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Sport specific performance analysis in skimountaineering: a comparison of laboratory and field tests

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Introduction: Skimountaineering is a competition sport that has gained popularity during the last years ultimately leading to being accepted as a discipline at the Youth Olympic Games in Lausanne in 2020. Along with this gain in popularity, the level of performance at international competition events rose constantly and a professional and sophisticated training approach became more and more important. Most competitions are held at altitudes between 1500 m and 3500 m and therefore a considerable amount of training takes place at various degrees of hypobaric hypoxia. After having established a sport specific spiroergometry testing protocol using regular skimountaineering equipment on a treadmill during the recent years, this study compares spiroergometric results between a sport specific laboratory test (LT) on a treadmill and a field test (FT) at 3100 m altitude.

Methods: 6 athletes of the German National Team (mean ± SD, age 24.17 ± 4.22) were tested using a telemetric spiroergometry (Metamax® 3B, Cortex) twice: firstly, an incremental step test with skies on a treadmill was used, then, four days later, on snow at 3100 m altitude after three days of intermittent hypobaric hypoxia (train high, live low concept). All athletes were exposed to repetitive intermittent hypoxia during the weeks before the test. Standard spiroergometric parameters as well as Borg scale values were recorded and individual training zones were defined according to VT2 thresholds.

Results: Mean heart rate (HR) max was 192.76 ± 7.39 for LT and 180.5 ± 8.96 for FT. Mean VO2 peak reached 71.83 ± 11.78 for LT and 54.17 ± 8.42 for FT. HR at VT2 had a mean value of 180.83 ± 7.47 for LT and 174.17 ± 7.99 for FT, with the individual difference in HR at VT2 ranging from 1 to 12 bpm.

Conclusion: While data analysis is still in progress, preliminary results demonstrate expected altitude related changes of parameters, such as the reduction of VO2 peak. The relatively wide range of difference in HR at VT2 strongly suggests individual field testing for professional athletes rather than a generalized correction factor applied to normoxic laboratory derived thresholds.

Does Intermittent Normobaric Hypoxic Exposure Induce Pre-Acclimatization?

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Introduction: There is a growing number of commercial gyms offering simulated-altitude training facilities and sleep chambers to aid performance in high altitude ascents and endurance events. This review specifically looks at the evidence surrounding the use of intermittent normobaric hypoxia and its effect on acclimatization.

Methods: Review of the literature was undertaken by systematic search of electronic databases including the use of key words, named author, reference scanning and citation tracking. Electronic searches of Google Scholar, EMBASE, PubMed and Web of Science were conducted.

Results: The "hypoxic dose" generated by intermittent hypoxic exposure(IHE) falls short of that required to induce endogenous erythropoietin production and erythrocytosis, thus any benefit in acclimatization is likely to be due to other mechanisms. Repeated exposure to lower partial pressures of oxygen results in up-regulation of transcription factors such as hypoxia inducible factor 1α. Additionally skeletal muscle oxidative metabolism is altered by exposure to hypoxia with increased glycolytic capacity – a hypoxia-induced substrate switch.

Conclusion: There has been a number of disparate studies looking at a range of physiological end-points in the study of normobaric hypoxia. Whilst these studies have allowed for better characterization of the physiological responses to hypoxia, it is to early to suggest that these demonstrate evidence of pre-acclimatisation. Molecular changes have been described as above, but the clinical ramifications of these needs clarifying. An increasing amount of research suggests that normobaric and hypobaric hypoxia induce different molecular and hormonal changes and these differences may be the key in inducing a state of pre-acclimatisation successfully. Future research should target several key questions if normobaric hypoxia is to be safely used for recreation, rescue and military preparedness: How persistent are the physiological effects of normobaric hypoxia? To what altitude would IHE pre-acclimatize an individual? What hypoxic dose is required and what is the best way to deliver it?

From civd curve to frostbite prevention

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Study 1

Purpose: To assess whether previous freezing cold injuries (FCI) would affect digit skin temperatures and rewarming rates during a follow-up cold stress test protocol.

Materials and methods: Twenty elite alpinists participated; alpinists with previous FCI requiring digit amputations (injured, INJ: n=10 total, n=8 male) were compared with ability-matched, uninjured alpinists (control, CON: n=10, all male). Digit skin temperature was measured using infrared thermography as an index of peripheral digit perfusion after a cold stress test, which consisted of 30 minutes of immersion in 8°C water.

Results: Although, absolutely, digits in the INJ group were colder in all phases,, there were no differences between the rates of rewarming of digits in both groups (Toes: INJ, 0.5° ± 0.11°C/min; CON, 0.7° ± 0.3°C/min); p=0,16). Fingers in the INJ group were colder than in the CON group after cold phase (2nd + 5th finger; p<0,05). During recovery, fingers in the INJ group were colder than in the CON group by 20%.

Conclusions: Even after FCI that requires digit amputation, there is no evidence of different tissue rates of rewarming between the injured and uninjured fingers or toes of elite alpinists.

Study 2

Purpose: The aim of the study was to assess whether previous freezing cold injury to fingers and/or toes might predispose alpinists to greater risk of further freezing cold injury, primarily due to a greater vasoconstrictor response to cold, resulting in a lower perfusion, reflected in lower skin temperature.

Materials and methods: Ten elite alpinists (N = 10; 8 male and 2 female) with amputations after freezing cold injury participated in a cold-water (8°C) immersion stress test of the hands and feet. Digit skin temperatures of amputated digits, their noninjured counterparts, noninjured digits of the affected side and noninjured digits of the corresponding side were measured. The skin temperatures were compared during three consecutive phases of the cold stress test: prewarming, cold water immersion, and passive heating.

Results: Amputated toes cooled much faster compared to their uninjured counterparts (n = 26, p < 0.001), and attained lower skin temperatures during the cold exposure test (n=26, p<0.001). Higher cooling rate was observed in all the toes on the injured limb compared with the toes on the uninjured limb (n = 40, p < 0.001). In contrast to the toes, the fingers on the injured limb after freezing cold injury were warmer during cooling phase compared to uninjured fingers (n = 15, p < 0.001).

Conclusions: The lower digit temperatures observed in affected toe stumps during the cold stress test compared to the nonamputated toes may indicate a heightened risk of future freezing cold injury with subsequent cold exposures, as a consequence of less perfusion, reflected in the lower skin temperature. This relationship was not confirmed by the fingers.

Selected possibilities to improve altitude tolerance – or: How to stay healthy at high altitudes?

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Activities at high altitude include mountaineering, military missions, humanitarian aid missions and work stays of expatriates. In addition, rescue operations can emerge in all those fields. Therefore, it is paramount to know strategies to cope with the challenges of mountainous environment/high altitude. The three main environmental factors of mountainous environment are difficult terrain, temperature and hypobaric hypoxia.

According to recommendations of international bodies such as the UIAA or the Wilderness Medical Society, possibilities to counteract the challenges of mountainous environments, especially hypobaric hypoxia, include acclimatization. In addition, pre-acclimatization at natural heights or in hypobaric or normobaric chambers is an alternative and is increasingly used among mountaineers. However, knowledge on de-acclimatization is poor. By using the latency time of altitude sickness, the impact of altitude can be reduced if people return before symptoms of high altitude sickness develop. A high physical activity at high altitude, especially anaerobic exercise, is a risk factor for altitude sickness and should therefore be reduced, for example by using alternative means of transportation, having more breaks and simply reduce work load and pace. Because of susceptibility to mountain sickness is highly individual, a personnel selection of people who are not highly susceptible to hypobaric hypoxia can contribute to building an effective team. A carbohydrate rich diet, a sufficient hydration and thorough hygienic measures mitigate the impact of high altitude and the hygienic constraints often found in mountainous environment. If altitude sickness occurs despite the prevention strategies mentioned above, a fast diagnosis and evidence-based treatment according to international recommendations is necessary. Special equipment, special training, experienced team members and a sound leadership also contribute to staying healthy at high altitude, especially by reducing the impact of environmental co-factors like UV radiation, cold, wind and alpine dangers.

Inflight measurements of oxygen saturations of pilots during high-altitude glider flights of the mountain wave project (MWP) in the Himalayan region and the French Alps

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Intorduction: After two expeditions to the Andes, the OSTIV-Mountain Wave Project Team carried out a research expedition to the Himalayas in 2013/2014. Based on a motor glider-specific multidisciplinary approach, the team, among others, took scientific measurements of the distribution and transport of atmospheric pollutants in Nepal as well as created new digital aerial imageries of exceptional resolution and highest accuracy to create a 3D terrain model of glaciers close to the Mount Everest and Aconcagua. As part of the project, members of the MWP worked together with scientists of the German Aerospace Center (DLR, Institute of Optical Sensor Systems), the Aerospace Technology Faculty of the University of Applied Sciences Aachen, the Karlsruhe Institute of Technology (KIT) and the German Air Force Center of Aerospace Medicine (GAF CAM) to put their concerted efforts into different objectives.

Objectives of the overall project: Firstly, participating pilots wanted to explore the Himalayas and the Mt. Everest region in pioneer flights by flying up to the height of the Mt. Everest with a motor-glider (STEMME S10VT). Secondly, the project served to enhance the knowledge in turbulence research and improvement of weather forecast models. Thirdly aerosol measurements were conducted in order to record the vertical distribution of particulate matter and their optical properties for source apportionment in Nepal. Fourthly, a digital aerial imagery with a resolution, as high as never used before, were created in this region to enhance the geographical knowledge about this region, draw conclusions regarding global warming, predict flood impacts and produce documentations of natural or cultural heritage. And last but not least, concomitant aeromedical aspects of human performance and limitations with a special focus on an early detection of hypoxic hypoxia among pilots under these uniquely extreme environmental conditions (high altitude, low temperature, turbulences) were of particular interest. Historically, oxygen deprivation was one of the first environmental challenges Aerospace medicine had to deal with. As recent high performance aircraft incidents have demonstrated impressively, it is still an issue this field of medicine is engaged in. Till now, sensors to detect oxygen deficiencies in flight are not in common use. With the introduction of pulse oximetry (SpO_2), an easy-to-use method to quantify oxygen deprivation of individuals was established in clinical routine. However, and this is surprising, not much effort regarding this technology in the field of Aerospace Medicine was made so far. The previous paper prepared by our group of the GAF CAM could demonstrate that several of those pulse oximetry systems, used in clinical routine, are accurate enough to be also considered as warning systems for pilots. With this in mind, a reflectance pulse oximetry system was tested in the environment of high-altitude glider flying. In addition, the intended measurements were tailored to optimize the crew's oxygen management during those high-altitude flights.

Methods: During the expedition the signal failure rate of pulse oximetry sensors was determined in 28 high-altitude glider flights (up to FL 290) in the Himalaya including the Mt. Everest region and (to enhance the number of flights) in the French Alps. All 7 individuals were equipped with three Nonin, bicolor reflectance sensors and the associated WristOx 3100 system. The sensors were fitted at three different measuring points (forehead, sternum and shin). In addition to oxygen saturation, the heart rate and altitude values were also recorded during the flights.

Results: In total, 19 complete data sets with readings from all sensor locations used could be gathered. SpO_2 values recorded at different measuring points showed distinct differences: the highest values were observed at the forehead (95.39 ± 2.11%) (Mean ± standard deviation), the values detected at the sternum were the lowest (84.38 ± 6.74%). Furthermore, the failure rate was highest at the sternum (26.51 ± 18.56% of the measuring time). At the shin, the mean SpO_2 was 93.93 ± 4.24% with a failure rate of 11.67 ± 19,74% of the measuring time. Measurements at the forehead were most robust, showing a failure rate of 3.28 ± 6.29% of the measuring time. The mean duration of failures was 12,8 ± 4,7 s at the forehead, 15,5 ± 12,8 s at the sternum and 13,7 ± 11,0 s at the shin.

Conclusions: Without any question, the use of pulse oximetry added enhanced flight safety in this expedition to the Himalayas. However, the results also clearly reveal the difficulties of obtaining robust signals that reliably reflect inflight blood oxygen saturation that have to be overcome. This is particularly true for the shortfalls inevitably inherent to the method itself. Nevertheless, in this day and age, the objective continuous detection of a pilot's oxygen deprivation is inevitable with respect to flight safety. Among the application points for the sensors tested, the forehead appears to be most suitable.

Effect of endurance training conducted under hypoxia conditions on change of exercise tolerance of patients after myocardial heart infarction (STEMI) treated with angioplasty or coronary artery bypass grafting

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Purpose: The main purpose of the study was to assess the effect of endurance training conducted under hypoxia conditions on change of exercise tolerance of patients after myocardial heart infarction (STEMI) treated with angioplasty or coronary artery bypass grafting.

Methods: 30 patients after myocardial infarction were randomly divided into two groups: A) 12 men (60 ± 10,60 yearsof age) participated in 22 training units under artificial hypoxia conditions (2000 m asl), B) Control group- 18 men (57,16± 9,72 years of age) participated in 22 training units under normoxia conditions. At the beginning (in normoxia conditions) all patients underwent: spiroergometric test using a treadmill, laboratory tests: lactic acid concentration (before and after test), morphology, lipids, mass and body composition. The oxygen saturation was measured each time during every training. After 22 days of training, all groups got re-examined (normoxia conditions).

Results: First group: after the training, there were statisticaly significant changes in: the test time (*0.001*) distance (*0.002*), HR_{peak} (*0.012*), RR_{peak} – systolic (*0.003*), diastolic (*0.030*), HCT (*0.033*). In the case of other analyzed parameters, favorable changes were obtained, however they are not statistically significant.Second group: after the training there were statisticaly significant changes in: the test time (*0.007*), distance (*0.008*), MET (*0.000*), LA_{rest} (*0.017*), LA_{peak} (*0.020*), HR_{rest} (*0.001*), HR_{peak} (*0.000*), RR_{rest} systolic (*0.036*), RR_{peak} – systolic (*0.016*), RBC (*0.020*), HCT (*0.003*). Comparing the two groups, differences were obtained in: MET (*0.045*), VE (*0.002*), RBC (*0.012*), HCT (*0.006*).

Conclusion: Exercise tolerance was improved in both groups. However, due to the lower oxygen content under hypoxia conditions, the range of changes was smaller than in control group.

Pre-acclimatization in normobaric hypoxia before climbing Manaslu (8163 m)

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Introduction: Above 2500 m acclimatization is necessary and this requires time. The use of normobaric hypoxia allows for pre-acclimatization at home instead of spending extra days on site in order to acclimatize following well established protocols [1; 2]. As a matter of fact pre-acclimatization is requested in the wide range of tourism activity and for military missions at high altitude [4-6]. Up to now no general accepted pre-acclimatization protocol has been established [3].

The purpose of this pilot study was to prove if pre-acclimatization in normobaric hypoxia allows for a rapid ascent to high and extreme altitude and if this is practicable during normal life.

Methods: Seven healthy soldiers of the German Special Forces were pre-acclimatizing over 10 days using rented Hypoxico Everest Summit II generators. They adapted the hypoxic training to their normal daily work routine during sleep, at rest and during physical exercise. All persons used a more progressive acclimatization profile than that recommended by the renting company. After the 10 days of training it took 5 days including the flight to Kathmandu (1400 m) until real high altitude exposure.

Result: During normobaric hypoxia training no serious incident happened. The group was able to fly by helicopter to Samergaun (3530 m) and to walk up to the base camp (4880 m) the next day. One day later the group slept in the base camp and two more days later they climbed to camp 1 (5600 m). Nine days after leaving Kathmandu camp 3 (6850 m) was reached. None of the soldiers suffered from acute mountain sickness.

Discussion: Normobaric hypoxia enables pre-acclimatization if on-site acclimatization is not possible. During normal work routine its application during sleep is most suitable. It remains unclear if this is the most effective way for pre-acclimatization and the minimal time of daily hypoxic exposure needed is currently still unknown. Regarding the altitude profile for pre-acclimatization, our experience suggests that the recommendations of commercial companies are far too conservative.

Literature available from the author.

A physiological window for detecting high altitude stress

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Introduction: Acute high altitude exposure among healthy subjects is commonly associated with complex pathophysiological acute mountain sickness (AMS) symptomology. Specifically, failure to adequately adapt to hypobaric hypoxia during rapid ascent to high altitude can result in hypoxemia and tissue oxidative stress (OxS). However, the non-invasive mechanistic processes necessary to define causal relationships between AMS, potential cerebral edema and increased intracranial pressure (ICP) remain unclear. Plus, the validity of potential surrogate measures for accurate definition of adaptive or maladaptive response to hypoxia remains under investigation.

Methods: A prospective study to monitor human physiological parameters on acute hypobaric hypoxic exposure of 16 healthy individuals to 3830 m was conducted via direct helicopter ascent to Mount Ortles glacier. Neurological signs and symptoms of AMS, HACE, clinical parameters, ultrasonography of ONSD and biological samples were prospectively assessed at baseline (262 m) and after passive ascent to 3830 m (9, 24 and 72 h) by blinded investigators. Reactive oxygen species (ROS) production rate was determined by means of an electron paramagnetic resonance method. OxS biomarkers were assessed by immune and/or enzymatic methods.

Results: ONSD increased with exposure to altitude among all participants ($p = 0.003$), more so among those with AMS ($p < 0.001$). After 24h the imbalance between ROS production (+141%) and scavenging (-41%) reflected an increase in OxS related damages by 50–85% ($p<0.05$). Despite the concurrent increase of ONSD, regression analysis did not infer a causal relationship between OxS biomarkers and changes in ONSD.

Conclusion: The relationship between ONSD, time, and mode of ascent to high altitude is extremely relevant for the delineating the role of sonography in supporting a diagnosis of AMS. These results provide new insight regarding ROS homeostasis and potential pathophysiological mechanisms of acute exposure to hypobaric hypoxia. However, caution should be recommended, as there remain limitations to the diagnostic utility of ONSD as a surrogate measure of ICP in these environments. In addition, mechanistic investigations are warranted to identify the sources of ROS production, the sequence of signaling pathways involved and timing of concomitant upregulation of biomarkers of OxS. Future work should focus on large cohort studies, where a range of concurrent environmental stressors may be investigated under controlled, standardized, hypobaric hypoxic conditions.

Sports Anemia and Hypobaric Hypoxia: Clinical and Biochemical Evaluation of Hematologic Changes and Muscle Damage during the Ultramarathon Aconcagua

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Introduction: Sports anemia and muscle damage have been observed especially among athletes who perform resistance exercises. The purpose of this study was to evaluate, in a clinical and biochemical way, the reaction to hypobaric hypoxia as an additional stress factor, observing clinical status and biochemical profile as inflammatory response, production of hemolysis or rhabdomyolysis during extreme exercise among the participants of Ultramarathon Aconcagua. The competition was held on November 29, 2014 in Aconcagua State Park (Mendoza, Argentina) with a distance of 50km and a cumulative altitude difference of 1590 meters, starting at 2900 masl, reaching 4200 masl and back to 2900 masl.

Methods: Control checks of pulse oximetry, heart rate, clinical status and Lake Louise Score at Confluence base camp (3400 masl) were performed on 14 competitors. Blood, urine and saliva samples were taken the day before and two hours after the race. A questionnaire about previous mountaineering experience, allergic response (aqua test), and fatigue/anxiety/sleep quality visual scales were also performed on the competitors before and after the competition.

Results: The increased values of LDH, CPK, myoglobin, troponin T ultrasensitive, NT-proBNP and White bloodcell count (neutrophils) after the race were statistically significant, but there were no changes related to the Red cells series. Saliva samples showed neither inflammatory nor immunologic changes. No significant difference was found between men and women.

Conclusion: Performing aerobic exercise in hypobaric hypoxia conditions is exhausting and causes subclinical muscle damage, but it is not associated with acute anemia. We consider

that this study contributes to confirm that practicing in this type of extreme sports does not cause pathologic or unhealthful consequences among healthy persons.

Keywords: marathon, anemia, hemolysis, rhabdomyolysis, altitude, hypobaric hypoxia.

Physiological Changes among Participants of an Ultramarathon in Subarctic Climate

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The knowledge about physiological changes among athletes participating in ultramarathons is scarce. While tens of thousands athletes compete in classic marathons, only a few hundred do so in ultramarathons, i.e. distances longer than 42.195 km. Nevertheless, the number of participants has continually increased over the last few decades [1] and furthermore, the number and the performances of athletes participating in extreme environments are increasing as well [2]. Therefore, and in order to gain more knowledge in this field, we conducted first studies on participants of the "Yukon Arctic Ultra" (YAU). This run takes place biennially in February in northwestern Canada and covers a maximum distance of 690 km. Temperatures range around -20°C during the day and can drop to -50°C during the night (max temp during the study: +5°C, min temp: -50°C). We surveyed n=24 athletes (17 male and 7 female, age: 41.4 ± 9.6 years, BMI: 24.0 ± 2.6 kg/m²), who competed in the foot-race-category, over three years (2013 n=6, 2015 n=8 and 2017 n=10) regarding various parameters. In total, 12 of the 24 participants (50%) completed the YAU's full distance of 690 km and 14 (58%) at least 480 km. We found considerable changes among various parameters in response to the race's stress, such as in body weight, body composition, serum parameters resembling tissue damage and heart-stress as well as in parameters indicating an increased function of brown adipose tissue [3] as well as of changes in vegetative control and psychometric measures such as mood and fatigue [4].

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Nocturnal hypoglycaemia, an often not sufficiently known special risk for diabetics (type 1) after intensive physical activities

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Introduction: Exercise is good for diabetics, an often used recommendation. Exercise may be complicated for diabetics, , because carbohydrate supply, insuline dosage and metabolism are to be balanced. Mountaineering/hiking is performed with high physical intensities, often performed only a few days/year (problem of experience) with depletion of glycogen stores, filled up during sleep with the risk of unnoticed dangerous hypoglycaemia. Informal remarks led to the assumption, that this fill-up effect, especially after activities in the afternoon or later, is not sufficiently known, in context with the dead-in-bed syndrome, too: A literature survey of Tattersall & Gill (1991, [1]) mentioned lack of relationship to intensive physical activities at afternoon or later. A comment from 2014 [2] also focussed on cardiac aspects, but mentioned „hence, some deaths may have been due to other conditions such as cardiomyopathy or diabetic precoma". An actual guideline [3] usually recommends physical activities, but does not describe in its chapter „Konsequenzen für sportliche Aktivität bei Typ-1-Diabetes" the special risk of unnoticed nocturnal hypoglycaemia after performing physical activities in the afternoon or later.

Methods: To clarify these aspects, we made a literature survey and conducted interviews with 14 diabetes advisers [4].

Results: (state 2013) Scientific literature at 31% (of n=39) and additional sources at 23% (of n=35) described this effect. Nightly check of bloodglucose was recommended in literature (23%) and only at 3% in sources. In training materials (n=9) this special aspect was described twice (22%). 69% of the 14 diabetes-advisers informed explicitly about the special risk of nocturnal hypoglycaemia after intensive metabolic activities and 67% recommended a nightly bloodglucose check.

Conclusions: We assume, that the special risk of nocturnal hypoglycaemia after glucose-consuming activitities is still not sufficiently well known (except the diabetes advisers). A relationship with dead-in-bed syndrome is probable and should be considered in the future. Especially, in the context where hikers and mountaineers are endangered by physical activities performed in the afternoon or later, if they are beginners or active only on holidays (less experience in handling bloodsugar in unusal situations). We recommend to use an alarm mobile/clock for checking bloodglucose at about 3 a.m. as one of prophylactic ways in dealing with this issue.

Literature – please ask: ulmer@uni-mainz.de

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Programming exertion for hiking uphill by percentage guide signs

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Intorduction: Usually guide signs for hikers in mountain landscapes indicate distances until the destination point in hours. Fit hikers need less time, while leisure hikers need more. Especially hikers with reduced fitness need information about the degree of exertion essential for reaching an uphill destination point or information for turning back in time to avoid unwelcome fatigue/exhaustion. For arthritic hikers (problems in descending) a funicular would be favorable.

Methods: The ascent (+ 470 m) to the attractive viewpoint Hirschkaser (1385 m, Region Ramsau, Germany), was marked by signs with 20, 40, 60, 80% of total essential exertion for reaching the destination point, tested before by a very experienced hiker. At starting point, special flyers explaining the meaning of these percentage-signs were provided. 126 hikers (73 m, 53 f, 27 to 85 years) were interviewed at the destination point about their experience in hiking, knowledge of the track and general comments about the new guide signs.

Results: 74 % were tourists, often with previous knowledge of the track. Only 16 % used the signs to plan the exertion spread in time, but for 67 % the signs were assessed as a positive method for improving the attractivity of the track. As consequence the Tourismus-Information Ramsau (1st mountaineering village in Germany) printed 1000 and 2000 flyers for 2017 and 2018, respectively.

Conclusions: Caused by the random conditions of the questioning, most of the interviewed tourists did not belong to the target group of leisure hikers or those with reduced fitness. However, the results indicate attentiveness and attractiveness of the percentage guide signs. So we recommend these special markings as a support for a gentle tourism for people seeking leisure activity even with reduced fitness.

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