

# Psychological and Psychophysiological Effects of a High-Mountain Expedition to Tibet



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In March 1999 a team of 8 mountaineers (6 men and 2 women) climbed up the 6th highest mountain of the world: The Cho Oyo (8201 m), located in the high mountains of Tibet. During the expedition, we investigated the effects of high mountaineering on various psychological variables (e.g., anxiety) and psychophysiological variables (e.g. blood pressure, pulse, skin-resistance) as well as the ability to relax at different points of time (2 pre-measures before, three measures during, and one post-measure immediate after the Expedition). Due to a long-term monitoring of the skin resistance, we can summarize that three different adaptation levels can be defined, that appear under increasing pressure: Inhibition of overload, unspecific hypersensitivity and exhaustion. The results can show that a tele-medical assessment is possible and necessary even under the circumstances of a high-mountainering expedition in order to determine and predict deficits in behaviour and health risks for individuals at high altitudes.

Expeditions in regions with extreme conditions (e.g. outer space, high mountains, the Arctic, Antarctic, desert) do not exist solely to satisfy the researcher's yearning, or to fulfill people's aspiration for maximum physical challenge, but are also useful to investigate the limits of performance and adaptation ability of healthy humans. In the last years a new scientific field has developed by Stück (2002, 2004,) at Leipzig university, which is called "Height Psychology" or "Psychological Science of Life and Behaviour of Humans under Extreme Conditions of High Altitude (Stück, 2004)." Space medicine has significantly contributed to this field by examining extreme terrestrial conditions in order to come up with possible models for settlements in space. In contributions from Auer (1976), Schneider et al. (1993), and Wagner (1991), extreme conditions and their effects on psychological and psychobiological processes were investigated.

We will report findings concerning the effects of high mountaineering on anxiety, on the ability to relax, and on various psychophysiological variables like blood pressure, pulse, and skin resistance. The high mountains have become a research environment for athletics and Adaptation Medicine since the Olympic Games of

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Figure 1. Scientist Dr. Marcus Stück saving the data on the laptop.

1968 (Auer, 1976; Wagner, 1991). At that time, the effects of exercising at altitudes between 1500 and 2500 m were determined. At altitudes above 5000 m, research on the human organism or psychological features is very rare. In March 1999 a team of eight mountaineers (six men and two women) climbed up the sixth highest mountain of the world: The Cho Oyo (8201 m), located in the high mountains of Tibet. Two months later, two members of the expedition team reached the peak. Besides the athletic challenge, the point of that expedition was a scientific study of stress- psychological issues.

We conducted a telemedicine experiment, which is completely unique for high-alpine research studies. The mountaineers carried a skin resistance measurement tool throughout the entire 10-week journey. The skin resistance is a parameter which allows us to make statements about vegetative-emotional stress and states of relaxation. The measured vegetative emotional arousal is influenced by the limbic system, the hypothalamus and the vegetative nervous system. Skin resistance reflects the state of arousal of these systems and can thus be seen as a biological expression of stress and relaxation.

The expedition was equipped with a satellite telephone, a solar device, and a laptop. With this equipment we could send data via the Internet to Germany.

There data was analysed, interpreted and sent back to the expedition group at the base camp of the Cho Oyu by email. Thus the mountaineers were always informed of their vegetative-emotional condition. Furthermore we established pulse, blood pressure, and blood pressure relaxation as the criteria for measurement of the ability to relax. We also established anxiety as a psychological variable. The results of this study are interesting mainly for depicting basic mechanisms which humans use to cope with stress, as the demands of mountaineering are extreme, and show few similarities to every day demands. According to Stück (2002) the following stressors can be named for mountaineering at high altitudes:

- Environmental Conditions (extreme iciness with temperatures below 40 degrees Celsius, Life threatening conditions)
- Long hikes with heavy pack (up to 30 kg)
- Group stressors (Communication problems, partner related aggressions)
- Personal stressors (egoistic tendencies are enhanced with altitude)

The operationalisation of scientific questions turned out to be extremely difficult in the given setting. For the choice of the methods used, the mentioned stressors had to be considered as well as the motivation of the mountaineers. There are very few

experiences with research during extreme expeditions. During data collection, the accompanying scientist had to be creative, to accept risk, to be persistent, to bare high uncertainty, to suffer, to be fit, and to have various alpine skills (see Figure 1).

In this article we will summarize the most important results and offer some insights into the scientific work during the Cho-Oyo-Expedition 1999.

## Method

The total duration of the expedition was 10 weeks (2 weeks acclimation, 1 week travel to the mountain, 6 weeks on the mountain, 1 week postprocess). The group consisted of eight people (six male, two female). Most of them had alpine experience in altitudes between 6500 and 8000 m. The dependent variables used were: anxiety, blood pressure, pulse, blood pressure relaxation, and skin resistance. They were assessed at seven times:

- Pre 1 Measure (one month before the start)
- Pre 2 Measure (directly before start)
- At the end of acclimatisation (Accl.)
- After reaching the base camp at 5400 m (Mountain 1)
- Before the climb to the peak (Mountain 2)
- Post 1 (directly at the end of the expedition) and
- Post 2 (Three months after the expedition)

Anxiety was measured using the emotionality inventory (Ullrich De Muynck & Ullrich, 1977) and analysed with descriptive single case methods. Blood

pressure and pulse, as well as the blood pressure relaxation test, were measured with a portable blood pressure instrument. For the blood pressure relaxation test (Balzer & Hecht, 2000; Hecht et al., 2001) the subjects are asked to relax for 10 min. During this time the blood pressure and heart rate are measured every minute. The ability to relax is determined using the decline of the systolic blood pressure and the heart rate. This is measured by taking the difference between the first, and the sixth to 10th values of the time line. The criteria for relaxation for normotonics (maximum systolic: 139, minimum: 120) was  $\geq 13$  mm/hg, for hypotonics (maximum systolic: 110)  $\geq 5$  mm/hg and for hypertonics (minimum systolic: 140)  $\geq 25$  mm/hg. If these critical differences are reached, it is interpreted as a good ability to relax.

During the total time of the expedition (10 weeks) we measured physiological process variables. The measurement method used for the measurement of stress- and relaxation status is the skin resistance (Hecht, 2001). The mountaineers carried before, during and after the expedition a portable skin resistance measurement tool, Himem (see Figure 2), which was attached to the wrist with a cable and sensors.

The skin-resistance is measured as an electric resistor of the skin using a floating, weak direct current (1 to 5mA, exosomatic method). In the instrument there is a capacitor, which is loaded up with electricity and then is unloaded in impulses, depending on the

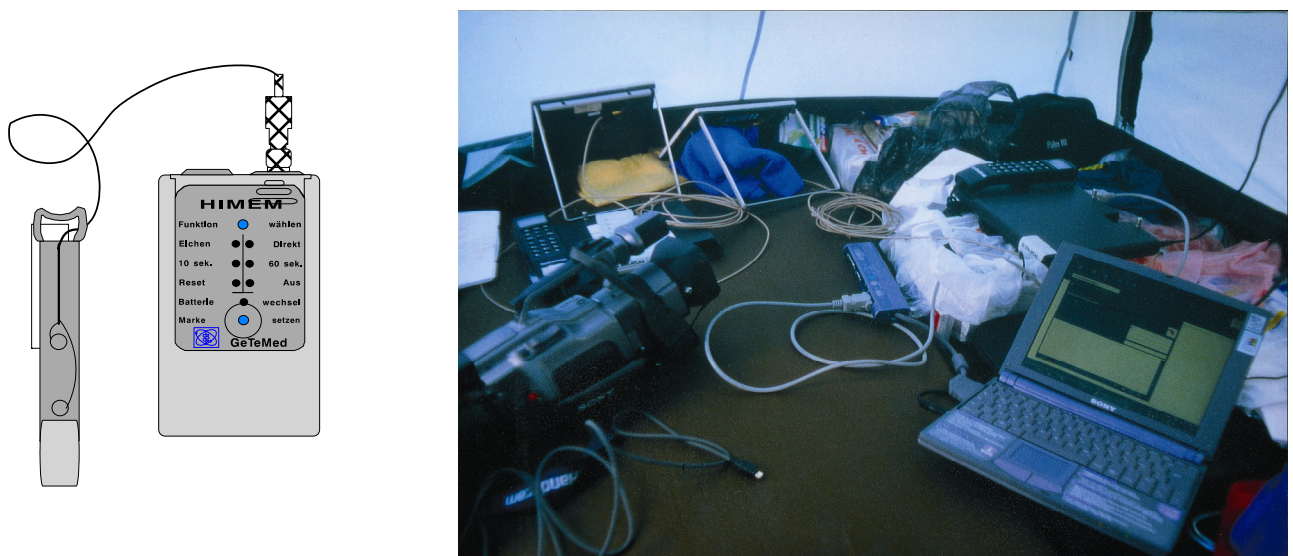


Figure 2. Portable skin response measurement tool "Himem" and computer connections.



Figure 3. Tent at the base camp at an altitude of 5400 m with solar panels for the laptop devices and satellite telephone for the transfer of the skin resistance data to Germany.

skin resistance (resistor-frequency-transformer). A high skin resistance is characterized by a slow frequency, and a low skin resistance by a high frequency.

The distance between impulses (data) is processed with special software. For the analysis we used the chronopsychobiological regulation diagnostics (Balzer & Hecht, 1989; 2000; Hecht, 1989; Hecht et al., 2001; Hecht & Balzer, 1999; Hecht, Balzer & Rosenkranz, 1998; Hecht, Balzer, Salzberg-Ludwig & Bossenz, 2000).

Chronopsychological analyses methods investigate the periodic changes of physiological parameters across points of time, also called biorythmometric time row analysis.

A biorythmometric time row analysis was used to measure skin resistance data. A time row consists of quasi stationary, periodic and stochastic parts. For the analysis of the EDA-regulation only the periodic parts should be used. The result of the biorythmometric time row analysis contains two pieces of information:

- If there is a stress- or relaxation status (stress=activation, relaxation=deactivation)
- The quality of regulation in the stress- and relaxation status (abnormal deregulated-or normal, well regulated stress- and relaxation statuses).

The gathered data was sent to Germany using a

telemetric system via a news satellite (see Figure 3). There the analysis was performed and the results were sent back along with recommendations for behavior to the mountaineers.

## Results

### Anxiety

Five of eight subjects had their highest anxiety scores (EMI-B-scale) before the expedition (see Table 1).

### Heart-Circulation Parameter

The Heart-Circulation parameter – systolic blood pressure and pulse show the highest values on the mountain, indicating a high altitude hypoxia (See Figures 4 and 5).

### Blood Pressure Relaxation (Ability to Relax)

One month before the start of the expedition, four of eight subjects reached the relaxation criteria. Immediately before the start, none of the members could relax adequately. That can be seen as a clear sign of stress and tension of the emotional-vegetative regulation. The poor ability to relax at Pre 2 is comparable to the last phase on the mountain, as the mountaineers were at an altitude up to 8000 m and had to stand high strain. The best ability to relax was measured at Post

**Table 1: Progression of Raw Scores of Anxiety**

Nr.	Pre 1	Pre 2	Acclimamitisa- tion	Mountain 1	Mountain 2	Post 1
Vp1	44	50	44	<b>56</b>	48	38
Vp2	50	54	<b>59</b>	44	53	54
Vp3	61	<b>75</b>	49	63	63	31
Vp4	<b>73</b>	40	37	41	38	30
Vp5	<b>74</b>	53	65	62	60	58
Vp6	<b>75</b>	72	51	74	55	41
Vp7	<b>74</b>	67	48	49	54	66
Vp8	55	43	<b>56</b>	52	54	
Mean	63.25	56.75	51.13	55.13	53.13	45.43

Note. Scale variation = 18 – 118 (18 items); scale mean: 58; bold numbers show the highest individual values.

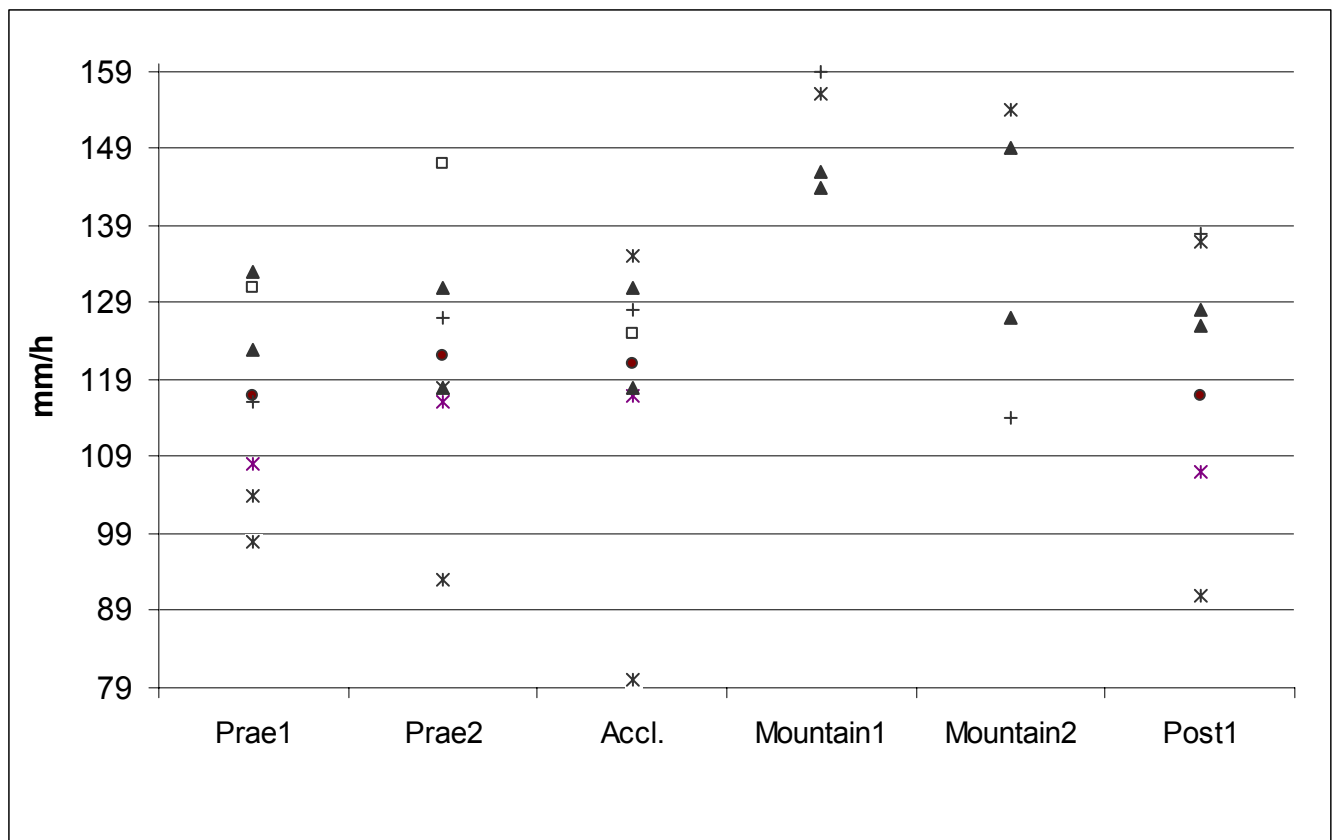


Figure 4. Systolic blood pressure

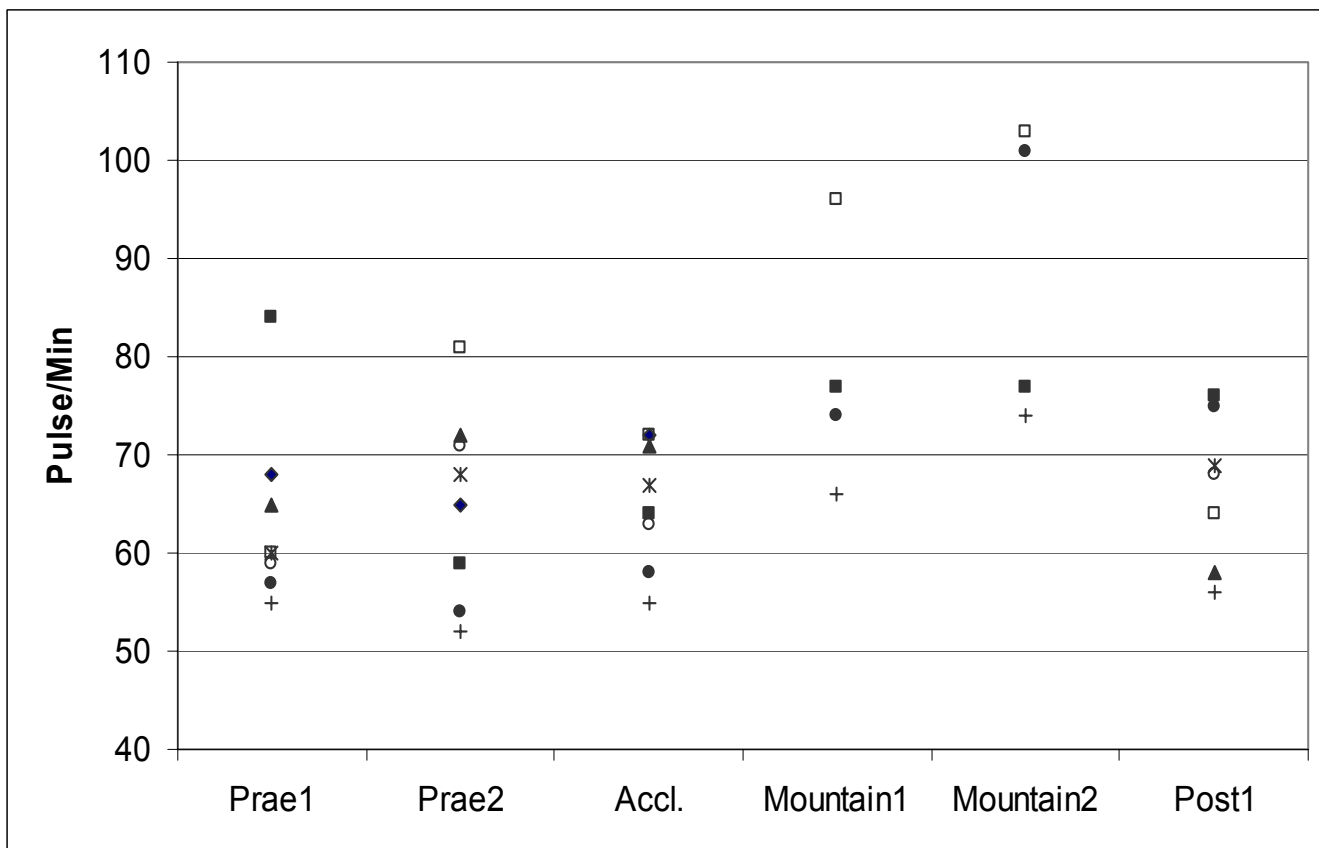


Figure 5. Pulse

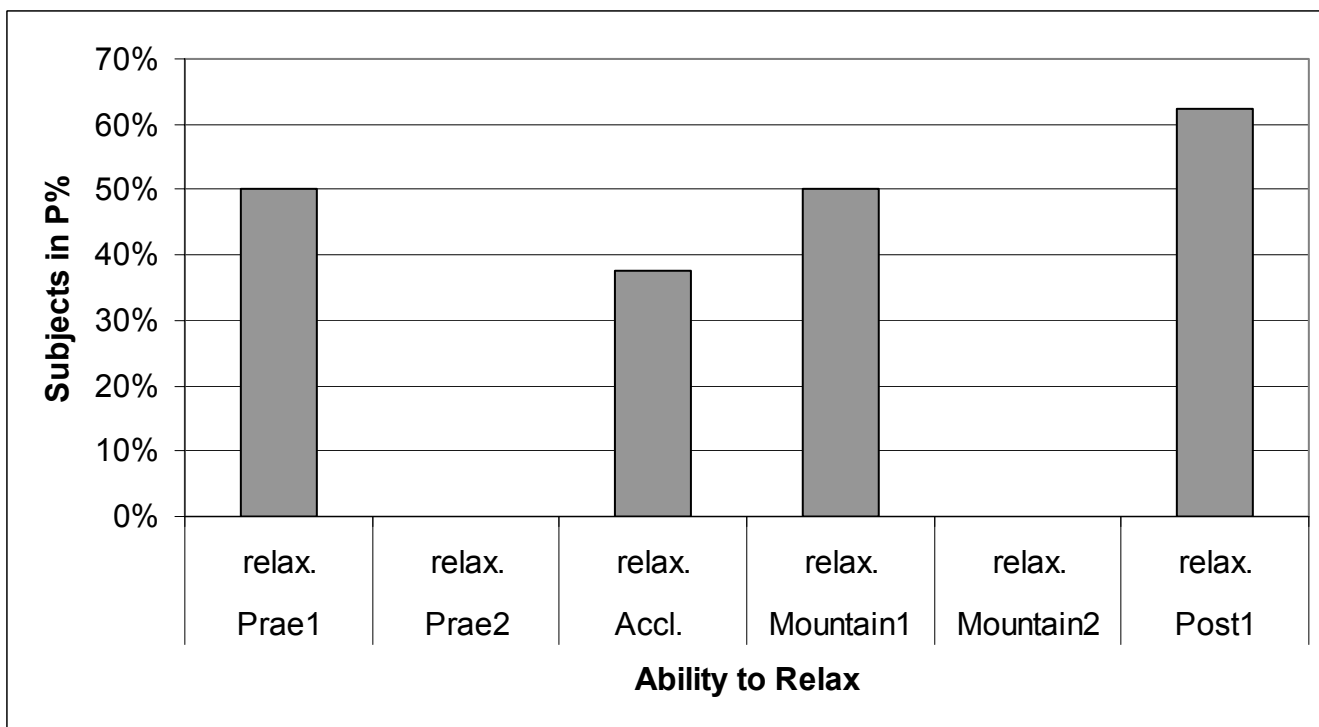


Figure 6. Ability to relax in the blood pressure relaxation test

1, after the return from the base camp. Five of eight subjects reached the criteria for good relaxation after the expedition (See Figure 6).

### **Skin Resistance**

The results of the skin resistance data over the 10-week period can be summarised as follows: We could find three psycho-physiological levels of adaptation or protection mechanisms under increasing pressure.

### **Inhibition of Overload**

After reaching the base camp (5400 m), all subjects showed a noticeable increase in relaxation. This increase of deactivation patterns can be traced back to inhibition mechanisms. The role of inhibition of overload as a physiological phenomenon has been widely neglected so far in psychobiology and psychology, though Pawlow (1927) and Sherrington (1932) described it in detail. Tram (1999) luckily rediscovered the phenomenon for psychology. Pawlow described the fear of being overburdened as a protection. Within the chronopsychobiological regulation diagnostic, inhibition of overload are found as spontaneous short or longer transitions from activation to deactivation. They express the overloading of emotional-vegetative regulation system as a protective inhibition.

### **Unspecific Hypersensitivity with Unspecific Activation**

On reaching the high camp (7400 m) all subjects showed a noticeable increase of activation patterns, i.e. excited conditions. They showed the following specifics: normally the impulse of the direct current causes a defined polarisation of the electrodes of the gauge. In the case of hypersensitivity there is a change of the potential of cell membranes. Frequent or slowly-changeable direct currents can be measured on the skin surface. The stimulus threshold is decreased and additional weak stimuli can lead to potentials in the overshoot-range (Deetjen & Speckmann, 1999). We interpret these states as increased sensitivity (hypersensitivity) of the emotional-vegetative system. The hypersensitivity can be seen as a second mechanism to protect oneself from being overloaded, because along with the hypersensitivity comes an increased vigilance, that can help to control possible hazards. But the hypersensitivity is a stress reaction, which insures the use of all available power for unusual problems. The unspecific hypersensitivity can be seen as an indicator that the mountaineers are operating at the border of their abilities and have reached the

edge. Besides the extreme demands and stress, the reasons for this can be explained by the reduced oxygen. Apparently, hypoxia is a strong distraction for the emotional-vegetative regulation. With hypoxia, humans generally cross their strain-borders more easily.

### **Exhaustion**

After reaching the goal, we found a sudden change of stress status, with long periods of deactivation for the two people who reached altitudes above 8000 m and stood on the top of the mountain at 8206 m. The deactivation conditions were accompanied by a sudden, persisting destabilisation of emotional-vegetative regulation. It is remarkable that this deterioration came not step-by-step, but with a sudden skip, this means from normal deactivation models to abnormal deregulation models. Only after a few days did the subjects become aware of the sudden deterioration of the psychophysical regulation. The deregulations persisted over a long period without an increase of the regulation quality. Correlating psychological and physiological symptoms to this exhaustion were: infections and depression. The expedition physician suspected one subject had a brain edema and ordered infusions to be sent to the high camp 1. This subject was exhausted to such an extent that he/she needed 4 hr to reach the tent in high camp 3, which was only 150 m away. Both subjects who reached the peak said that they had no emotions on the top and had no fear though they were under a lot of stress. Apparently, because of the exhaustion of the subjects neither had their emotion-transmitters, because the link between threat appraisal indicators and anxiety was disconnected. Anxiety is hardly compatible with exhaustion (though one may be being treated), because of the exhaustion the organism is not able to produce a state of stress as a correlation to anxiety. Emotions can only do their job as stimuli to threats without exhaustion.

### **The Telemedicine Investigation**

We could successfully implement a psychophysiological monitoring via satellite on the mountain. This means it was possible to inform mountaineers about their current psychophysiological status in order to guarantee suitable coping strategies and breaks. This objective information was highly necessary, because the mountaineer was not aware (or too late) of deteriorations of the vegetative-emotional regulation. Nevertheless, not all subjects followed the advised interventions for a better regulation. Ambition, impatience and

weather conditions structured the behavior and hindered adequate coping.

## Discussion

This article is a contribution to a new psychological discipline: Height Psychology. It was founded in 2002 by the psychologist Marcus Stück at the University of Leipzig, in Germany. Dr Stück has led and participated in several scientific expeditions in the high mountain of Tibet, Nepal, Pakistan, Argentina and Ecuador. The aim of this new psychological discipline is to investigate and describe human psychological experiences and behaviour of mountain climbers in high altitudes (Stück, 2004). This discipline is intended to be recognised alongside High medicine.

In the reported Cho Oyu Expedition, the results relating to anxiety, showed that most of the subjects had the highest anxiety scores before the onset of the expedition. This indicates the importance of good organisation and psychological supervision during the preparation phase. This result was confirmed by blood pressure relaxation tests as the parameter for the ability to relax. Immediately before the expedition (Pre 2), none of the subjects could adequately relax. That can be seen as a clear sign of stress and disturbance of the emotional-vegetative regulation. Similar findings could be found with cosmonauts (Simonov, 1975).

Both the pulse and the systolic blood pressure increased with the altitude and reached the highest scores after reaching the base camp at 5400 m. Apart from that, the heart circulation parameter fluctuates greatly between individuals. In the results from the long-term monitoring of skin resistance, the influence of high altitude hypoxia on the emotional vegetative regulation could be determined. Furthermore, the slow loss of energy reserves, as a result of the altitude, and a decreased ability to replace lost energy, due to the lack of oxygen, can be shown. Also, connections regulation status, protection methods used to deal with the inhibition of overload, and subjective assessment of status, could be shown. During the expedition all subjects showed changes from a successive deterioration of emotional-vegetative regulation, to long periods of exhaustion. Summarised, three psychophysiological levels of adaptation can be defined, that occur under increased stress:

- Inhibition of overload
- Unspecific hypersensitivity with unspecific activation
- Exhaustion

We interpret inhibition of overload and unspecific hypersensitivity as emergency reactions, which are meant to protect the individual from becoming overburdened. Different gradations of fear of overburdened exist that continue until exhaustion. That is in our view the first compensatory level if the emotional-vegetative regulation system is under high strain.

A generalised unspecific hypersensitivity is triggered by the mobilisation of the last resources. The goal is to bring the blurred regulation system back to homeostasis. The sensitivity is lowered. That is the second emergency reaction respectively the second compensatory level of the emotional-vegetative regulation. As the results of the experiment show, a telemedical investigation is possible and necessary, even under the conditions of high mountains, to correct deficits in behavior and to predict health risks for individuals in high altitudes. In following studies, this “Warning and Control” system should be further optimised.

The key to success for mountaineering besides the unalterable strategic, and physical competence, seems to lie above all in the art of self monitoring, the ability to preserve resources, the team spirit and the acceptance of individual borders. From the results we can deduce the following clues for good stress prevention:

- Necessity of a conscious transition from tenseness to relaxation phases to prevent a physiological destabilisation (e.g., heart attack in holidays)
- Prevention of hypersensitivity and exhaustion and the destabilisation of biosystems through an enhanced personal ability to relax (e.g., self-regulation, meditation and yoga)
- Training of subjective perception of stress symptoms and signals as needful part of a stress management training
- Use of emotions as trigger for the situation. Training of emotional intelligence
- “Turn back” at the right moment to prevent exhaustion

These statements are based on single cases and should be seen in that context and should be countersigned by other studies.

Overall, we can state that mountaineering is a good paradigm for the investigation of human performance in extreme situations. The alpinists could not flee from the mountain, thus one of the reactions to extreme stress described by Lazarus (1974, 1982) is not available to the mountaineers. They are forced to

find other ways of coping. We assume that the physiological mechanisms found in this study may also apply to other extreme conditions in which the stressful situation can not be left and strain accumulates. We would like to emphasize again that we found a discrepancy between the conscious awareness of the status of arousal and physiological parameters. A bio-feedback system can help to fill this gap, but the compliance of individuals has to be taken into account.

Knowledge of the physiological reactions of humans under extreme conditions can also offer us a better understanding of coping mechanisms in daily life. For example, the different phases of a high-mountain expedition, as presented in this study, were successfully implemented in an educational context in the form of a stress-management training program for teachers (cf., Stück et al., 2003; Stück, Rigotti & Mohr, 2004).

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