is indicated to discern the impact that changes in hormone levels pose on psychological functions and exercise performance.

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Preliminary Data on a New Non-Invasive Method to Measure Core Temperature with the Double Sensor under Cold Conditions

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Keywords: non-invasive, body core temperature, cold environment

Introduction: To evaluate human efficiency, the measurement and continuous monitoring of the body core temperature (T_{core}) under extreme climatic conditions (heat, coldness) is important. Recordings can be carried out invasively as well as non-invasively. The golden standard is the aortic measurement which cannot always be applied. The other procedures have smaller measuring inaccuracies and are mostly not very comfortable (e.g. rectal), non-invasive procedures mostly have bigger inaccuracies but a pleasant comfort (e.g. tympanale). To do justice to these, a new device (DoubleSensor) was examined in cold environments.
Methods: In a climate chamber test persons were examined in cold-immersion in a survival-suit. ECG was measured continuously; blood pressure intermittently. Continuous recordings of T_{core} were done by a rectal probe; the new DoubleSensor (T_{DS}) was placed on the sternum. Withdrawal criteria were pathological ECG, increase or decrease of heart frequency or blood pressure, the core temperature over 38.5°C or under 35.5°C, clinical signs or subject´s wish.
Results: 13 healthy subjects (w/m = 6/7) were examined. Climate chamber data were: T_{water} +4 ± 0.1 °C, rel. humidity 55 ± 2%. All subjects were up to 90 min in cold immersion, 8 for longer. Initial core temperatures were T_{rec} = 37.7 ± 0.22 °C and T_{DS} = 37.4 ± 0.24 °C, after 120 min T_{core} decreased to T_{rec} = 36,9 ± 0.54 °C and T_{DS} = 36.9 ± 0.52 °C. The mean difference between T_{rec} and T_{DS} was initially 0.27 °C and after 120 min -0.03 °C. Comparing T_{DS} with T_{rec} (Bland-Altman) revealed that the recordings of T_{DS} differed by between 0.70 °C and -0.28 °C from mean T_{rec}, CCC was 0.590.
Discussion: Continuous measurement of T_{core} with the new DoubleSensor achieved comparable values to T_{rec} recordings. The requirements mobile, comfortable and non-invasive were fulfilled and demonstrated a good possibility to carry out measurements in extreme environments. Currently the Double sensor system cannot completely replace rectal or radio pill T_{core} recordings. Further studies are indicated to implement the device as a reliable system to calculate strain index.

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Early Prediction of Acute Mountain Sickness by Bioelectrical Impedance Analysis II

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Aim: We want to show, if it is possible to predict Acute Mountain Sickness (AMS) with Bioelectrical Impedance Analysis (BIA) in connection with Echocardiography and NT-Pro-BNP as a parameter for cardiac insuffiency.

Material and methods: 13 healthy volunteers were investigated before and during exposition to hypoxia at a simulated altitude from 4500 to 5500m in a hypoxic chamber about 15 hours. Every 3 hours the subjects were investigated by echocardiography, every 45 min we measured BIA and oxygen saturation, every 5 hours we took a blood sample for NT-Pro-BNP. AMS-symptoms were collected by the Lake-Louise-score.

Results: All subjects showed an increasing of TBW during hypoxic exposition, 3 of them only after exposition on 5500m. 12 subjects showed a right-ventricular dilatation, in 12 subjects the pressure of pulmonal artery increased (6 of them showed a relevant PA-Hypertension over 35 mmHg + central venous pressure). 8 subjects suffered from AMS (7 of them after or during a TBW-increasing).

The samples for NT-Pro-BNP are in the laboratory yet, but during a training we found an increased marker in subjects with increased PAH. So, we expect simular results.

Conclusion: As other authors described before, we found an increasing of PAH and a right-ventricular dilatation during simulated altitude exposition as a risk for AMS. Peripheral edemas are described as caused by insufficience of the right heart or the kidneys. We showed an increased TBW in subjects before or during suffering from AMS. So, we conclude, that it is possible to predict the risk for AMS by continous BIA.

Occupational Aspects of Work in Hypoxic Conditions – the New Recommendation of the Medical Commission of the Union Internationale des Associations d'Alpinisme (UIAA MedCom)

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More and more persons are exposed to hypoxia while working, e.g. when working for cable cars or ski areas in the Alps, for business in South America or Asia, as airline crews, or in rooms with reduced oxygen pressure for hypoxia training or fire protection. Unfortunately the different countries have a multitude of regulations for occupational health and safety concerning hypoxia – most of them with major deficiencies and a significant lack of knowledge about hypoxia and possible specific risks. So far no national regulation differentiates the different types of hypoxia and the environment, both having significant influence on the specific risk profile of the employees and the consequences for occupational health and safety.

As the world's umbrella body for preventive medicine at altitude / hypoxia UIAA MedCom recently established a recommendation to enable the national bodies to establish knowledge-based pragmatic procedures for occupational health and safety.

The most important message is as follows: Any environment with oxygen concentration of 14.0% or more or an altitude of 3,000m or less is safe for any person without severe cardiopulmonary disease (<NYHA III or CCS III) and without severe anaemia (Hb >10 g/dl) and an exposure of some hours. These environments include most alpine cable cars, ski areas, aircrafts flying on long-range distances, most towns or villages where businessmen might go and rooms for fire protection.

The lecture will give details on the specific risks of the different types of exposure and detailed information how to manage them.

Enteritis during Mountaineering Above the Snow Line – How to Practice Prophylaxis?*

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Key words: diarrhea during mountaineering, infection by melted snow and gloves, hand-disinfection during mountaineering

Introduction: A previous study [4] showed: diarrhea by faecal bacteria under difficult hygienic conditions above the snow-line appertains to a typical problem in mountaineering. To prevent reinfection with bacteria from faeces, usually snow water was boiled or disinfected chemically. A specialist of hygiene [3] argued, however: The danger of infection by the own hands could be more important than it of infection by melted snow. Therefore disinfection of the hands would be very important. **Aims**: 1) Check melted snow and gloves: Coliform bacteria etc are an indicator for faecal contamination. 2) Check practicability of hand disinfection in high altitude.

Methods: 1. Bacteriologic check of melted snow from the Muztagh Ata region (Kunlun-mountains –brought by B. HONKA, [2]): 4 steps between 4.400 and 6.800 m, 25 snow specimens, each. 2. For comparison: 3 specimen of melted water from Kleinwalsertal (touristic region with many restaurants, cottages etc, 1.800 m). 3. Bacteriologic check of a pair of gloves, used 14 days before during mountaineering, 4) testing typical hand-disinfection with alcohol tampons.

Results (preliminary, [1])**:** In 21 of 100 Kunlun specimen coliform bacteria or E. coli were found, the higher, the lesser. In the other 3 specimen: No faecal bacteria. Also in all fingers of the gloves faecal bacteria were found. The use of typical alcohol tampons under mountaineering conditions was not practicable, especially caused by the additional cooling effect.

Conclusions: The exemplary results show already, that a relevant part of the melted snow (Kunlun) and all fingers of a pair of gloves were contaminated with faecal bacteria. To prevent reinfection of enteritis, melted water should be disinfected further on. Reinfection by gloves – until today not discussed – seems to be a relevant problem, too. The classic hand-disinfection is not practicable, the gloves are a reservoir for faecal bacteria. So it seems to be very important, to avoid infection of the food with the own hands by handling all food carefully. Disinfection of the gloves before and during mountaineering should be tested.

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Utilization of Trekking-Sticks in Mountaineering – An Inquiry in the Watzmann-Region

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Key words: accidents by trekking-sticks, history of trekking-sticks, utilization of trekking-sticks

Introduction: Since many centuries men often have used one stick for mountaineering, too. R. Messner was one of the first introducing two sticks, since 1975 (2). Today two special trekking-sticks are used (1); obviously with advantages (e.g. for the joints) and disadvantages (e.g. accidents). Therefore we are interested in the frequency of use of these stick and the reasons why mountaineers use these sticks or not (the considerations of mountaineers why they use these sticks or not).

Methods: Inquiry with a special manual (5) of 106 subjects (60 mountaineers in the Watzmann-house (1930 m) and 46 mountain walkers in the valley (Wimbachschloss, 937 m).

Results: Altogether 77 subjects (73 %) used two sticks, with a distinct increase since 2002, for walking up- and downhill, rarely in the plain. The main reason to use these sticks was *facilitation* (walking uphill) and *discharge of the knee-joints* (walking downhill). The main reason not to use the sticks was "*sticks are hindering*". Nearly all answers contained positive and negative aspects of trekking-sticks for mountaineering, including the risk of accidents by using sticks. 58 participants (≈ 75 % of 77) used telescope-sticks. By internet studies (5) it was found out, that modern sticks for nordic walking and for mountaineering are very similar, but with one essential difference: Handgrip and strap (3, 4). In nordic walking-sticks the hand is fixed by the strap, a very disadvantageous construction in case of mountaineering (causing accidents).

Conclusions: Walking with two sticks in mountaineering is more and more common as typical equipment in our century. It includes some advantages, but also disadvantages as causing accidents. Therefore nordic walking sticks should not bee used for mountaineering, only trekking-sticks with a special handgrip and strap are recommended.

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Danger of Icing of the Scuba Regulator – A Neglected Risk while Diving in Mountain Lakes

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Key words: diving accidents, diving courses, diving risks

Introduction: Diving in mountain lakes is very attractive. However, some special risks are described in literature, especially the problem of decompression under changed pressure conditions (1). As an other problem the icing of the scuba regulator is described (caused by lower water temperature and the Joule-Thomson-effect, 1, 4). Diving in mountain lakes is only marginally included in the basic courses of the great diving associations PADI und SSI (3, 5), and only referring to the modified decompression; a similar situation is found in nearly all other special courses for diving in mountain lakes. So it seems that this danger is not sufficiently known among divers.

Methods: Inquiry with a special manual of 30 divers at the Walchensee (802 m), interview with 3 regional therapeutic recompression centres (2).

Results:

Inquiry of the divers: Most of them knew the necessity of special decompression procedures, but only half of them knew the danger of icing of the scuba regulator and used, in consequence, a complete redundant regulator system (2). Only a minority had passed a special course for diving in mountain lakes.

Interview with decompression centres: Nearly all serious accidents of divers in mountain lakes were caused by iced scuba regulators (2).

Conclusions: In every basic course for divers the risk of icing of the scuba regulator should be underlined, combined with the necessity to join special courses for diving in mountain lakes. In these special courses the necessity to use redundant regulator systems should be explained and it should be trained, how to use them in the case of icing of the primary system.

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The Influence Of A Month Of Ski-Walking On CHO And FAT Metabolism. A Single Subject Experience

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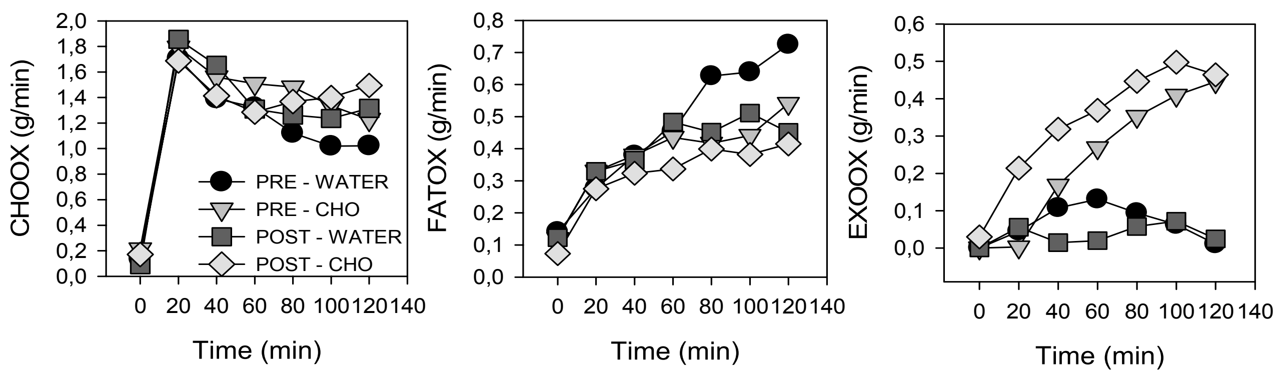
Key words: stable isotopes, ^{13}C-Glucose, endurance

Introduction: Endurance training influences the increasing of fat (FAT) and reducing carbohydrate (CHO) oxidation rates. This general assumption however needs more specific definitions, because nutrition manipulations during exercise (drinking CHO solutions and/or consuming concentrated CHO in solid form) additionally affected metabolism adaptations reached by training. The aim of the study was to ascertain the adaptations of FAT and CHO metabolism affected by a month of everyday ski-walking in cold weather conditions.
Material and methods: A single, trained subject (55 yrs, 175 cm, 74 kg) performed a month ski-walking competition tour in Finland, consisted of each day, about 40-80 km distance. Additionally every competitor pulling sledges by his own clothes, drinks and food. Before and after the ski-tour, he performed two similar continuous, 2 hrs walking test on treadmill: by drinking water and 7% CHO solution, enriched by naturally labeled stable ^{13}C isotope, 2 ml/kg, every 20 min. The walking velocity was constant (5 km/h) at 10% grade. The V29c (sensor Medics) metabolic cart and EUROPA 20-20 isotope instrument were using for measurements Vo_2, Vco_2 and V_E parameters and ^{13}C enrichments in expired air.
Results (figures) showed that CHO oxidation rate (left) actually increased after 60 min walking during post expedition testing, when subject drunk water and similarly, but with increased rate of oxidation, when drunk CHO solution. The rate of FAT oxidation showed mirrored figure (middle), again after the 60 min of exercise. The increase of CHO oxidation rate was occurred mainly by increased of exogenous CHO oxidation rate (right) which comes from drinking solution.



Conclusions: The month of regular every day, for about 7-9 hrs ski-walking influences metabolism to enhanced CHO and reduced FAT oxidation rates, if subject was observed during 2 hrs walking on treadmill.

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