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Travelling to High Altitudes Lead to Difficult Sleeping- Review

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Abstract

Background: High-altitude (HA) environments have adverse effects on the normal physiological functioning of body in the people who are accustomed to living at low altitudes. New arrivals to altitude commonly experience decline in quality sleep. Most people don't sleep well at altitude. Sojourns commonly report vivid dreams, feelings of being suffocated and wake up in the morning feeling un-refreshed. These complaints are commonly associated with increased fragmentation of sleep by frequent brief arousals, which are in turn linked to periodic breathing.

Findings: Changes in sleep architecture include a shift toward lighter sleep stages, with noticeable decrements in slow wave sleep and with variable decreases in REM sleep. Increased hypoxic ventilatory responsiveness and loss of regularization of breathing during sleep contribute to the occurrence of periodicity.

Conclusions: One of the immediate effects of altitude exposure is to cause a general reduction in sleep quality. The purpose of this review was to consolidate the findings of the significant studies that examined the effects of HA on the sleep disturbances so far, so that further study in this regard can take new dimensions.

Keywords: Barometric pressure; Hypobaric hypoxia; Difficult Sleeping; High Altitudes

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Introduction

High altitude (HA) is among the most challenging environments on Earth, due to poor oxygen availability, hard weather conditions (cold and windy), dangers related to glaciers and difficult accessibility for transport means. Modern travel facilities facilitate mountain tours to large number of individuals had little access to high mountains previously. Traveling to elevations over 2,500 meters may lead to signs and symptoms of HA illness [1]. Effects of HA depend on several factors which include the rate of ascent to altitude, final altitude attained, altitude at which a person sleeps and individual physiology [2-4]. HA that typically reflects the lowered amount of gases including O_2 in the atmosphere is defined as [5]: Intermediate altitude: 1500-2500 m; HA: 2500-3500 m; Very HA: 3500-5800 m; Extreme altitude: above 5800 m. The concentration of gases is essentially constant over earth terrestrial elevations [3] i.e., the amount of O_2 in the atmosphere, 20.93 percent, remains constant at any given altitude. However since the partial pressure of O_2 (PaO_2) in the atmosphere at HA falls as barometric pressure (BP) falls, therefore, the change in BP becomes is the basic cause of decrease in the amount of O_2 available for breathing, leading to condition referred to as hypobaric hypoxia [6,7]. It is reported that the atmospheric PaO_2 is 159 mm Hg at sea level and 53 mm Hg on the summit of Mount Everest [8,9]. Sustained exposure to hypoxia has adverse effects on body weight, muscle structure and exercise capacity, mental functioning, and sleep quality. Altitude affecting sleep and cardiac output, are the other determinants of oxygen delivery. The most prominent effects are frequent periods of apnea (a temporary pause in breathing) and fragmented sleep. Reports of 'not being able to sleep' and 'being awake half the night" are common at HA and may also contribute to mood changes and daytime drowsiness. These effects have been reported at elevations as low as 1,524m and are very common at higher altitudes. People at HA often wake frequently, have arousals, and do not feel refreshed in the morning and during day, and they experience somnolence [10]. Experienced trekkers and mountain climbers often recommend climbing high but sleeping mitigates these problems. The cold, the wind, noisy, or smelly tent companions and long distance travel can also disturb the sleep. Keeping these considerations in mind, it would be interesting to review some of the key studies and their findings in this regard.

Sleep disturbances at HA

Human sleep is comprised of rapid eye movement (REM) sleep and non-rapid eye movement (NREM) sleep. NREM sleep is further divided into three stages representing a continuum from 'light' sleep to 'deep' sleep [11]. REM sleep and deep sleep are the most important stages because the former aids mental recovery, learning and memory consolidation [12] and the latter aids physical recovery and growth [13,14]. The normal composition of sleep stages within a sleep period, that is, 'sleep architecture', is 61% light, 16% deep, and 23% REM for adults (aged 30 years) and 57% light, 22% deep, and 21% REM for adolescents (aged 16 years) [15]. Altitude exposure may have significant adverse effects on sleep. The most important step of acclimatization is the hyperventilation which is achieved by hypoxic ventilatory response of the peripheral chemoreceptors. Hyperventilation results in increase in arterial carbondioxide concentration by increasing the rate and depth of breathing. The body is under hypobaric hypoxic stress and the reduced oxygen content of the blood induces breathing instability, with periods of deep and rapid breathing alternating with central apnea. This breathing pattern is called high-altitude periodic breathing (PB). It occurs even in healthy persons at altitudes above 6000 ft. Periodic breathing involves alternating periods of deep breathing and shallow breathing. Typically, three to five deep breaths will be followed by a couple of very shallow breaths or even a complete pause in breathing which is called apnea [16]. It leads to sleep disturbances with frequent awakenings all night and a feeling of lack of air [17]. Depressive mood, anger and fatigue tend to increase under hypoxic conditions. De Aquino and co-workers found that hypoxia reduced total sleep time, sleep efficiency, slow-wave sleep and REM [18]. They further stated that changes in sleep patterns can modulate mood and cognition after 24 h leading to vigour, attention, visual and working memory, concentration, executive functions, inhibitory control and speed of mental processing worsened [18]. The periodic breathing that occurs in most of the people at altitudes above 13000 ft is probably the main causative factor for frequent awakenings at night [16,19]. Latshang and co-workers described that at HA, nocturnal periodic breathing affects males more than females [20]. They studied that females present a significant number of central sleep apneas only at the highest reached altitude. After 10 days at 17000 ft gender differences in the apnea-hypopnea index similar to those observed after acute exposure were observed along with differences in respiratory cycle length [20]. Weil [10] stated that the sleep disorder of altitude is largely due to respiratory disturbance arising from the physiologic ventilatory dilemma due to acute ascent, where stimulation by hypoxia alternates with inhibition by hypocapnic alkalosis. The decompression chamber studies found severe sleep fragmentation and PB at all altitudes especially at the HAs. These brief 2 to 5 second arousals from sleep increased from an average of 22 times per hour at sea level to as high as 161 times per hour at 25,000 ft [21,22]. Although total sleep time was reported to not change however it was found that there was a strong shift from deeper to lighter sleep stages and a marked increase in frequency of brief arousals [23]. In another study, Nussbaumer-Ochsner and coworkers concluded that in healthy mountaineers ascending rapidly to HA, sleep quality is initially impaired but improves with acclimatization in association with improved oxygen saturation, while periodic breathing persists. Therefore, HA sleep disturbances seem to be more related predominantly to hypoxemia rather than to periodic breathing [24].

Periodic breathing and sleep monitoring

Sleep can be divided into stages that are defined by the pattern of electrical activity in the brain and eye movement. Sleep at HA causes one to experience a decrease in sleep efficiency, reduced total sleep time, slow wave sleep and REM sleep [25]. During slow wave sleep a person is in the deepest sleep and the brain slows, becoming less responsive to external stimuli, while during REM sleep a person is dreaming. At HA the cycles of sleep happen quicker so we are more likely to wake up during a bout of REM sleep. The reduced slow wave and REM sleep may be what causes the vivid dreams, but how this happens remains unanswered. Deeper stages of sleep and REM sleep are reduced at altitude, therefore more of the night will be spent as light sleep and sleep quality will not be as good as at sea level. During sleep at HA, the levels of CO_2 in the blood can drop very low and this can switch off the drive to breathe. Only after the body senses a further drop in O_2 levels breathing is started again. Periodic breathing results from instability in the control system through the hypoxic drive or the response to CO_2 [10,16]. Cheyne Stokes breathing or PB is common at HA and becomes more frequent with increase in altitude. Periodic breathing involves alternating periods of deep breathing and shallow breathing. Typically, three to five deep breaths are followed by a couple of shallow breaths or even a complete pause in breathing. A pause in breathing lasts around few seconds usually and is termed as apnoea. Apnoeas may end with a gasp that sometimes wakes the individual and even the sleeping companions! During the apnoea carbon dioxide levels rise but levels fall again when ventilation resumes, continuing the cycle. Breathing faster and deeper at HA leads to a profound reduction in the carbon dioxide levels in the blood. During sleep at HA, the levels of carbon dioxide in the blood can drop very low and this can switch off the drive to breathe. Only after the body senses a further drop in oxygen levels, one starts breathing again.Oxygen level drops during apnoeic phases and heart rate slows. Oxygen levels and heart rate rise again when breathing resumes resulting in cyclical variations in heart rate. PB may also contribute to arousals at night when an individual almost or completely wakes up. Arousals are more frequent at altitude, but they can occur even in the absence of periodic breathing. Data on sleep at altitude are scanty, due to the limited availability of polysomnography. Although polysomnographic recordings are very reliable, actigraphy can also accurately estimate sleep efficiency and duration. Due to its portability and simple use and the potential application over several weeks, it is a convenient tool for investigating altitude effects on sleep during field studies [26].

Therapeutic interventions for sleep improvement at HA

Apnea is a feature of 'unstable breathing' [27]. Among the primary factors leading to instability in the control of breathing are hypoxemia and respiratory alkalosis, universally seen in subjects exposed to HA. This instability in the ventilatory system induced by altitude can lead to the development of periodic breathing and central apneas during sleep. Chronic hypocapnia has been proposed as the common pathway leading to breathing instability during sleep [28]. A series of studies indicate that central apnea responds to treatment with supplemental oxygen. For mountaineers at very high altitudes, a primary beneficial effect obtained from the use of supplemental oxygen is an observed decline in apneic events during sleep [29]. Low-flow oxygen has been shown to decrease the rate of sleep disordered breathing during sleep, having particular effects on reported central and mixed apneas, and increasing the percentage of events described as obstructive [30,31]. Other interventions that improve sleep quality at HA include acetazolamide and benzodiazepines. Acetazolamide improves sleep, AMS symptoms, and hypoxemia at HA. Low doses of a short acting benzodiazepine (temazepam) may also be useful in improving sleep in HA [32].

Conclusions

This is a brief review on the sleep disturbances due to hypobaric hypoxic atmosphere of HA. Future studies should examine whether or not breathing abnormalities during sleep at HA, and the accompanying sleep fragmentation, adversely affect the performance of an individual and to what extent. Also, the other therapeutic interventions that can improve sleep quality without any adverse effects could be worked upon

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