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Is acute mountain sickness related to trait anxiety? A normobaric chamber study

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HIGHLIGHTS

- No evidence for different trait anxiety in AMS cases and non-AMS cases was found.
- Results of studies using hypobaric hypoxia could not be replicated.
- Trait anxiety might be linked to the AMS symptom sleep disturbances.

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ABSTRACT

Introduction: Some mountaineers are more prone to the occurrence of acute mountain sickness (AMS) than others. State anxiety during altitude exposure might be associated with AMS development. We hypothesized that trait anxiety might be higher in AMS cases compared to non-AMS cases. The aim of the present study was to study the relationship between AMS development and trait anxiety.
Methods: In an observational study design, AMS incidence during a 12-hour exposure to normobaric hypoxia ($F_iO_2 = 12.6\%$, equivalent to 4500 m) was determined by the Lake Louise Scoring System. Trait anxiety (State Trait Anxiety Inventory) and confounding variables were assessed in a follow-up questionnaire (37 months after hypoxic exposure).
Results: Twenty nine participants returned the follow-up questionnaire. AMS incidence was 38%. Both unadjusted and adjusted logistic regression analyses did not reveal trait anxiety as a significant variable in relation to AMS.
Discussion: Based on the findings of this preliminary study, there is no evidence that AMS development under normobaric conditions is related to trait anxiety. Differences to previous studies might be explained by the type of hypoxia, by different sample characteristics and by considering sleep disturbances in the calculation of the AMS score. However, future studies with larger sample sizes may help to clear the relationship between AMS development and the personality factor anxiety.

1. Introduction

Acute mountain sickness (AMS) is the most common illness during exposure to high altitude without sufficient acclimatisation [1]. The prevalence of AMS depends on several factors, e.g., degree of pre-acclimatisation, achieved altitude, and rate of ascent [2,3]. Depending on the altitude attained, prevalence rates of AMS vary between 9% on 2800 m [4,5], 53% on 4500 m [4], and over 70% on nearly 6000 m altitude [6]. These figures can be reduced, when mountaineers follow previously published guidelines regarding appropriate ascent rates and rest days [7]. A new method to control ascent rate and rest days is a mobile, smart phone based AMS-scoring-system [8].

However, there is a large inter-individual variability in the development of AMS [9]. Thus, it is of importance to identify risk factors to provide individual recommendations depending on prior assessment of the mountaineer. Such knowledge would help AMS-susceptible individuals to plan travelling to high altitude adequately (e.g., slower ascent rate, pre-acclimatisation, medical prophylaxis) or even to abstain completely from ascending to high altitude.

In the past, several attempts have been conducted to predict AMS development [5,6,10–14]. However, there is still no consensus in literature regarding the best parameters to predicting AMS development [1,15]. Prediction has been tried on demographic, behavioural, and physiological parameters, e.g., sex, age, physical exertion, smoking, blood pressure, arterial oxygen saturation in hypoxia, and hypoxic

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ventilatory response [1]. Only a few authors included potential psychological factors [16]. Oliver et al. [17] measured state anxiety at different time points in high altitude and found a positive correlation between the total AMS symptom score and state anxiety during the altitude exposure. However, assessing anxiety during high altitude exposure might be biased due to anxiety generated by the altitude exposure per se. Furthermore, scoring state anxiety during the altitude exposure cannot be used as a screening tool before going to high altitude.

Anxiety does not only show intra-individual differences (state anxiety), but also inter-individual differences as a personal trait (trait anxiety, [18]). Trait anxiety (TA) is considered to be a habitual characteristic with a stable tendency to report negative emotions such as fears, worries, and anxiety across many situations [19]. Both TA and AMS show correlations to fatigue and sleep disturbances [1,20,21]. Indeed, in previously conducted studies, a positive relationship between TA and AMS severity was found: higher anxiety values were connected with higher AMS scores [22,23]. However, in both studies participants preparing for an expedition to the Himalayan mountains were included. Generalization of these results to mountain tourists remains doubtful. Especially the population of mountain tourists would benefit by an exact estimation of AMS risk, because the high altitude experience of this population is limited. We were therefore interested, if the results of Missoum et al. [22] and Waanders [23] (field studies) can be replicated in a sample not preparing for an Himalayan expedition. In accordance with previous findings, we hypothesized that TA may be higher in AMS cases compared to non-AMS cases. If confirmed, the individual TA score might be used as an additional variable within screening tools for AMS development in mountain tourist samples.

Thus, the aim of the present study was to predict the development of AMS on the basis of trait anxiety in a mountain tourist sample.

2. Materials and methods

2.1. Design

The present study was conducted in an observational study design and consisted of two data collection occasions. AMS incidence was assessed in a study previously published [24]. Briefly, in the study of Burtscher et al. [24], the participants were passively exposed for 12 h to normobaric hypoxia ($F_iO_2 = 12.6\%$, corresponding to 4500 m). AMS data was recorded at 6 different time points: before the exposure, after 30 min, 3, 6, 9, and 12 h in hypoxia. The hypoxia exposure was performed in the normobaric hypoxia chamber of the Department of Sport Science, University of Innsbruck, at 600 m above sea level. To avoid bias in the assessment of anxiety due to the hypoxic exposure, we collected anxiety information in a follow-up questionnaire (37 months after the exposure to normobaric hypoxia). Also demographic data was collected at this time point. The study protocol was approved by the ethics committee of the Medical University and all participants signed a consent form after obtaining written and spoken information about the study procedure.

2.2. Participants and measurements

In total, 77 participants were recruited to participate in the initial study. The required sample size was based on an a priori power analysis with the following assumptions. The population effect size was assumed with $r = 0.74$ based on the previously conducted study of Waanders [23]. Using G*Power 3.1 [26] we calculated a total sample size of 21 participants to detect equally sized effects with a power of 0.80 and an AMS incidence of 38% in the regression model. Since we were not able to estimate the response rate to the TA questionnaire, we contacted every participant in the follow-up. Exclusion criteria were cardiovascular, respiratory, and neurological diseases, migraine, chronic headaches, permanent residence >1000 m, an overnight stay at altitudes >2500 m in the previous month, and exposure above >2500 m two weeks prior to the starting of the study [24].

The follow-up web-based questionnaire consisted of 52 items. Information about trait anxiety, sociodemographic variables, chronic diseases, and altitude-related anamnesis was collected. The trait-part of the German version of the State Trait Anxiety Inventory (STAI [27,28]) was used for the measurement of TA. Total scores range from 20 to 80, with higher scores suggesting greater levels of anxiety and lower scores suggesting mild anxiety. The German version of the STAI showed Cronbachs α for internal consistency (trait) between 0.88 and 0.94 [28]. Convergent validity and other psychometric values can be found in Laux et al. [28]. Cronbachs α in the present sample was $\alpha = 0.87$, which indicates good internal consistency.

The following covariates were collected because of a potential association with the development of AMS: sex (male, female), age in years, body mass index (BMI) in kg/m^2, self-rated fitness on a 4 point Likert scale (1: insufficient, 2: satisfying, 3: good, 4: very good), self-rated alcohol intake on a 4 point Likert scale (1: often, 2: sometimes, 3: rarely, 4: never), smoking (yes, no), chronic diseases (yes, no), and history of AMS (yes, no).

The incidence of AMS was assessed by using the self-reported questionnaire Lake Louise Scoring system (LLS, [29]). The participants were asked to rate the symptom complex headache, gastrointestinal symptoms, fatigue and/or weakness, and dizziness from 0 (not present) to 3 (severe). We did not include sleep disturbances since subjects did not sleep in the hypoxia chamber. The items were summed up to calculate a total score ranging from 0 (no AMS symptoms at all) to 12 (severe AMS symptoms). Cases and non-cases were identified using the LLS. Subjects were considered as cases (AMS+) if the total score of LLS was ≥3 and the symptom headache and at least one other symptom were present at least at one of the 5 time points in hypoxia [24]. Otherwise subjects were considered as non-cases (AMS−).

2.3. Statistical analyses

We assessed possible differences in AMS+ and AMS-. All continuous variables were tested on normal distribution using Shapiro-Wilk test. Subsequently, differences between the 2 subgroups were tested by Student *t*-test (normally distributed, continuous variables), Mann-Whitney-*U* test (non-normally distributed, continuous variables) or Pearson-χ^2-test (frequencies), as appropriate.

Univariate binary logistic regression analyses were used to generate unadjusted AMS incidence odds ratio including 95% confidence intervals. Odds ratios of continuous variables were calculated for a 1-standard-deviation change of the total sample. *p*-Values of <0.05 were considered statistically significant (two-tailed).

For covariates-adjusted estimates of odds ratio and 95% confidence intervals, all variables with $p < 0.15$ and TA were included into a multivariate binary logistic regression. In accordance with previous authors (e.g., Richalet et al. [13]), we used a *p*-value of 0.15 for electing predictors for the multivariate model.

3. Results

Out of 77 participants, 29 returned the follow-up questionnaire (female: 48%). Response rate in the follow-up questionnaire was 38% in the total group (AMS−: 49%, AMS+: 28%). For detailed information, compare Fig. 1.

There was no missing data in any of the analysed variables. AMS incidence was 38%. None of the participants was classified as AMS+ before hypoxia exposure. See Table 1 for differences in TA and demographic variables between AMS+ and AMS−. The covariates age and self-rated fitness showed *p*-values < 0.15. Mean age was higher and percentage of good or very good self-rated fitness was lower in the subgroup of AMS+. Mean TA was comparable between both subgroups.