Wilderness and Environmental Medicine, **20,** 305–310 (2009)

ORIGINAL RESEARCH

Subjective Sleep Quality Alterations at High Altitude

Robert K. Szymczak, MD; Emilia J. Sitek, MA; Jarosław W. Sławek, MD, PhD; Andrzej Basiński, Prof, MD, PhD; Mariusz Siemiński, MD, PhD; Dariusz Wieczorek, PhD

From the Clinical Department of Emergency Medicine, Medical University of Gdańsk, Poland (Drs Szymczak and Basiński); the Department of Neurological and Psychiatric Nursing, Medical University of Gdańsk, Poland (Ms Sitek and Dr Sławek); the Department of Rehabilitation, Medical University of Gdańsk, Poland (Dr Wieczorek); the Neurology Department, St Adalbert Hospital, Gdańsk, Poland (Ms Sitek and Dr Sławek); and the Clinical Department of Adult Neurology, Medical University of Gdańsk, Poland (Dr Siemiński).

Objective.—Sleep pattern at high altitude has been studied, mainly with the use of polysomnography. This study aimed to analyze subjective sleep quality at high altitude using the following standardized scales: the Pittsburgh Sleep Quality Index (PSQI) and the Athens Insomnia Scale (AIS-8).

Methods.—Thirty-two members of 2 expeditions—28 males and 4 females (mean age 31 years)—participated in this study conducted in Nepal, Himalayas (Lobuche East, 6119 m above sea level [masl]), Kyrgyzstan, Pamirs (Lenin Peak, 7134 masl), and Poland (sea level). The scales were administered twice, at high altitude (mean altitude 4524 masl) and at sea level.

Results.—Both measures showed a decrease in sleep quality at high altitude (statistical significance, $P < .001$). Sleep problems affected general sleep quality and sleep induction. Sleep disturbances due to awakenings during the night, temperature-related discomfort, and breathing difficulties were reported. High altitude had no statistically significant effect on sleep duration or daytime dysfunction as measured by PSQI.

Conclusions.—The overall results of PSQI and AIS-8 confirm the data based on the climbers' subjective accounts and polysomnographic results reported in previous studies. The introduction of standardized methods of subjective sleep quality assessment might resolve the problem of being able to perform precise evaluations and research in the field of sleep disturbances at high altitude.

Key words: altitude, hypoxia, insomnia, mountaineering, sleep

Introduction

Sleep, which constitutes one third of a lifetime, is significantly affected by high-altitude environment.[1] Poor-quality sleep may provoke emotional instability, disturbed cognitive functioning,[2] and high-altitude daytime dysfunction.[3] The main cause of reduced quality sleep at high altitude seems to be hypobaric hypoxia due to decrease in the partial pressure of oxygen with rising altitude. Sleep quality improvement with a decrease in altitude[4] and application of supplementary oxygen[5] might confirm the dominant role of hypobaric hypoxia. Other factors affecting sleep quality may be a fall in the air temperature[6] and the season of the year.[7] Poor nocturnal sleep may induce sleepiness during the day.[8]

From the first descriptions of a decrease in the quality of sleep in hypobaric hypoxia conditions provided by West et al[1] and Barcroft[9] there has been significant development of objective sleep quality measures, such as polysomnography, that have been used in high-altitude field research and that have enabled further insight into sleep patterns at high altitude.[10–12] At high altitude there is a shift in sleep stage distribution, with a prevalence of the lighter non–rapid eye movement (NREM) sleep stages I and II and almost complete elimination of the deeper NREM stages III and IV.[13] Rapid eye movement sleep period is of variable duration, and an increased frequency of brief arousals at high altitude is connected with the appearance of periodic breathing during NREM.[13]

The work was presented as a poster during Mountain & Wilderness Medicine World Congress, Aviemore, Scotland, October 3–7, 2007.

The work is attributed to Clinical Department of Emergency Medicine, Medical University of Gdańsk, Poland. The research was not supported financially.

Corresponding author: Robert K. Szymczak, MD, Clinical Department of Emergency Medicine, Medical University of Gdańsk, Skłodowskiej-Curie 3a, 80-210, Gdańsk, Poland (e-mail: nepall_2000@tlen.pl).

Such objective data about the changes in sleep at high altitude are supported by a subjective decrease in the quality of sleep. Trekkers and alpinists complain about the superficiality of sleep, problems with sleep induction, incidents of awakening with a sense of suffocation and about feeling unrefreshed in the morning.[1] The current literature, however, is lacking in standardized subjective sleep quality measures at high altitude, apart from the work of Pedlar et al,[14] who used the Leeds Sleep Evaluation Questionnaire (LSEQ) in the conditions of normobaric hypoxia. Conclusions are often based on climbers' personal accounts[1] and nonstandardized ratings of separate aspects of sleep quality.[5,15] This does not allow for duplication of methods or extrapolation of results, and it provides insufficient information about different aspects of sleep quality.

The aim of our study was to evaluate the subjective quality of sleep at high altitude using reliable, standardized scales: the Pittsburgh Sleep Quality Index (PSQI)[16] and the Athens Insomnia Scale (AIS-8),[17] which have been validated at sea level. The introduction of such standardized methods of assessment of subjective sleep quality might facilitate future research in the field of sleep disturbances at high altitude.

Methods

Volunteers included 38 healthy Caucasian adults, 34 men and 4 women, with a mean age of 31 ± 9 years (range 19–55 years), who were the participants in 2 mountaineering expeditions (Lobuche East, 6119 m above sea level [masl], Himalayas, Nepal; and Lenin Peak, 7134 masl, Pamirs, Kyrgyzstan). All volunteers gave informed consent to participate in the study, which was approved by the Medical University of Gdansk Regional Ethics Committee. The participants were asked to refrain from taking any medications that could enhance acclimatization or alter quality of sleep. Question No. 6 in PSQI asks about using any sleeping medications. Participants were asked to write the name and dose of any medication used during the research period.

Modified versions of PSQI and AIS-8 were used in the study. The assessment of subjective sleep quality was performed twice in each volunteer—first at high altitude during the expedition and later at sea level after the expedition. Sleep time was habitual. The assessment at high altitude was conducted on average 9 ± 3 days after beginning the high-altitude sojourn (at an altitude over 2500 masl), at an average altitude of 4329 ± 218 masl. The assessment at sea level was performed on average 57 ± 31 days after the end of the expedition.

The PSQI consists of 19 self-rated questions designed to assess 7 components of sleep quality: subjective sleep quality (C1), sleep latency (C2), sleep duration (C3), habitual sleep efficiency (C4), sleep disturbances (C5), use of sleeping medication (C6), and daytime dysfunction (C7). Each component is scored on a scale ranging from 0 to 3, and the global score has a possible range of 0 to 21 points, where higher scores indicate a greater decrease in the quality of sleep. Results measuring over 5 indicate poor sleep quality (poor sleepers). As a result of the study conditions, the PSQI was modified in such a manner that participants rated their sleep quality during the past week, not the past month, as in the original version. The reliability of PSQI was found to be satisfactory at sea level (Cronbach's $\alpha = 0.83$).[16]

The AIS-8 consists of 8 items assessing the following: 1, sleep induction; 2, awakening during the night; 3, final awakening; 4, total sleep duration; 5, sleep quality; 6, well-being during the day; 7, functioning capacity during the day; and 8, sleepiness during the day. Each item is scored from 0 to 3, and the total score ranges from 0 to 24, where higher scores indicate greater sleep impairment. Participants considered their past week in the sleep quality assessment. A result of ≥6 indicates insomnia (insomniacs). The reliability of AIS-8 was found to be satisfactory at sea level (Cronbach's $\alpha = 0.89$).[17]

The PSQI is based mainly on the quantitative questions that have to be answered using concrete units (minutes, hours) or on the frequency of occurrence of specific problems affecting sleep quality (eg, the number of awakenings because of respiratory problems). Questions used in the AIS-8 refer to the subjective perception of sleep problems. For instance, sleep duration is not computed in hours, as in the PSQI, but rather the participant is asked whether it was sufficient or not. The AIS-8 seems to rely more on the individual perception of the sleep quality than does the PSQI. As early reports[1] underline the discrepancy between qualitative and quantitative accounts of sleep problems, both of these types of account were included in our research design.

Statistical analysis of the results was based on Cronbach's internal consistency reliability coefficient for all the scales. The difference between results of the PSQI and AIS-8 at sea level and at high altitude was analyzed using the nonparametric Bonferroni-adjusted Wilcoxon rank test (z) to account for multiple comparisons. SPSS 12.0 for Windows was used as a statistical program.

Results

Six participants were excluded from the study because they used medications such as Diuramid (acetazolamide, ZF Polpharma SA, Starogard Gdanski, Poland) and Stilnox (zolpidem, Synthelabo, Paris, France), which