Research Project "Safety and Health in High-altitude Observatories"

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Goal of the research project

Modern astrophysics is characterised by the world wide strategy to develop extremely large optical-IR collectors with exquisite image quality (European Extremely Large Telescope, Giant Magellan Telescope, and Thirty Meter Telescope) as well as innovative ground-based submillimetre astronomy observatories like the Atacama Large Millimeter/submillimeter Array (ALMA) or projects like the Atacama Pathfinder Experiment (APEX).

To guarantee the best observation conditions the atmosphere above the observation sites must be transparent. Therefore, the astronomical community tries to take advantage of the natural conditions of dry, high-altitude sites. But, working at high altitude does have a major impact on safety, health and performance of staff.

On the basis of the enhanced developments in ground-based astronomy, an increasing number of people will be exposed to high-altitude conditions. Therefore, measures to improve work conditions and organisation at high altitude must be developed. A research project is being initiated which will consider particularly those people who, within the next years, will be required to work above 5 050 m altitude at the Llano de Chajnantor (ALMA, APEX), district of San Pedro de Atacama, and at 2 635 m altitude at Cerro Paranal, Taltal district in Chile. The goal of this project is to create and promote knowledge in the field of human activities in high-altitude observatories, which will then be offered for utilisation in work organisation. While we know a lot about biomedical changes at high altitude, relatively few studies focus on psychological changes, for example with respect to mental task performance, consciousness and emotionality. Both, biomedical and psychological changes, are relevant factors in occupational safety and health.

Problem and scope

Workers whose itineraries take them above an altitude of about 2 400 m should be aware of the risk of altitude illness and potentially impaired mental performance. While the individual response to high altitude can vary, all people are at risk of altitude illness above about 3 000 m altitude.

Therefore, the negative influence of high altitude is present especially at ESO's very high-altitude sites of APEX and ALMA (5 050 m at the observation site and about 2 500 m to 3 000 m at operation control site, offices and lodging). The current ESO internal medical statistics suggest that certain demographics, like age, sex or physical condition, do not correlate with the susceptibility to altitude sickness. Some people suffer from it and some people do not, and some people are more susceptible than others.

The conditions in the high-altitude environment also have a negative impact on human physiology and psychology. They affect nearly all biological processes, particularly rhythms, including sleep. Due to the reduced adjustment of the body at high altitude, the person concerned has to work against the demands of his or her body. Finally, the low oxygen (hypoxic) stress of altitude can impair work efficiency, performance and best practice mainly due to maladaptive behaviour, distorted consciousness, impaired biomedical functioning, and reduced sleep quality.

The final scope of the research project is the provision of practical recommendations to maintain work efficiency at high altitude. This will be done by gathering and disseminating knowledge about high-altitude work considering both, psychology and physiology. Thus, more adequate risk estimations during work are supported with further practical benefits for ESO and ALMA in:
– accident prevention and emergency process optimisation, and
– work organisation (shift work, daily working hours, operational safety procedures, etc.).

In addition, the project will support work organisation by providing further input to staff selection and training. Figure 1 summarises the rationale of the research project. A proper strategy of Technical, Organisational and Personnel measures adapted to the high altitude environment will positively affect the human and the organisation. The research will provide an input in finding and developing an adequate way.

Furthermore, the project results and data will be used to improve the scientific data base about people working at high-altitude workplaces and to enhance, by this means, the integral understanding of the interactions of human beings with their natural surroundings.

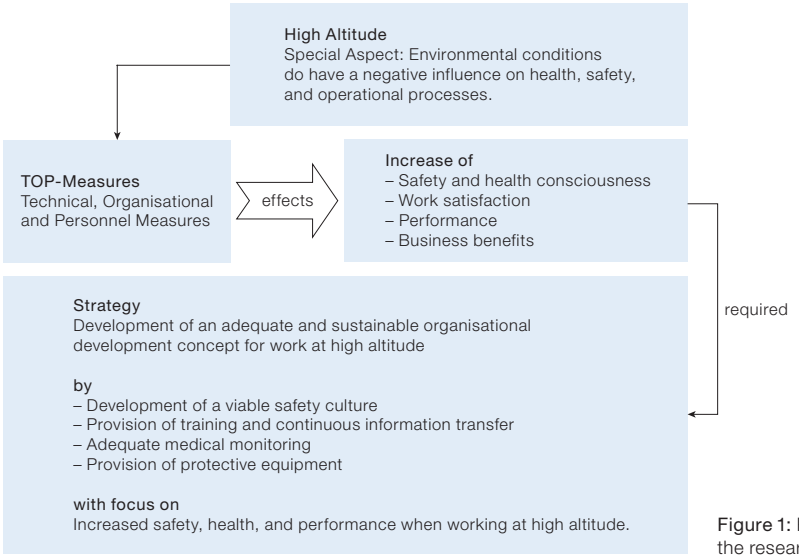

Figure 1: Rationale of the research project.

The research approach

The target group within the research project mainly consists of volunteers, as there are local and international ESO staff members working at La Silla Paranal Observatory, ESO Staff members from Garching travelling to ESO high-altitude sites, staff working at APEX and ALMA, ALMA partners, scientists and contractors. All these people will be asked to volunteer for biomedical, questionnaire, and interview investigations.

These investigations deal with the following main research fields:
– Stress and strain when working in shifts
– Susceptibility to shift work
– Optimisation of daily working hours
– Consequences for work performance,
– Long-term influence on human body
– Effectiveness of supplementation with antioxidants.

To be able to analyse the above-mentioned main research areas, the data collection needs to be multidisciplinary considering medical, physiological, psychological and economic approaches:

Medical and physiological issues (responsible: University of Antofagasta, University of Chile, already started at ALMA)
– Monitoring of cardiovascular, respiratory, oxymetric[1] and polysomnographic[2] (EEG[3], EOG[4], EMG[5]) data through small portable devices
– Measurement of hormone levels
– Application of psychometric tests
– Analysis of circadian rhythms and the relationship with mental and physical functions
– Questionnaire to obtain information on current habits (nutrition, exercise, etc.) and personal background (perinatal data, diseases, etc.).

Psychological and work organisation issues (responsible: University of Copenhagen)
– Questionnaire about shift work and breaks
– Questionnaire about stress and strain during daily work, work satisfaction, performance drivers and obstacles.

Business benefits (responsible: University of Copenhagen)
– Monitoring of economic benefit and strategic impact of occupational safety and health measures.

Data-base evaluation
– Data collection through networks, data bases and collaborations.

The informed consent of participants, data protection, confidentiality, and anonymous data handling shall be a main concern in the project to support a smooth and trustworthy process. Particularly, a high number of participants will guarantee the anonymity and validity of the results.

Current research project

Currently, a research concept is being developed which will be used to apply for funds from external third parties. The research partners intend to evaluate existing data provided by the observatories. Therefore, a close cooperation with the paramedics at the high-altitude sites is sought.

In addition, there will be a small pre-study to support the validity of the research concept. The results will have a major impact to obtain external monetary support. So far, five staff members of an ALMA contractor already agreed to participate in such a pre-study. In addition, two ESO international staff members with duty station at ESO headquarters in Garching also volunteered to provide personal data when visiting the observatories. The data collection in the field study will be done with minimum effort for employees (about one hour per working week), by using very small devices which will not interfere with the test persons' work. The data collection involves mainly filling out a questionnaire and providing data (O_2 saturation and heart rate).

Generally, close cooperation and coordination with ALMA and ESO as well as anonymous data collection are essential and self-evident. To get data directly from ESO/ALMA personnel, the research group will formally request approval by the respective organisations. It is recommended to involve the Ethical Committee of the Faculty of Medicine of the University of Chile. Provision of detailed information to the management as well as staff concerned, staff association and other interested groups is also self-evident.

Bilateral agreements and start-up status

Bilateral letters of intent between ALMA and the research partners have been established. The bilateral letter of intent between ESO and the research partners is in preparation.

The University of Antofagasta and the University of Chile have already started to collect biomedical data from ALMA, APEX and the Paranal site. The University of Copenhagen will start with the evalua-tion as soon as the bilateral letter of intent between ESO and the University of Copenhagen has been finalised.

Research team (in alphabetical order)

Prof. Dr. Claus Behn (Chairman of the research group; Laboratory of Extreme Environments, Programme of Physiology and Biophysics, Institute of Biomedical Sciences (ICBM), Faculty of Medicine, University of Chile, Chile)
Michael Böcker (Project leader for ESO research; ESO Safety Manager/ALMA European Executive Safety Representative, ESO)
Jody Bolyard (NRAO Safety Manager/ALMA North American Executive Safety Representative, National Radio Astronomy Observatory, USA)
Jacques Lassalle (Project leader for ALMA research; ALMA Safety Manager)
Ohta Masahiko (ALMA-Japan Project Office, National Astronomical Observatory of Japan, National Institutes of Natural Sciences, Japan)
Dr. Juan Silva Urra (University of Antofagasta, Chile)
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Prof. Dr. med. Hans-Christian Gunga (Zentrum für Weltraummedizin Berlin, c/o Institut für Physiologie, Charité – Universitätsmedizin Berlin)

[1] Measurement of systolic arterial blood pressure using a pulse oximeter.
[2] Polysomnography is the evaluation of a broad range of sleep disorders.
[3] A graphic record of the electrical activity of the brain as recorded by an electroencephalograph; abbreviated to EEG and also called encephalogram.
[4] The electroencephalographic tracings made while moving the eyes a constant distance between two fixation points, inducing a deflection of fairly constant amplitude; abbreviated to EOG and also called electro-oculogram.
[5] A graphic record of the electrical activity of a muscle as recorded by an electromyography; abbreviated to EMG and also called electromyogram.