

# ANNALES

UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA

SECTIO D

## MEDICINA



VOL. LXII, SUPPL. XVIII, N. 8

LUBLIN

2007

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UNIwersytet Marii Curie-Skłodowskiej  
Akademia Medyczna  
ISSN 0066-2240

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### *The subjective quality of sleep in relation to the chosen physiological parameters at the high altitude*

#### **Związek subiektywnej oceny jakości snu z wybranymi parametrami fizjologicznymi w warunkach wysokogórskich**

There are many physiological parameters of almost all of the human organism systems that are changed by the hypoxic hypobaric conditions at the high altitude [7,6]. The changes of the arterial oxygen saturation (SaO<sub>2</sub>), heart rate (HR), respiratory rate (RR) measured during entire period of sleep influence the quality of sleep [7,8,4]. Changes of the SaO<sub>2</sub> during high altitude sleep, connected with the high incidence of the periodic breathing has an impact on the quality of sleep too [4]. The data gathered thanks to polysomnographic studies confirmed the influence of the high altitude on the objective parameters of the sleep [7,8].

In our research, which was the part of the Project PHARE 2005 (Polish High Altitude Research Expeditions 2005), we tried to estimate how the everyday single measurement of the SaO<sub>2</sub>, HR and RR at the high altitude relate to the subjective quality of sleep. We expected to observe among the participants of the expedition sleep problems such as frequent arousals, feeling of not being refreshed in the morning, problems with getting to sleep [7] contributing to poor sleep quality. In order to assess the quality of sleep, we used questionnaires which may constitute a good alternative to clinical interviews and polysomnographic studies, especially for the lay persons. As the changes of the physiological parameters such as SaO<sub>2</sub>, HR and RR and the subjective quality of sleep can be observed by a lay person, the potential conclusions of this work can be easily introduced to high altitude expeditions' reality.

#### **MATERIAL AND METHODS**

Twenty one members of the high altitude expedition (Zdobywcy Expedition 2005) volunteered for this study. The aim of the expedition was a successful climb of the Lobuche East 6119 meters above sea level (m asl), the summit in the Himalayas in Nepal. Among 21 subjects there were 18 males and 3 females, mean age of the group was 34.05 ( $\pm 9.85$ ) (SD) years of age. The minimum age was 19 and the maximum age was 55 years. All the participants gave informed oral consent to participate in the

study. They denied history of any serious medical problems, drugs, alcohol abuse or sleep problems at the sea level. The study was approved by the Medical University of Gdansk regional ethics committee.

As an assessment of the subjective quality of sleep there were used two questionnaires: Pittsburgh Sleep Quality Index (PSQI) [2] and Athens Insomnia Scale (AIS) [5], that were filled after a week spent at the high altitude 4575.12 ( $\pm 496.22$ ) m asl. The questionnaires were administered in the mid-day. PSQI assesses seven components of sleep quality: 1(PSQI)-subjective sleep quality, 2(PSQI)-sleep latency, 3(PSQI)-sleep duration, 4(PSQI)-habitual sleep efficiency, 5(PSQI)-sleep disturbances, 6(PSQI)-use of sleeping medication, and 7(PSQI)-daytime dysfunction. In order to adjust PSQI to the study conditions we modified it asking participants to rate their sleep quality during the past week, not the past month as in the original version. Each component score ranges from 0 (no difficulty) to 3 (severe difficulty). The PSQI global score has a possible range of 0-21 points

AIS is a shorter 8- item scale assessing 1(AIS)-sleep induction, 2(AIS)-awakening during the night, 3(AIS)-final awakening, 4(AIS)-total sleep duration, 5(AIS)-sleep quality, 6(AIS)-well-being during the day, 7(AIS)-functioning capacity during the day, 8(AIS)-and sleepiness during the day. Each component is assessed on the scale ranging from 0 (no problem) to 3 (severe problem). The global score ranges from 0 to 24 [5].

During the same week, that was later assessed using PSQI and AIS in terms of the quality of sleep, the physiological data was collected. During seven days in the evening at the altitude reached by the group there were done measurements of SaO<sub>2</sub>, HR and RR. SaO<sub>2</sub> and HR were measured using pulseoximetry equipment (Dolphin 2150, AxMediTec Poland). The data was collected in tents, after the warming up of the index finger used for the pulseoximetry measurements. The highest SaO<sub>2</sub> and lowest HR observed over a 30 seconds interval were recorded for data analysis [6,3]. RR was measured during one minute by the subjects themselves.

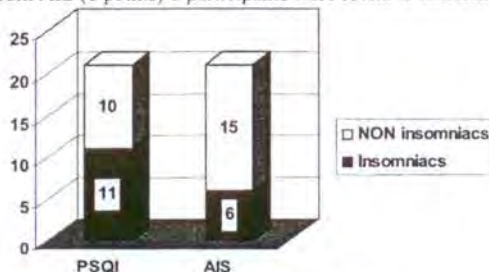
## RESULTS:

The data was analyzed using tau-Kendall correlation coefficient. The mean scores of the physiological parameters: SaO<sub>2</sub>, HR and RR and the subjective sleep quality scores of PSQI and AIS are presented in Table 1. No significant correlations between the total scores of the subjective sleep quality measures and physiological parameters were observed at the high altitude for the tested group as a whole.

**Table 1. Mean score for the physiological parameters and sleep quality measures at the altitude 4575.12 ( $\pm 496.22$ ) m asl (N=21). Standard deviation are given in brackets**

HR [beat · min <sup>-1</sup> ]	SaO <sub>2</sub> [%]	RR [breath · min <sup>-1</sup> ]	PSQI	AIS
87.26 ( $\pm 20.31$ )	79.21 ( $\pm 6.74$ )	12.97 ( $\pm 3.31$ )	7.38 ( $\pm 5.46$ )	5.92 ( $\pm 3.92$ )

By means of each scale it was possible to identify participants suffering from insomnia. According to the cut-off score from PSQI (5 points) 11 subjects exhibited sleep problems, whereas in accordance with the cut-off score from AIS (6 points) 6 participants were found to suffer from insomnia (Fig. 1).



**Fig. 1. Participants with insomnia according to PSQI and AIS**

We selected 11 PSQI-insomniac subjects, that constitute 52% of the entire group. Then the correlation coefficients were computed for the 11 selected participants among physiological parameters and all the components of the subjective sleep quality measures (8 for AIS and 7 for PSQI respectively). In PSQI-insomniacs three items from AIS significantly positively correlated with SaO<sub>2</sub>: 2 (AIS)-

awakenings during the night ( $\tau$ -b=0.51,  $p<0.05$ ), 4 (AIS)-total sleep duration ( $\tau$ -b=0.55,  $p=0.03$ ) and 5 (AIS)-sleep quality ( $\tau$ -b=0.6,  $p=0.02$ ). In these subjects higher SaO<sub>2</sub> levels were associated with more 2 (AIS)-awakenings during the night, 4 (AIS)-insufficient sleep duration and poorer 5(AIS)-sleep quality. The same procedure was applied for the AIS: 6 participants, 29% of the entire group, exceeded the cut-off score and were classified as AIS-insomniacs. Again, the correlations among all the physiological parameters and subjective sleep quality aspects (for PSQI) and items (for AIS) were computed. In 6 AIS-insomniacs 7(AIS)-functioning capacity during the day was negatively correlated with SaO<sub>2</sub> ( $\tau$ -b= -0.86,  $p=0.03$ ) which means that higher SaO<sub>2</sub> was related to better 7(AIS)-functioning during the day in the AIS-insomniacs.

## DISCUSSION

There was not observed the relation between SaO<sub>2</sub>, HR and RR with global subjective sleep quality measures. It may suggest that the quality of sleep is determined mainly by the changes of the physiological parameters that occur during the sleep time [7,8], not during a day activity. In other studies there was observed that the minimum SaO<sub>2</sub> during sleep was much lower than the minimum SaO<sub>2</sub> during the exercise [1]. This finding suggests the importance of the physiological measurements done during sleep time, as daily and nocturnal physiological response to high altitude may vary.

On the other hand, the correlation analysis between SaO<sub>2</sub>, HR and RR and the single components of the PSQI and AIS produced following results. There were no correlations observed between HR, RR and the components of PSQI and AIS in the PSQI and AIS insomniacs. Contrary to our expectations, in the PSQI-insomniac group higher SaO<sub>2</sub> levels were associated with more awakenings during the night, insufficient sleep duration and poorer sleep quality measured by AIS. This relation requires further research on the larger sample with measurements of physiological parameters during day activity and sleep. Higher SaO<sub>2</sub> level was related to better functioning during the day in the AIS-insomniacs. This result confirms many previous works that stated negative correlation between SaO<sub>2</sub> measured during a day time and Lake Louise Acute Mountain Sickness Score (LLAMSS) [7].

The relationship between physiological parameters and the subjective sleep quality at the high altitude remains unclear. It seems that physiological parameters such as SaO<sub>2</sub>, HR and RR that are measured once a day in the evening are not related to subjective sleep quality as a whole. Different components of sleep quality should be tested separately in relation to physiological parameters.

## CONCLUSIONS

1. Arterial oxygen saturation (SaO<sub>2</sub>), heart rate (HR), respiratory rate (RR) assessed during a day at high altitude do not relate to subjective quality of sleep measured by Pittsburgh Sleep Quality Index (PSQI) and Athens Insomnia Scale (AIS).
2. Further research addressing the relation between physiological parameters and subjective sleep quality should be undertaken on the larger sample and focused on the selected components of sleep quality.

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### SUMMARY

**Aim:** Assessment of the relation between the everyday single measurement of the SaO<sub>2</sub>, HR and RR and the subjective quality of sleep at high altitude. **Material:** 21 members of the high altitude expedition volunteered for this study -18 males and 3 females, mean age was 34.05 ( $\pm$ 9.85) (SD) years of age. **Methods:** The subjective quality of sleep was assessed with the use of two questionnaires: Pittsburgh Sleep Quality Index (PSQI) and Athens Insomnia Scale (AIS), filled after a week spent at the high altitude 4575.12 ( $\pm$ 496.22) m asl. During seven days in the evening at the altitude reached by the group there were done measurements of SaO<sub>2</sub>, HR and RR. **Results:** No significant correlations between the total scores of the subjective sleep quality measures and physiological parameters were observed. According to the PSQI 11 subjects, whereas in accordance with AIS 6 participants, were found to suffer from insomnia. In the group of insomniacs, awakenings during the night total sleep duration and sleep quality significantly positively correlated with SaO<sub>2</sub> whereas functioning capacity during the day was negatively correlated with SaO<sub>2</sub>. **Conclusions:** Arterial oxygen saturation (SaO<sub>2</sub>), heart rate (HR), respiratory rate (RR) assessed during a day at high altitude do not relate to the global subjective quality of sleep measured by Pittsburgh Sleep Quality Index (PSQI) and Athens Insomnia Scale (AIS). Further research addressing the relation between physiological parameters and subjective sleep quality should be undertaken on the larger sample and focused on the selected components of sleep quality.

### STRESZCZENIE

**Cel pracy:** Ocena zależności pomiędzy codziennymi pojedynczymi pomiarami saturacji krwi tętniczej, częstości akcji serca i częstości oddechów a subiektywną oceną jakości snu na wysokości. **Materiał:** 21 członków wyprawy wysokogórskiej, 18 mężczyzn, 3 kobiety, średnia wieku 34.05 ( $\pm$ 9.85) (SD) lat. **Metody:** Do oceny subiektywnej jakości snu użyto dwóch kwestionariuszy: Pittsburgh Sleep Quality Index (PSQI) and Athens Insomnia Scale (AIS), które były wypełniane po tygodniu spędzonym przez członków wyprawy na wysokości 4575.12 ( $\pm$ 496.22) m n.p.m. **Wieczorem** podczas 7 dni wyprawy na wysokości zdobytej przez badanych dokonywano pomiarów saturacji krwi tętniczej, częstości akcji serca i częstości oddechów. **Wyniki:** Nie zaobserwowano statystycznie znaczących korelacji pomiędzy globalnymi wskaźnikami jakości snu i parametrami fizjologicznymi. Zgodnie ze skalą PSQI u 11 badanych, natomiast zgodnie ze skalą AIS u 6 osób badanych stwierdzono bezsenność. W grupie cierpiących na bezsenność, budzenie się podczas nocy, całkowita długość snu i jakość snu w sposób istotny statystycznie pozytywnie korelowały z SaO<sub>2</sub>, natomiast funkcjonowanie podczas dnia negatywnie korelowało z SaO<sub>2</sub>. **Wnioski:** Nie ma zależności pomiędzy saturacją krwi tętniczej (SaO<sub>2</sub>), częstością akcji serca (HR), częstością oddechów (RR) rejestrowanymi podczas dnia a globalnymi wskaźnikami jakości snu mierzonymi za pomocą Pittsburgh Sleep Quality Index (PSQI) and Athens Insomnia Scale (AIS) na wysokości. Ustalenie zależności pomiędzy parametrami fizjologicznymi a subiektywną oceną jakości snu wymaga dalszych badań wybranych aspektów jakości snu na większej próbie.