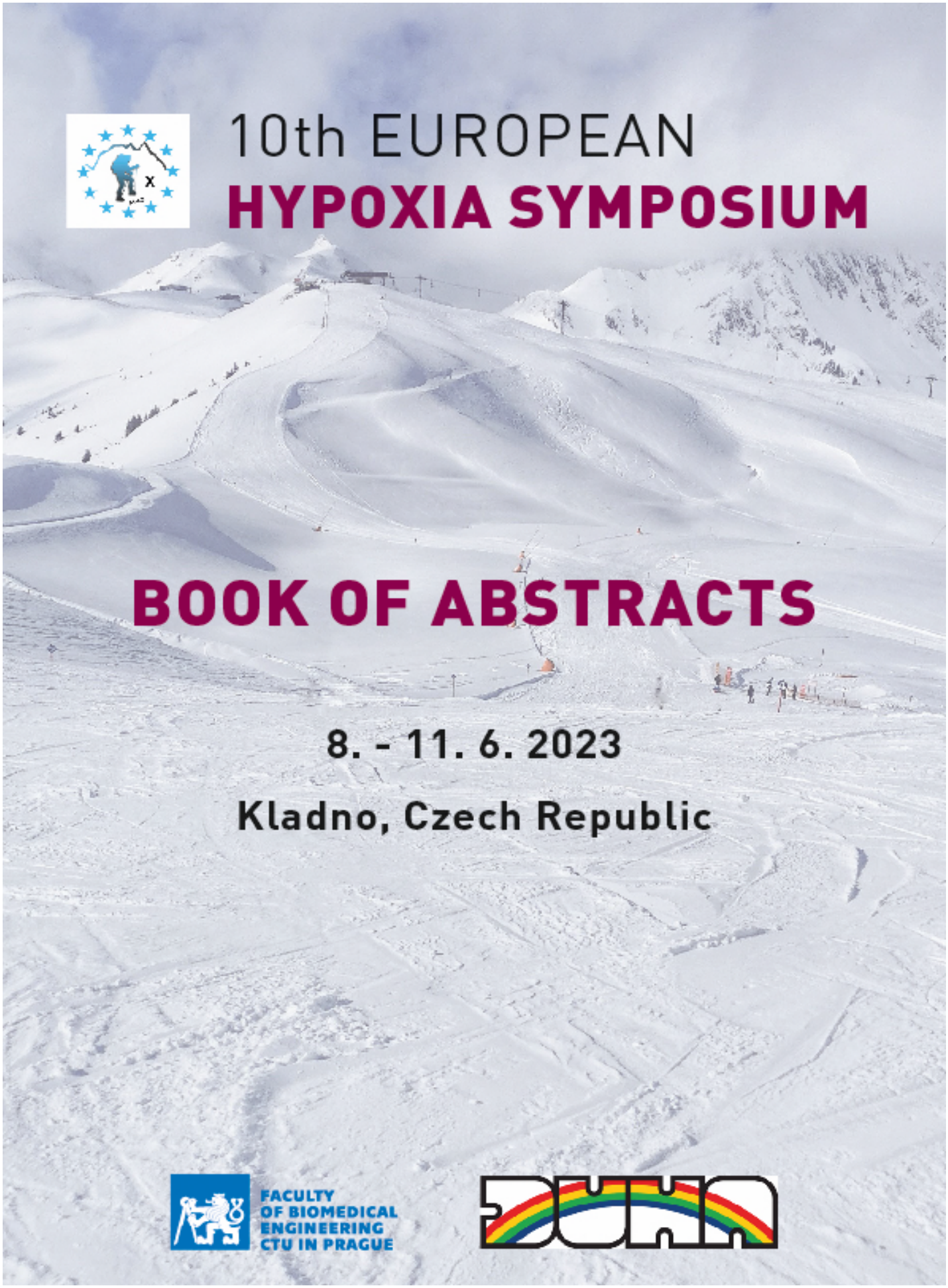

10th EUROPEAN

HYPOXIA SYMPOSIUM

BOOK OF ABSTRACTS

8. - 11. 6. 2023

Kladno, Czech Republic

FACULTY OF BIOMEDICAL ENGINEERING CTU IN PRAGUE

DUHA

10th HYPOXIA SYMPOSIUM

From Molecules to Mt. Everest –
From Science to Practice

Kladno, Czech Republic
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BOOK OF ABSTRACTS

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M. de Haan[1,2], M. Gerrits[1], J. Verbruggen[2], S.T.J. van der Landen[1], G.M. Lötgerink[1] & R. De Jongh[2,3]

[1] Philips Integrated Technology Solutions, Eindhoven, the Netherlands; [2] Complementary Medical Centre, Genk, Belgium; [3] Department of Anaesthesiology, Ziekenhuis Oost Limburg, Genk, Belgium

Introduction: Periodic Breathing (PB) is characterized by recurrent clusters of hyperpnea followed by a period of apnea [1]. PB is the result of respiratory instability caused by the disbalance between several feedback loops [2,3]. During environmental (hypobaric)hypoxia, PB is obviated by two to five breaths of high tidal-volume alternated with prolongated expiratory pause after the last breath. To our knowledge PB during normobaric hypoxia in sitting or supine position has not been investigated.

Objectives: The aim of this study was to investigate differences in detected PB; in terms of its prevalence, its commencing SpO2 level and its pattern. During this study with progressive, controlled and normobaric desaturation differences in terms of PB in sitting versus supine position were evaluated.

Methods: Healthy adult volunteers were included in group 1 (n=18) in sitting position and group 2 (n=18) in supine position. FiO2 in the hypoxia room decreased almost linearly with 0.01 oxygen every 9 minutes till FiO2 is 0.10 for 10 minutes or till volunteers reached a SpO2 of 73% for >1min. Respiration was monitored by capnography, statistical (signal) analysis was performed with Python and SPSS.

Results: Volunteers with PB in group 1 (n=4) were 40.0 ± 16.1 and without PB 29.7 ± 10.8 years old (p=0.429). In group 2 the age was 39.6 ± 13.6 with PB (n=5) and 29.9 ± 12.3 without PB. Prevalence of PB was 25% of the total cases (n=36). PB was detectable from SpO2 of 89.3% in group 1 and 85.8% in group 2 (p=0.805). The pattern of PB in group 1 was 4.3 ± 1.0 breaths followed by apnea of 12.5 ± 2.8 seconds and in group 2 3.8 ± 1.0 breaths followed by 14.0 ± 3.2 seconds of apnea (p=0.730).

Conclusions: In this small sample sized study, the prevalence of PB during progressive hypoxia until FiO2 of 0.10 is rather low (25%). Moreover, PB seems not to be influenced by the sitting or lying position of the volunteer.

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Oxygen Saturation Variability in Sitting and Supine Position during Normobaric Hypoxia; a Controlled Desaturation Study

M. de Haan[1,2], L.P.J. Vosters[1], J. Verbruggen[2], S.T.J. van der Landen[1], G.M. Lötgerink[1] & R. De Jongh[2,3]

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Introduction: Pulse oximetry is worldwide a well-established technique for monitoring patients' oxygen saturation (SpO2) level and forms a proven critical indicator for clinical deterioration [1-3]. However, in a high-altitude environment with hypobaric hypoxia or in a hypoxia-room with normobaric hypoxia, SpO2 measurements show increasing variability (VarSpO2) related to decreasing O2 concentrations [4,5].

Objectives: The aim of this study was to investigate VarSpO2 in sitting and supine position during progressive controlled desaturation.

Methods: Healthy adult volunteers were included in group 1 (n=18) in sitting position and group 2 (n=18) in supine position. FiO2 in the hypoxia room decreased almost linearly with 0.01 oxygen every 9 minutes till minimal FiO2 of 0.10 for 10 minutes or if volunteers reached a SpO2 of 73% for >1min. SpO2 was monitored with transmissive photoplethysmography and statistics were performed with SPSS. VarSpO2 was calculated in R-statistics via Sample Entropy with window sizes of 9 minutes combined with MultiScale Entropy.

Results: The mean age in group 1 was 29.7 ± 10.8 and 32.6 ± 13.1 years old in group 2 (p=0.332). Further there was an equal distribution over gender and BMI. In both groups, there is an obvious increase in VarSpO2 in relation to the decrease FiO2 in the hypoxia room (figure 1), without significant differences between groups.

Conclusions: To our knowledge this is the first study that investigated continuously VarSpO2 during controlled progressive desaturation. A clear inverse relation between VarSpO2 and FiO2 was found in the hypoxia room independently if volunteers were in sitting or supine position.

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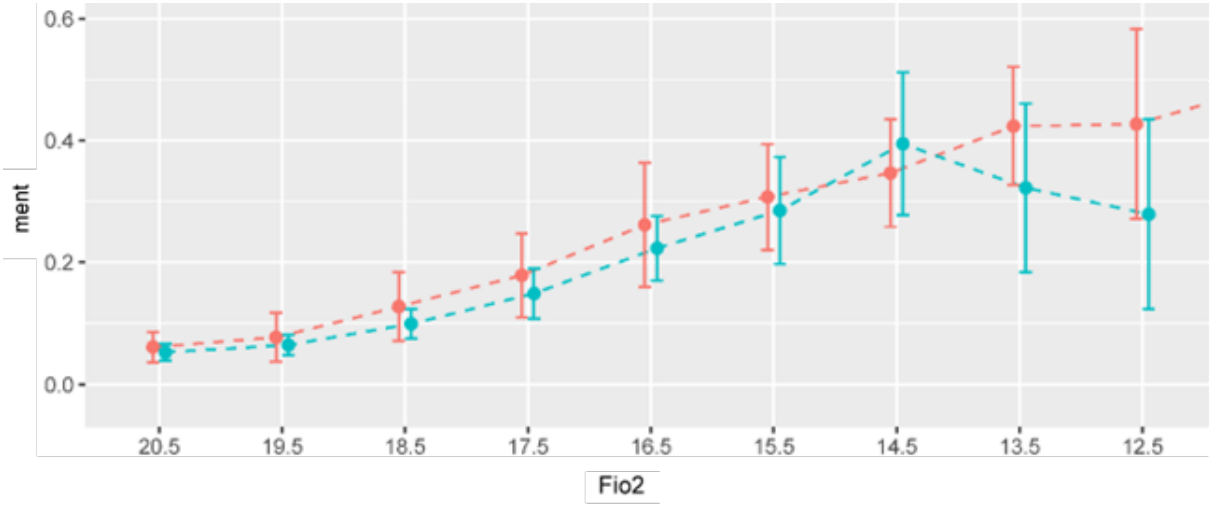

Figure 1

Research of gas exchange of a victim covered with avalanche snow—Limitations of ICU devices

K. Roubík

Department of Biomedical Technology, Faculty of Biomedical Engineering, Czech Technical University in Prague, Czech Republic

Introduction: Avalanche snow burial causes rebreathing of already expired gas and thus inducing severe hypoxia and hypercapnia. Asphyxia is the most frequent cause of death of victims under avalanche snow. Knowledge of gas exchange and associated changes of physiological parameters are important for guidelines for terrain rescue operations and subsequent resuscitation and medical care. These guidelines are updated regularly based on the results of latest field experiments and experience with medical interventions and their outcomes.

Objectives: The aim of the work is to summarize current knowledge about gas exchange of a victim covered with avalanche snow, to summarize the experiments currently conducted worldwide and to introduce results of research conducted at Czech Technical University in this field and to analyze problems with medical equipment used during these experiments.

Methods: Data recorded during three outdoor experiments [1–3] were analyzed and problems with medical equipment used were studied.

Results: Experimental research of effects associated with presence and absence of an air pocket in front of the airways in the snow is the most frequent one. There are several factors affecting gas exchange of a victim, especially gas mixing and thus changing concentration profile of respiratory gases during inspirium, and significant changes in work of breathing. Breathing with zero air pocket (i.e. without any free space in front of the airways opening) is also possible as was confirmed experimentally. Devices designed for ICU can provide improper or misleading data during outdoor experiments even though they are used according to the operating conditions listed in the manual. They are optimized for scenarios expected at ICU.

Conclusions: Raw data inspection (or analysis) is strongly recommended. Caution and a combination of several monitoring techniques are needed when measured data are used as safety limits.

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Rapid ascents to Mt Everest: normobaric hypoxic preacclimatization

M. Tannheimer

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Introduction: Acclimatization to high altitude is time consuming, an expedition to Mount Everest (8,848 m) requires roughly 8 weeks. Therefore it seems very attractive to reach the summit within three weeks from home, which is currently promised by some expedition tour operators. Since physiology is not easy to outsmart, the question arises how well the so-called FLASH concept works.

Methods: We conducted a review of the public available data concerning the FLASH concept. It is based on two components, first the liberal use of supplementary oxygen and second normobaric hypoxic training (NHT) prior to the expedition, with sleeping altitudes comparable to 7,100 m. We evaluated these data on the basis of the current literature and our experiences made during an expedition to Manaslu (8,163 m) using normobaric hypoxia for pre-acclimatization. To evaluate the effect of an increased O2-flow rate we calculated its effect for different activity levels at altitudes above 8000 m.

Results: In 2018, 2019 as well 2022 the new concept was successful with 100% of the participants reaching the summit. NHT is the decisive component. An increased O2-flow rate of 8 l/min is not necessary for climbing Mount Everest.

Conclusions: It can be assumed that NHT will be widely used in the future for pre-acclimatization. The most effective way of NHT is still unclear and requires further studies to evaluate the relative importance of its different variables like the daily necessary time, the activity level (during sleep, at rest, during physical activity) and the extent of the applied hypoxia.

In practice, the concept which can be integrated best into the daily working routine will prevail, even if it is not the most optimal from a scientific point of view. Therefore, we expect that NHT will primarily be used during sleep.

Do we have a procedure to predict altitude tolerance?

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So far no test procedure validated for altitude conditions (hypobaric hypoxia), although several different approaches were done as there are: ergometry, VO2max, breathing hypoxic air and measurement of SaO2, maximum exercise capacity in hypoxia, cardio-circulatory factors during submaximal work in normoxia and hypoxia ("Richalet-test"), hypoxic ventilatory response, plasma proteonic investigations, decrease of asymmetric dimethylarginine, gene patterns, and others.

All these tests lack from limited positive predictive value of about 60 to 70%. There is just one option for a good prediction: The climber's history. If he/she was at high altitude before without problems, this will be also true for other altitude sojourn when there will be a similar altitude profile. In future there may be better options by an approach with machine learning.

Health status and aerobic performance at moderate altitude of military mountain guides

R. Pühringer

University of Innsbruck, Innsbruck, Austria; Österreichische Gesellschaft für Alpin- und Höhenmedizin (ÖGAHM)

Introduction: Living and working/exercising at moderate altitudes may beneficially impact on health and exercise performance. Whether living at low altitude and regular altitude exposures, including mountaineering activities, as true for mountain guides, are beneficial in the long term is not well explored.

Objectives: This study set out to evaluate the age-dependent health status and fitness level in Austrian military mountain guides, and changes of the aerobic capacity (VO2max) when exposed to moderate altitude (1, 2).

Methods: A total of 166 professional mountain guides had undergone a comprehensive health check and maximal exercise testing (N = 128) at low and moderate altitude (2000 m).

Results: Mountain guides demonstrated higher aerobic endurance capacity, lower prevalence of being overweight and suffering from systemic hypertension and diabetes when compared to similar age groups of the overall population. Interestingly, VO2max decline at a moderate altitude of 2000 m was better prevented in mountain guides with lower VO2max levels.

Conclusions: Long-term regular active exposures to moderate altitude of mountain guides promote healthy aging and favor maintenance of exercise performance with aging. Whether these effects surpass those of a similar life-style at low altitude remains to be established. Notably, loss of VO2max at moderate altitude is largely prevented in acclimatized mountain guides, however, more pronounced in those with VO2max values below 50 mL/min/kg.

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We are particularly grateful to the Austrian Ministry of Defense, the University of Innsbruck, and the Austrian Society for Alpine and High-Altitude Medicine for the extremely helpful support.

The use of artificial hypoxia in endurance training in patients after myocardial infarction

A. Nowak-Lis[1], D. Grzybowska- Ganszczyk[1], Z. Nowak[1]

[1] *Institute of Physiotherapy and Health Sciences at J. Kukuczka Academy of Physical Education, Katowice, Poland*

Introduction: Currently there is little documented research evaluating the effect of endurance training conducted under normobaric hypoxia on patients after myocardial infarction.

Objective: The aim of the study was to assess the effect of endurance training conducted under normobaric hypoxia in patients after myocardial infarction on the level of exercise tolerance and hemodynamic parameters of the left ventricle.

Methods: 17 men aged 41 to 74 (59,62 ± 9,86 years of age) after myocardial infarction were qualified. In normoxia environment each patient underwent: resting ECG, spiroergometric test using a treadmill, laboratory tests (morphology, cytokines). All patients participated in 22 thirty-minutes endurance training units under artificial hypoxia conditions (3000 m asl). After 22 days of training, all patients have been re-examined (normoxia conditions).

Results: After the training there were statistically significant changes in: time of test (p= 0,0001), distance (0,0001), MET (0,0000), VE (0,008), VO2peak/kg (0,004), BF (0,03), RER (0,002), BPsys_rest (0,01), BPd_rest (0,01), blood parameters: IL 10 (0,0000), echocardiography: E-wave (0,007), E septal (0,01), LVEDd (0,002), LVESd (0,005) and BMI (0,0000), BSA (0, 0001), body mass (0,0000). All results were compared with a results of control group (standard rehabilitation trainings).

Conclusion: Training under normobaric hypoxia influenced on parameters of exercise tolerance, interleukin 10, body mass and BMI as well as on echocardiographical parameters.

Morphology and function of the heart during freediving session

R. Pudil

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Introduction: During a breath-holding dive, circulation is affected by a number of influences: the water environment (pressure at depth, water temperature), breath holding (hypoxia, hypercapnia) and physical stress during the dive. Very little is known about the changes in the cardiovascular system that occur during a breath-hold dive.

Objectives: The aim of the study was to assess the effect of inhalation diving training on the function of both ventricles.

Methods: 19 elite competitive freedivers (2 women, 37.2±7.6 years) were included in the file. Echocardiography examination was performed just before entering the water and immediately after exiting the water. All freedivers completed at least 20 dives to a depth of 20 m (constant weight, 5 mm thick neoprene suit, water temperature 12°C).

Results: We observed significant changes in left ventricular diastolic function indicators: E/A: 1.5±0.3 vs. 1.2±0.2, p<0.001; E: 92.1±16.2 vs. 70.3±10.5 cm/s, p<0.001; A: 62±14.3 vs. 58.5±10.1 cm/s, p ns; DT of wave E: 129.8±34.2 vs. 157.8±38.6 ms, p<0.01). Similarly, there were changes in the tissue pulse Doppler parameters of the mitral annulus: (e'sept: 14.5±3.2 vs. 11.2±2.8 cm/s, p<0.01; e'lat.: 16.8±3.0 vs. 14.5±3.1 cm/s, p < 0.05). Indicators of left ventricular systolic function (EF, FS) were unchanged. The value of TAPSE decreased after training (26.8±2.8 vs. 21.1±2.7 mm, p<0.001), similarly we noted changes in pulse Doppler characteristics of the tricuspid annulus (e': 15.8±3.1 cm/s vs. 12.7±2.2, p<0.05). At the same time, we

recorded a decrease in the myocardial performance index (MPI) of the right ventricle (0.51±0.07 vs. 0.46±0.07, p<0.01) and an increase in the peak degree of tricuspid regurgitation (6.5±4.8 vs. 15.3±6.2 mmHg, p<0.01).

Conclusions: For the first time, echocardiography was used in the field to measure changes in the function of heart chambers in breath-taking divers. The study proved that inhalation diving is accompanied by a number of reactive changes in the function of the heart compartments and underlines the necessity of good physical condition and health status of inhalation divers.

Acknowledgements:

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Cooling of helicopter flight crews and ground handling personnel during missions in cold regions

A. Werner

Introduction: Military operations can occur worldwide, in all dimensions (land, air, and maritime) and at any time of the year. Often missions arise in extreme environments, including all combinations of heat, cold, wind, precipitation, etc. The acra are most affected in cold weather, so this is where the focus of damage is initially seen. There is always a disparity between optimum cold protection, enough movement, and comfort to perform operational tasks. Crews in a helicopter with open side doors or ramp are particularly affected on the different workstations. Low temperatures, cold wind, and moisture can affect crew members up to hypothermia, local cold injury, and permanent tissue damage (necrosis). This affects the proper operation of an aircraft, survivability in hostile environments, and flight safety, in general.

Methods: During a 3-week helicopter winter operation in Sweden (January/February 2020, flying and ground personnel were examined with the mobPhysioLab® (KORA, Hambühren, DEU) configured precisely to the required physiological parameters during the respective missions. The skin temperatures (Tskin) of the fingers and wrists, toes and ankles, as well as in the face (cheekbone) and the neck were considered. In addition, the core body temperature (CBT), as well as the heart (Hf) and respiratory rate (Bf), were synchronized recorded additionally with the environmental parameters (T, Hum, PresEnvir) in real flight. Furthermore, the extremities' thermographic images (FLIR) were obtained to compare physiological parameters.

Results: The ground-bound outside temperatures were AvΔTEnvir -10°C (range: -3 to -25°C) by in-flight activities. From 14 soldiers, 46 records could be generated and evaluated. Of these, 5 were in the cockpit, 24 were on the open side door in flight, and 17 were on the ground personnel during activities at the flying helicopter (e.g., downwash). All in all, a continuous cooling of the Tskin fingers (AvΔT -10°C, range -3 to -18°C) and Tskin toe (AvΔT -17°C, range -10 to -27°C) could be obtained during flight time only up to 50min; the lowest cooling could be found in the cockpit, the most in the helicopters' cargo bay. The thermographic images supported the physiological data after the flights were completed. The remaining parameters are still in analyzing.

Conclusions: Strong cooling of the extremities reduces blood circulation, leading to stagnancy. Through this protective mechanism of centralization, the extremities are virtually abandoned in favor of the organism's survival. Depending on the exposure time and the depth of the cold, damage up to necrosis occurs. In parallel, the functionality is increasingly restricted, which means the loss of dexterity when the Tskin hand falls below 15°C.; at 8°C, a nerve block is formed (loss of function). The preliminary results of this study show that despite protection, the skin temperatures continuously drop to a critical threshold in a short period of time of only 50min flights, which can endanger specific workflows and thus mean both damage to the human subsystem and the overall system.

Frostbite Incidence – A fact or a puzzle?

B. F. Schneider[1], J. Gorjanc[2]

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Introduction: Although frostbite has been a known phenomenon for several millennia, the exact incidence of frostbite is not known. This is partly due

to variable internal and external etiological factors. Studies in the past have mostly focused on frostbite in military personnel. One of the many consequences of climate change are extreme cold events, which increase the risk of frostbite in the general population, particularly among individuals who are involuntarily exposed to cold for prolonged periods of time. Severe cold injury can lead to deep frostbite with irreversible sequalae such as amputations.

Objectives: The reviews objective is to compare data collection and incidence rates of frostbite in different studies and populations.

Methods: Out of a total of 61 studies using the keywords "frostbite" and "incidence", 7 were selected that dealt with frostbite causes and incidence over 20 years. The studies results were briefly summarized and their conditions were compared

Results: Frostbite can damage tissue superficially or deeply, depending on its degree. The results of the seven studies show a great variation of frostbite incidence depending on population, its size, and method of data collection. Studies that include the entirety of the civilian population show significantly lower frostbite incidence rates than studies focusing individuals who are exposed to temperatures below -0.55°C for long periods of time, such as mountaineers, military personnel, or homeless people. Although cold injuries are rare, they are becoming increasingly problematic for individuals who are exposed to a cold environment for prolonged periods of time due to climate change. This includes homeless individuals, outdoor workers in cold regions, alpinists and persons with inadequate equipment. The results underline different incidence rates for different populations and show that retrospectively collected data are insufficiently comparable. Enhanced frostbite susceptibility in some individuals should also be considered in the future in order to estimate the frostbite incidence more accurately. Moreover, defining frostbite susceptibility in advance could prevent frostbite incidence in the future to some degree, especially in military operations in the cold and certain leisure activities (e.g. mountaineering).

Conclusions: Methodology for analyzing frostbite incidence varies among different studies, mostly of them are retrospective. A registry or database that records incidence rates of frostbite while considering the respective framework conditions could lead to better data quality and improve preventive measurements against frostbite. Preventing frostbite incidence by estimating frostbite susceptibility should be considered in the future.

Acknowledgement:

I would like to express my gratitude to Assist. Prof. Jurij Gorjanc, who provided valuable assistance in generating ideas for this article, helped me to establish a framework for this work, and proofread the article. Additionally, I would like to thank Dr. Hintze-Neumann for enabling me to work on this article alongside my teaching responsibilities at the Gesamtschule Kürten.

The Planica protocol for frostbite management: three case reports

J. Gorjanc[1], I. B. Mekjavič[2], P. J. Mekjavič[3], B. Schneider[4]

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Introduction: Frostbite is a consequence of tissue freezing. Deep frostbite injury without proper treatment results in tissue loss. The damage is mainly a consequence of irreversibly damaged vascular endothelium and vascular occlusion and partly a direct effect of cold on peripheral body areas. Amputations in hands have a strong impact on functional impairment and leave behind permanently disabled patients.

Objectives: Different diagnostic and therapeutic protocols for frostbite management have been developed and are implemented nowadays. The Planica protocol for frostbite management has evolved from our own research in years of clinical practice. It emphasizes frostbite as emergency condition.

Methods: Three cases of alpinists are presented, who suffered frostbite during climbs in Slovenian Alps (2800m), on Matterhorn (4478m) and Pik Lenin (7134m), respectively. After hospital admission, all three alpinists were treated according to the Planica diagnostic and therapeutic algorithm for frostbite management. After diagnosis of deep frostbite was confirmed in all three alpinists, medication with iloprost, pentoxifylline, enoxaparin, ibuprofen, pantoprazole, amoxicillin/clavulanic acid was started. Additionally, management with hyperbaric oxygen

therapy (HBO) was administered. Treatment with tPA was considered as an option in case 2.

Results: In all patients, the preserved length of injured digits was larger, as it had been estimated at the initial bone scan.

Conclusions: The Planica protocol for frostbite management consists of proper first aid, prompt emergency medical assistance and standardized hospital treatment, which are the key for a favorable outcome (without tissue loss).

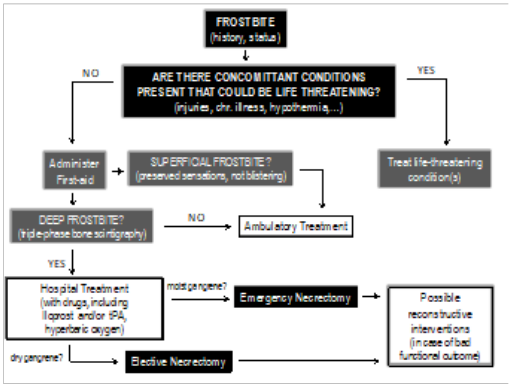

Figure 1 – The Planica Protocol for Frostbite Management

A physiological device to measure human performance during environmental parachute jumping with and without oxygen supplementation

S. Michael[1], A. Werner[1,2]

[1]German Air Force – Centre of Aerospace Medicine, Aviation Physiology Training Centre, Aviation Physiology Diagnostic and Research, Königsbrück, Germany; [2]Institute of Physiology, Center for Space Medicine and Extreme Environments Berlin, Charité – Universitätsmedizin Berlin, Berlin, Germany

Introduction: Present standard surface parachutes allow jumps from a height of more than 30.000ft. These possibilities expose jumpers to extreme environments. Therefore, portable oxygen apparatus and protection against cold were created. The laboratory results were transferred into the real environment.

Methods: Based on the developed mobPhysioLab®, data were recorded in a real setting. After adaption for parachutists, it was feasible to test oxygen equipment for high-altitude jumps in extreme conditions.

Results: Volunteers were included for several jumps (up to 25.000ft) with and without oxygen supply (up to 12.000ft). The results show that an oxygen supply could be already necessary for a height of 12.000ft. The offered oxygen was always sufficient for the higher altitudes, and the saturation never reached a critical value. The body surface temperatures showed a significant cooling of the extremities during freefall. The time of rewarming was much longer. A lower peripheral temperature of the extremities limits the ability to operate due to reduced motor skills during the jump and exposes skydivers to increased danger after landing.

Discussion: The results revealed that high-quality continuous physiological data acquisition is difficult. Further technical development is necessary. Nevertheless, oxygen supply for every jumper should already be provided at altitudes of 12.000ft. An innovative development of clothing is required to counteract cooling more effectively because cooling down hampers oxygen transport into cells due to the left shift of the acid-base-curve. The mobPhysioLab® is an appropriate device with which such questions could be answered.

Tell me stories about yesterday: Results of the big physiologists of the 19th century and the consequences for today

T. Küpper

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As reviewer I have got the author's remark "To our best knowledge, this is the first study…" several times. Often my comment was: "No, look at X. YYY, 1876"! Obviously younger scientists just follow electronic literature research and ignores the great

experimenters of the 19th and early 20th century. In molecular biology that would be o.k., but it is a big mistake in altitude physiology. This mistake often causes costs, waste of time and personnel.

Based on the original books and papers of J. Acosta (1589), R. Boyle (1670), J. A. de Luc (1772), H. B. Saussure (1786), E. F. Pöppig (1836), A. v. Humboldt (1845), J. J. Tschudi (1846), C. Meyer-Ahrens (1854), J. Tyndall (1860), H. Schlaginweit (1861), J. Glaisher (1862), P. Bert (1878), W. M. Conway (1884), F. Viault (1890), G. Katzenstein (1891), A. Loewy (1891), M. Miescher (1893), J. Loeb (1896), A. Mosso (1898), A. Jaquet (1898), E. Bürgi (1900), R. Staehlin (1901), E. Abderhalden (1902), A. Durig (1904-1906), N. Zuntz (1906) and others the lecture will give a brief overview over altitude physiology of the "classic era".

Lessons from the past - facts from rediscovered publications and historical events about (accidental) hypothermia

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Introduction: Medical knowledge is estimated to double every 5 to 50 years [1]. Keeping an overview of this rapidly growing amount of data is almost impossible. How productive is this growth in knowledge in the example of prehospital hypothermia treatment and what can we learn from old data?

Objectives: A historical case vignette is used to illustrate the prehospital diagnosis and treatment of accidental hypothermia through the ages and (patho)physiologic records are presented.

Methods: Selective literature search.

Results: Presented is the case of a 16-year-old hypothermic boy who was rewarmed in 1805 using the most basic methods similar to the basic principle of today's heat packs (protection from environmental conditions/evacuation, removal of wet clothing, various external heat sources, insulation). [2]. The prehospital diagnosis of hypothermia (clinical examination and situation versus temperature measurement), the triggering of cardiac arrhythmias by cold (temperature thresholds for cardiac arrhythmias, ventricular fibrillation, and asystole), and the lowest core temperature survived to date in accidental hypothermia, compared with temperatures in induced hypothermia, are critically discussed on the basis of the case report and old rediscovered and current literature [3–5].

Conclusions: The basic features of improvised rewarming have been known for centuries. Prehospital diagnosis of hypothermia is still mainly based on clinical findings. In part, historical data are lost in the modern flood of information and are simply forgotten.

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High Altitude Headache - Acute Mountain Sickness. Observations Compiled at the Aconcagua Mountain in the Andes Mountain Range

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Introduction: Altitude headache (CA) originates at altitudes above 2500 meters above sea level (masl), within 24 hours of exposure to altitude and resolves in 8 hours when altitude decreases. It occurs in isolation or as Mountain Sickness (AMS)

The objective: The objective of the study was to describe the characteristics of the "CA" and correlate it with AMS, hematocrit and the different altitudes in Aconcagua Mountain (MA), Argentina.

Material and method: A cross-sectional, descriptive, observational and correlational analysis of the MA population was carried out in January-February 2013. Climbers, park rangers and rescuers participated; they were studied in relation to the height at which they were staying at the time of the study: H1:3300masl; H2:4370masl, H3:5050masl, H4:5935masl. The exclusion criteria of the study were: people under 16 years of age or over 65 years of age, headache onset after 24 hours, headache below 2500masl. Anamnesis was carried out oriented to a history of arterial hypertension, previous AMS, previous headache; time of permanence in the MA, time of onset of the headache and the characteristics of the pain: onset, location, intensity, exacerbations, accompanying symptoms; and preventive medication for AMS. A neurological examination was performed, fundus of the eye (FO) by ophthalmoscopy without previous pupil dilation, heart and respiratory rate measurement, oxygen saturation by pulse oximetry, blood pressure by a sphygmomanometer and manual hematocrit measurement by blood extraction, centrifugation for 5 minutes in Centrifuge ROLCOCH50. People were classified according to whether they presented high altitude headache (CA) or not (NCA).

Results: Out of 160 participants, 30 were excluded; 53 presented CA and 77 did not present NCA. The CA group had a mean age of 37±9 years ($p=0.02$). The days spent on MA in the CA group was 7±4 days and in the NCA group it was 37±14 days ($p<0.01$). The mean O2 saturation showed statistically significant differences: 86±6% for the CA group and 92±5% for the group NCA ($p<0.001$). Hematocrit value in the CA group: 48±7%, and 55±7% ($p<0.001$) for NCA group. There was a positive association between the severity of AMS with height (Kendall'sTAU B=0.424). The CA was oppressive 56%, bifrontal 62%, hyporexia and nausea being the main accompanying symptoms, reporting in CA ataxia of the upper limbs in 57%, with loss of venous pulse 54.7% and papilledema 7,5% in the FO.

Conclusion: The directly proportional correlation between the presence of CA, altitude and AMS severity is confirmed, observing that the higher the height reached, the shorter the time of onset of headache, indirect signs of intracranial hypertension and variations in the hematocrit.

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Changes in neuroconduction of peripheral nerves of healthy climbers

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Introduction: Some high-altitude climbers present signs and symptoms associated with sensory and motor deficits in the extremities, without visible tissue lesions. At high altitudes, the body generates a physiological polyglobulia, which can sometimes be associated with dehydration, nutritional problems, vasoconstriction due to cold, and low oxygen availability, which can cause nerve ischemia.

Objectives: The objective of the study was to determine the presence or absence of peripheral nerve injury in climbers exposed to high altitude hypoxia through motor neuroconduction studies in upper and lower limbs at Mount Aconcagua, Mendoza, Argentina.

Material and methods: A cross-sectional, descriptive, observational and correlational analysis of climbers exposed to hypoxia related to the ascent of Mount Aconcagua in January 2020 was carried out. Participants: Rescue patrol personnel participated, who maintain a regimen of 14 days at altitude/14 days at low altitude (near sea level), and high-altitude climbers who remained on the mountain for 14 ± 3 days. Exclusion criteria: Participants who did not complete the study, who had pre-existing pathologies or previous neuropathy, climbers without ascent plan or with prior treatment for AMS. An anamnesis of neuropathy, neurological examination, measurement of vital parameters, and a study of motor neuroconduction by EMG of the ulnar, median, and posterior tibial nerves were performed at the beginning of the expedition and at the end of it, these determinations being carried out at 3430masl.

Results: Out of 87 participants, 44 were excluded. The mean age of the remaining 43 was 39.8±5.5 (mean±SD). The mean height reached was 5959masl±1136 (mean±SD). In relation to the explored nerves, significant differences were found pre- and post-ascent in latencies and distal and proximal amplitudes of the explored motor nerves ($p< 0.01$), not showing significant differences in conduction velocities pre- and post-ascent ($p=0.610$). Likewise, no differences were observed between the right and left nerves ($p= 0.83$).

Conclusions: The altitude hypoxia which the participants were exposed to seems to have an important influence on our findings of axonal damage in peripheral nerves of the high-altitude climbers, although that can also be associated with the risk factors mentioned above. Controlled studies in circumstances where these variables can be excluded could help to clarify the etiopathogenesis of the phenomenon and thus enable us to take measures to avoid chronic and irreversible damage.

Statistical evaluation of medical check-ups to climbers in base camps of Cerro Aconcagua

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Introduction: Mount Aconcagua, the highest mountain in the Americas, with its 6962 masl, is a destination increasingly frequented by mountaineers from all over the world. At the base camps, routine medical check-ups are carried out to preserve the health of the climbers and prevent complications that can be life-threatening at this altitude.

Objectives: Based on the large number of records obtained every year for medical controls in these camps at high altitude, it is our aim with this study to evaluate the possibility of defining guideline values for the parameters of saturation, heart rate and blood pressure for these altitudes and latitudes and thus provide a "normal range" for future medical evaluations of mountaineers.

Methods: In this descriptive, observational and retrospective work we present the statistical

assessment of the data of peripheral oxygen saturation, heart rate, diastolic and systolic blood pressure recorded in more than 2500 climbers who accessed the Aconcagua base camps during the 2015/2016 season. We have records of two large groups of climbers, different for the approach route to the camps. One route starts at 2400masl in "Punta de Vacas" and leads in 3 days to the camp "Plaza Argentina" at an altitude of 4200masl where the record of the mentioned parameters is made. The other route starts in "Horcones" at 2900masl, arrives in 1 day to "Confluencia" camp (3400masl) where the first medical check-up is done the following morning, an acclimatization hike is done on day 2 to "Plaza Francia" (4200masl) and returns the same day to "Confluencia". Day 3 we ascend to "Plaza de Mulas" camp at 4200 masl, where the second medical check-up is carried out the following morning.

Results: The data collected are expressed as mean values with standard deviation. Analysis of the measured parameters comparing the corresponding altitudes at which they were taken is presented. To draw conclusions on the influence of age and gender, the mountaineers are grouped into age clusters and men and women are separated.

Conclusions: Taking into account the multiple factors that can influence measurements in mountain terrain we could determine “normal ranges” for some items, for others there have to be done further investigations.

Post-Sars Cov2 sleep hypoxia versus high altitude sleep

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The aim of this study is to compare sleep hypoxia sequelae of Post-Sars Cov2 patients with High Altitude Sleep in a normal subject.

Sleep was studied with Respiratory Polygraphy both in a male patient with Post-Sars Cov2 fibrosis and female patient with sequelae of Pulmonary Thromboembolism due to Covid, both performed at sea level. These studies were compared with the nocturnal respiratory polygraphy of a healthy male performed at 4300 meters above sea level (Plaza de Mulas-Cerro Aconcagua).

Our results show the presence of severe periodic respiration with minimal oxygen saturation values in context of severe apnea-hypopnea indexes in all three subjects.

Effects of pre-term birth on the physiological responses to steady-state exercise across a three-day high-altitude exposure in healthy adults

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Introduction: An appropriate altitude acclimatisation response is critical to mitigate altitude-related illness risk and manage physical activity requirements. Given the physiological stress induced by exercise and hypoxia, it is important to explore altitude acclimatisation patterns in clinical populations [1]. Prematurely-born adults appear to exhibit differential responses to these stimuli [2], having demonstrated blunted hypoxic ventilatory responsiveness [3] and impaired cardiorespiratory fitness [4] relative to their term-born counterparts. Whilst our understanding of pre-term physiology in response to acute hypoxia is growing, investigations into more prolonged hypoxic exposures remain scarce [5].

Objectives: To investigate the integrated physiological responses to moderate intensity exercise across a three-day high-altitude sojourn in prematurely-born adults, compared to a well-matched control group.

Methods: 16 prematurely-born (<32 weeks gestational age) and 16 full-term healthy male adults – matched for age (Mean±SD; 22±3 y), body mass index (22.5±2.2 kg/m2) and peak oxygen uptake (50±10 ml/kg/min) – completed a three-day high-altitude sojourn at 3375 m. Upon arrival (A), and prior

to departure (D3), participants performed a bout of moderate-intensity exercise on a cycle ergometer. Participants cycled for two minutes at 20 W, then at a moderate exercise intensity for eight minutes (20% below gas exchange threshold, adjusted for hypoxia-induced exercise capacity reductions). Oxygen uptake (V̇O2), pulmonary ventilation (V̇E), capillary oxygen saturation (SpO2), cardiac output (CO) and muscle oxygenation (TSI) were continuously measured. The data outlined below are 60-s averages calculated for each variable in the final minute of the exercise bout, analysed via two-way mixed-effects ANOVA. These data are to be complemented by exercise onset kinetics data, whereby second-by-second traces of each of the above variables were fitted with mono-exponential functions using least squares regression techniques.

Results: There was no main effect of time (A vs. D3; 1.46±0.31 vs. 1.48±0.29 L/min; p=0.091) or group (pre-term vs. full-term; 1.37±0.29 vs. 1.56±0.28 L/min; p=0.091) in V̇O2. However, increases in V̇E (46±11 vs. 53±12 L/min; p<0.001), SpO2 (84±4 vs. 89±3%; p<0.001) and TSI (61±6 vs. 62±5%; p=0.028), and a decrease in CO (17±3 vs. 15±2 L/min; p<0.001), were observed from A to D3. Pre-term individuals demonstrated a lower CO than full-term individuals (15±3 vs. 17±2 L/min; p=0.003). No time*group interaction effects were observed in any variable.

Conclusions: These data suggest that prematurely-born adults exhibit similar altitude acclimatisation patterns during exercise to their term-born counterparts across a three-day exposure at 3375 m.

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Premature birth and altitude acclimatization - the knowns and unknowns

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Introduction: As global premature birth rates continue to increase [1] there is an ever-increasing number of preterm birth survivors reaching adulthood and, consequently, a growing interest in the long-term sequelae of prematurity. Given that the number of individuals venturing to altitude regions >2,500 m for leisure and professional reasons is also increasing [2], numerous prematurely born individuals are, or will prospectively be, exposed to high-altitudes. As successful high-altitude acclimatization hinges on numerous cardio-respiratory and redox balance adaptations - that have previously been shown to be underdeveloped and/or compromised in preterm born individuals [3] - it is crucial to improve our understanding of the altitude acclimatization capacity of prematurely born individuals [4].

Objectives*:* To comprehensively characterise specific physiological responses of prematurely born individuals during high altitude acclimatization, compare their responses to their full term born

counterparts and elucidate the underlying mechanisms of the potential differential responses between the two cohorts.

Methods: To achieve the above goals we conducted a series of studies across the last five years – within the framework of the PretermHypo and the PreAlti projects – involving adults and children born prematurely (gestational age ≤ 32 wks. & gestational mass ≤ 1500 g), and their age and aerobic capacity matched full-term born counterparts (gestational age ≥ 38 wks.). Acute and prolonged exposure experiments were conducted under both normobaric (Ljubljana laboratory and Planica normobaric hypoxic facility, both in Slovenia) and hypobaric hypoxia, the latter of which were conducted at the Aiguille du Midi Iffremont laboratory (Chamonix, France; 3,842 m) and the Torino high altitude Refuge (Courmayeur, Italy; 3,375 m). To integratively assess acclimatization modulation in these individuals, comprehensive physiological and biochemical assessments were conducted at rest and during exercise, as well as during sleep.

Results: Key results from our studies, particularly those relating to the cardio-respiratory system, convective and diffusive O_2 transport and redox balance modulation will be presented and discussed. While some preterm-specific responses might appear detrimental for optimal altitude acclimatization, other data suggest that prematurely born individuals could tolerate altitude/hypoxia better than their term-born peers, suggesting potential »hypoxic preconditioning« in these individuals.

Conclusions: Overall, the data obtained from our studies as well as evidence from other recent investigations clearly demonstrate prematurity-specific responses, both at rest and during exercise, in hypoxic/high-altitude conditions. Given that the exact mechanisms and underlying reasons for these divergent responses remain unclear, prospective high-quality mechanistic and interventional studies seem warranted.

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Sprint interval training in hypoxia and exercise performance

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Introduction: Hypoxia is often used during training to augment metabolic load and heighten physiological adaptations with the ultimate aim of improving exercise performance. Up-to-date, sprint interval training in normoxia (SIT) has been recognized as an effective and time-efficient training strategy for enhancing cardiac output, maximal oxygen uptake, skeletal muscle mitochondrial content, and exercise performance [1]. Additionally, exercising in hypoxia enables greater physiological adaptations in muscle tissue throughout the activation of various signaling pathways in hypoxia [2]. Accordingly, a novel hypoxic training method, termed »sprint interval training in hypoxia« (SIH) has recently been proposed, comprising multiple 30 s »all-out« Wingate sprints conducted under hypoxic conditions, interspersed with 3–5 min recovery periods [3].

Objectives: Given the hypothesized further augmentation of exercise performance following SIH as compared to SIT [4] the purpose of this work was to elucide the evidence supporting the use of SIH for performance enhancement.

Methods: For this purpose, we conducted a systematic review of the up-to-date available literature. The PubMed, SportDiscusTM, and Web of Science online databases were searched for original articles in the English language—published up to March 2023—assessing changes in exercise performance following SIH and SIT.

Results: Six unique studies (randomized controlled trials (RCTs)), evaluating SIH and SIT interventions lasting 2–6 weeks with 2 or 3 exercise sessions per week fitted all inclusion criteria and were scrutinized. Four studies investigated recreationally active and two, well-trained athletes. In all studies, the SIT training sessions were performed using a cycle ergometer, including 4–9 × 30 s Wingate sprints, with 4–4.5 min intermediate recoveries. During the SIH session, the participants in all studies underwent normobaric hypoxic exposures, simulating altitudes from 2000 m to 4000 m (FIO2=16.7–13.0%).

Conclusions: Overall, the currently available scientific evidence does not suggest that SIH additively augments exercise performance in comparison to SIT. However, the potential changes related to anaerobic thresholds (indicating up-regulation of muscular aerobic capacity and improved oxidative phosphorylation) after SIH, but not after SIT, require further scrutiny to fully elucidate the subsequent effects on exercise performance. Nevertheless, there is some evidence to support beneficial peripheral adaptations known to increase the oxidative and glycolytic capacity, especially in type II, fast-twitch fibers, following SIH, but not SIT. These local adaptations could potentially enable superior improvement in exercise performance after SIH training protocols of sufficient duration. Future RCTs on SIH and, particularly, on the performance-related underlying mechanisms seem warranted.

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Differences in physiological variables of U23 cyclists between normoxia and hypoxia

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Introduction: The effects of altitude on endurance performance is complex. The integration of altitude in athletes preparation towards their seasonal goals has become more popular than ever. Since the summer Olympic Games 1968 in Mexico City altitude is used in preparation only the way altitude is used has changed over time.

Many athletes use simulated altitude, most professional cyclists sleep at altitude and train in low lands to legally enhance their endurance performance.

Objectives: The goal in the long run is to create a SED-card that clearly demonstrates an athlete what benefit one can expect from altitude. A guidebook that shows the athlete the individual best altitude he needs, how long it takes to best adapt to this altitude with the biggest output in performance possible.

The goal must be to help the athletes understand their reaction to altitude and minimize the risk of failure using it. If there were objective ways to unterline the individual stress caused by altitude it can be better implemented in the training regime never losing the balance of training stress in combination with the triggered altitude stress.

Methods: The participants of this study were twelve U23 cyclists (N=12) from a UCI continental team. The subjects underwent two consecutive graded incremental exercise tests (GXT). The first GXT was conducted in normoxia at 574m above sea-level and the second GXT in a custom build altitude chamber corresponding to a simulated altitude of 1800m above sea-level. Both GXTs were performed on the participants' individual road bike mounted on an electromagnetically braked ergometer starting at an initial load of 100 watts with an increment of 20W every minute until volitional exhaustion.

In addition to the conventionally measured parameters (respiratory parameters by Cortex, heart rate by Polar) in sports medicine examinations, oxygen saturation was measured at both GXT to take a look into desaturation.

Results: The findings of the present study show inter-individual differences in desaturation that nicely correspond with the athletes performed adaptation response to simulated altitude at home (that was not part of this study). There seems to be parallels between acute hypoxia response to long-term altitude adaptation.

Conclusion: Extended protocols need to be done to be able to make even more precise statements to athletes on how beneficial altitude is to them and create a template that enables athletes to optimize the use of altitude without it being an experiment and making sure the desired effects always fully show.

Who is fit for rescue at altitude?

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Mountain rescue – organized (OR) or as companion (CR) – is a demanding task. The lecture summarises several studies which investigate individual and environmental conditions which define the minimal requirements. The most important take home messages are:

According to DIN 33404.5 a total of 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. Due to limited duration of exposure the most important danger for OR is frostbite, for CR also hypothermia.

In at least 30.7% of all rescue operations, personal advanced alpine climbing skills were required for the rescue personnel, and in 6.0%, the difficulties of the rocky terrain correspond to UIAA scale grade iii with another 2.4% to UIAA grade IV or above. About 1.5% of all operations took place in ice faces steeper than 50°. To be able to manage 90% of all operations safely, all crew members, except the pilot, must be competent at climbing rock terrain of uiAA scale grade iv and ice of 50° steepness using appropriate rescue, rope, and belaying techniques. These recommendations include a technical safety margin for adverse conditions, such as bad weather.

CPR at high altitude needs an exercise capacity of at least 2.3 W/kg body weight. Any situation where the patient must be carried by one person (e.g. crevasse rescue) needs at 3.5 to 4.4 W/kg. With a need of 4.8 to 5.5 W/kg when a patient must be carried uphill this will be impossible for normal persons without the help of others.

OR, CR, the patient and bystanders are exposed to significant noise if a helicopter should be involved in the operation. With up to 120 dB(A) a single event may cause permanent damage to the inner ear ("permanent threshold shift", PTS = noise-induced hearing loss).

Effects of combined heat and intermittent hypoxic training on aerobic performance in untrained men – preliminary report

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Introduction: Hypoxia and heat are considered factors that can improve aerobic performance. Training in hypoxia can improve oxygen carrying capacity of blood and training in heat can improve performance by increasing plasma volume at rest [1].

Objective: The purpose of study was to determine the effects of physical training performed in simultaneous hypoxic and heat on aerobic capacity in young untrained men.

Methods: Before the study, the sample size was calculated, and 16 untrained participants were recruited into each group (four groups; N=64). After taking somatic measurements (body height and body mass), participants performed a graded test to volitional exhaustion, during which maximal oxygen uptake (VO2max) was measured and the first (VT1) and second (VT2) ventilatory thresholds were determined for each participant. Participants were randomly divided into control group and 3 groups

performing the same interval training, but under different environmental conditions: normoxia (200 m asl) and 21°C (NT+21°C); in intermittent hypoxia (3000 m asl, FIO2=14.4%) and 21°C (IHT+21°C); and in intermittent hypoxia (3000 m asl, FIO2=14.4%) and 31°C (IHT+31°C). Training took place 3 times a week for 4 weeks (12 workouts). Training was performed in a hypoxic thermoclimatic chamber, on bicycle ergometers, and lasted 60 minutes. The training consisted of a warm-up (6 minutes) followed by 6 series of efforts lasting 6 minutes with active recovery of 3 minutes. The intensity of the efforts was determined individually and corresponded to the power at VT2 (effort) and VT1 (active recovery). After 7-10 days from the end of training, the participants performed the graded test again.

The ANOVA with repeated measures was used to assess significance of the effect of training on changes in aerobic performance. Post hoc analysis was performed using the Tukey test. The differences were considered statistically significant at $p<0.05$. The effect size (ES: Cohen's d) was calculated and interpreted as small (0.20), medium (0.50), or large (0.80).

Results: Physical training under all environmental conditions was effective in improving absolute VO2max. Analyzing the effect size, the data indicate that IHT+31°C showed the greatest effectiveness in improving aerobic performance ($p<0.001$, ES=0.64; +10.1%) compared to controls ($p=0.99$, ES=0.09; +1.4%), NT+21°C ($p=0.04$, ES=0.51; +5.5%) and IHT+21°C ($p=0.003$, ES=0.47; +7.0%).

Conclusions: Training in combined heat and intermittent hypoxia may be a more effective form of training in improving VO2max than training in intermittent hypoxia under thermoneutral conditions or training in normoxia.

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Risk of weather-related falls at medium altitudes – repeatedly neglected Institut of sports science (as retired), FB 02, Johannes Gutenberg-University

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Not presented because of health reasons.

Introduction: At the beginning in February 2023, 2 highly motivated, adventurous "mountaineers" (one of them without previous experience) wanted to climb the Watzmann (2,713 m) and had to be rescued early at 1500 m (lost, poor visibility, problems with the mobile phone battery). Regarding incidents as such becoming more frequent – what about tours at low altitudes?

Case reports: without avalanche accidents: 1) Schauinsland (17.4.1936): Only one day after arrival a teacher from London took his 27 pupils (most only dressed in shorts and low shoes) on a hike from Freiburg (Germany, starting altitude 280 m) over the Schauinsland (Black Forest, 1284 m). Despite repeated warnings and falls of sleet at start and en route the teacher continued without any knowledge of the area, got into thick fog and a snowstorm ("it was hell"). Because their teacher did not want to interrupt the hike under any circumstances, 5 boys (aged 12 to 15) died of exhaustion and hypothermia. 2) China (22.5.2021, 100 km mountain marathon up to 2000 m altitude). Near checkpoint 2 (after 20/30 km) a weather storm with hail, freezing rain and squalls hit. This ended fatally for 21 of 172 runners (some dressed only in shorts and T-shirts), 8 others were hospitalised. 3) Dachstein disaster (15.4.1954): All 10 pupils and 3 of 4 teachers died during a mountain tour at altitudes of approximal 1960 m. They started despite repeated warnings and unfavourable weather conditions, got into a blizzard with knee-deep snow and lost orientation.

Mountain races in the Alps are major sporting events marketed by the media; for 2022 were announced 72 (D: 17, A: 21, CH: 34). Even though safety measures (concerning equipment, clothing, limitation of participant numbers and regulated starting permission) were introduced, references to

life-threatening weather drops (possible mid-summer snowfalls!) are only made occasionally.

Common misconduct in the examples: Disregarding warnings from local experts and predicted hazardous weather, underestimation of risks in spring/summer, lacking equipment (especially clothing) and preparation e. g. through local knowledge, misplaced ambitions and risk-taking.

Conclusions: Underestimation of weather-related dangers and irresponsible risk-taking ("no risk, no fun") can even lead to fatal disasters in low mountain altitudes. Today, the risk is probably less in supervised mass events, whose attractiveness, however, can motivate private groups to undertake hikes even in low altitude regions, similar to the Watzmann mountain tour that failed in February 2022 at 1500 m, dangerous and unreasonable concerning rescue teams.

References:

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Cross-country skiing as a component of clinical sports therapy for infantile and juvenile obesity

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Introduction: The knowledge of the energy expenditure of specific sports is elementary using sports as part of therapy for obese children and youngsters.

Objectives: Determination of energy expenditure (MetaMax3B spirometry system) during cross-country skiing in the context of a clinical rehabilitation programme for obesity.

Methods: Eleven subjects (5 f), 13-18 years old (M=15) with body height of 1.69 m (± 0.04), body weight of 99 kg (± 12) and BMI of 34.6 kg/m² (± 3.6) received a reduction diet of 1500/1800 kcal/day, respectively. After an initial spiroergometry (bicycle ergometer, WHO step scheme), the participants underwent a mobile spiroergometry on a 1.76 km cross-country skiing track (650 to 654 m above sea level) in a test-retest procedure after a previous five-minute rest measurement. Test sequence: morning or afternoon, if possible at the same time, approx. 2 hours postprandial, with an interval of one to three days. The evaluation of the measured values (O2/CO2) was done with the MetaSoft 2 software. The sensors of the spirometry system were calibrated daily before each series of measurements. Due to low outdoor temperatures, only a part of the 90 min runs could be measured.

Results: During bicycle ergometry, an average test duration of 11:31 min (± 2:41) was achieved and a maximal power output of 184 W (± 29) was obtained. The V`O2max was 33.5 ml/min/kg (± 5.2), the HRmax was 182/min (± 29).

The stress intensity during cross-country skiing of the subjects - measured by heart rate - was 148/min (± 13), measured by V`O2 was 22.5 ml/min/kg (± 3.4).

Cross-country skiing measurements between -10° and 10°C air temperature with duration of 29:04 min (± 4:41) and average speed from test and retest of 3.7 km/h (± 0.6) resulted in an average gross energy expenditure of 6.4 kcal/h/kg (± 1.0) or 633 kcal/h (± 71). The net energy expenditure was on average 495 kcal/h (± 71) and 5.0 kcal/h/kg (± 0.9), respectively.

Conclusions: The results show that the net energy expenditure (239 kcal/29 min) extrapolated to 1.5 h (≈ 742 kcal) in whole-body cross-country skiing and adequate exertion with reference to the reduction diet (1800 kcal/day) represents a relevant supplement of approx. 41%. Thus, the whole-body sport cross-country skiing was suitable for increasing the therapeutically intended negative energy balance of the obese, which is necessary for weight reduction.

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Requirements for a system for measuring physiological data in a caisson-type ICE environment

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Introduction: The purpose of the study was to conduct research and choose the characteristics of a system for monitoring the physiological data of workers in demanding professions for their screening and preselection in an ICE (Isolated, Confined, Extreme) environment. The system parameters are designed and subsequently developed and tested for 24/7 measurement in the ICE environment. A Hydronaut caisson was used as the ICE environment to simulate analog space missions.

Objectives: The aim is to design a system of biomedical data sensors regarding the requirements for use in a caisson and the required standards.

Methods: An analysis of current methods for processing biomedical data and national and international standards is performed. Standards are used to design the system characteristics: EN 60529 Protective case: IP68; EN 60601-1: Medical electrical equipment: basic safety standard + IEC 60601-1-2 + IEC 60601-2-25 + IEC 60601-2-47 + IEC 60601-2-51; CEI 60529: Small craft — Electrical systems — Extra-low-voltage installations; EN 14225-3: Diving suits; EN13319 Depth gauges and combined depth and time measuring devices; EN 14931: Pressure vessels for human occupancy. During the test the system was at 2 bar pressure like that expected during the dive. The pressure change speed was about 0.002 bar/min. The proposed biomedical data were recorded.

Results: Based on consultations with clinical workplaces (UP in Olomouc, NUDZ, etc.), the following physiological data sensors are selected:

- ECG sensor with R-R interval detector and sampling frequency 500 Hz.
- Mechatronic respiratory rate sensor with a sampling frequency of 125 Hz.
- SRL sensor with Ohm output and 125 Hz sampling rate.

The technology is designed to meet the requirements of the standards.

Conclusions: Characteristics of the system for measuring the physical and psychological state of persons in the ICE environment during analog missions are recommended and proposed.

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