Medicina Sportiva
Med Sport 18 (3): 91-94, 2014
DOI: 10.5604/17342260.1120659

OXYGEN SATURATION AND AMS-SYMPTOMATOLOGY AMONG SKIERS AFTER FAST ASCENT TO HIGH ALTITUDE (3440 M)*

Markus Tannheimer[1,2] (A-F), Raimund Lechner[2] (A,B, E), Marcel Stahl[2] (C-E), Jürgen Steinacker[1] (D,E)

[1]Department of Sport and Rehabilitation Medicine, University of Ulm, Ulm, Germany
[2]German Armed Forces Hospital, Ulm, Germany

Abstract

Due to decreasing snowfalls in the Alps and increasing popularity of skiing, glacier ski regions are highly frequented.

Objective: to determine the status of arterial oxygen saturation SpO_2 at rest and AMS-Symptomatology among not acclimatized skiers at a glacier ski resort at 3440 m.

Methods: After a fast ascent to an altitude of 3440 m oxygen saturation (SpO_2), as well as high altitude symptoms of 37 skiers (15 female, 22 male, medianage: 28 (19-53)) were determined by pulse oximetry and by high altitude symptoms questionnaire.

Results: No correlation between SpO_2 (Median: 89%, Min: 82, Max: 95) and questionnaire result could be found, in addition a preceding short-term stay at high altitude had no effect on the results. Despite of a notable hypoxia the skiers displayed only weak, primarily not agonizing AMS-symptoms (increasing pulse rate, reduced urine output, weakness/tiredness). The highest questionnaire score as well as the lowest SpO_2 values were found among persons older than 40 years.

Conclusions: Because of the latency of the high altitude illness, single-day glacier skiing at middle/high altitude is possible even in not acclimatized condition. With an increase in time spent on the glacier, a worsening of high altitude symptoms has to be expected. This can contribute to the risk of afternoon ski accidents, besides muscular fatigue.

Keywords: *acute mountain sickness, skiing, pulse oximetry, oxygen saturation, high altitude illness*

Introduction

Due to decreasing snowfalls in the Alps and increasing popularity of skiing, glacier ski regions at high altitudes are highly frequented. High altitude pulmonary edema (HAPE) is a severe high altitude related illness that occurs very seldom below 2500 m [1,2]. Therefore, the study of Gabry et al. [3] that reports of 52 cases of HAPE from 1992 – 2000 in French alpine ski resorts at an altitude of only 1400 – 2400 m is surprising and raises the question if there is a specific risk for high altitude illness among skiers. This question is supported by the studies of Honigman et al. [4] and Hultgren et al. [5]. They report an incidence of acute mountain sickness (AMS) of 25% in Colorado ski resorts (2928 m) and a large number of 150 HAPE cases in 39 months and even some cases of the rare high altitude cerebral edema (HACE). Besides altitude, the combination of intensive exercise (static muscular work and exhaling on exertion) with cold temperatures seems to increase the risk of HAPE and AMS in skiers [6]. For early detection of AMS and HAPE pulse oximetry is widely used [7,8].

Objective

The aim of the study was to determine the status of arterial oxygen saturation SpO_2 at rest and AMS-Symptomatology among not acclimatized skiers at a glacier ski resort at 3440 m.

Methods

The study was performed at the top station of Pitztal glacier ski resort (3440 m above sea level, barometric pressure: 675 mbar). Included were 37 skiers (15♀, 22♂; age median: 28 (19-53)) that participated voluntarily in this study. 8 subjects reported one stay at similar altitude within the last week. All skiers had been skiing for 4-5 hours (2800–3440 m) and rested for ~20 min prior to the study. SpO_2 was measured in standing position at the right cleaned and warmed index finger that was covered under the anorak with the Nellcor N-20 in the continuous mode over 2 minutes. The display of the pulse oximeter was not visible for the tested person. The representative value of the measurement period was used for further analysis. The investigator paid attention for hyperventilation.

* Results were presented during the 6th EUROPEAN HYPOXIA SYMPOSIUM – Hypoxia, High Altitude Physiology And Sports In Science And Practice, Zakopane, Dolina Chochołowska, 12-15 September, 2013.

In addition altitude symptomatology was quantified by the high altitude symptoms questionnaire (Fig. 1) that is used in the German Armed Forces [9] and that is similar to the Lake Louise Score. The sum of the questionnaire is called Individual-Score (I.S.). An I.S. ≤ 3 corresponds to healthy person, 3 < I.S. ≤ 9 corresponds to altitude discomfort and IS > 9 corresponds to AMS [7]. The symptom "I didn`t sleep well did not count for the I.S. because none of the skiers slept above threshold altitude (2500 m). The symptom index (SI) characterizes the presence of a symptom within the group

$$SI = \frac{\text{symptom severity sum}}{\text{number of subjects}}$$

Statistical analysis

Statistical analysis was done using Spearman's rank correlation coefficient with binding and *chi-square* test. Results are expressed as Median (Minimum – Maximum).

Results

We found a decreased SpO_2 at rest: 89% (82–95%) with a wide individual range. 22% of the skiers had

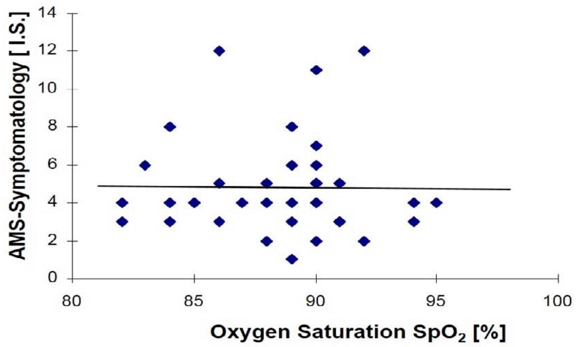

Fig. 2. *Oxygen Saturation and AMS-Symptomatology among skiers at 3440 m after 4-5 hours skiing between 2800–3440 m*

a SpO_2 below 85% indicating a substantial hypoxemia in these not adapted subjects. In this regard, the presented AMS symptoms were only weak with a median I.S. of 5 (1 – 12). The most frequent symptoms were "increasing pulse rate" (SI: 1.6), "reduced urine output" (SI: 1.0) and "weakness" (SI: 0.7). The highest questionnaire score as well as the lowest SpO_2 values were found among persons older than 40 years. After 4-5 hours skiing at an altitude of 2800–3440 m no correlation between I.S. and SpO_2 could be found; rs = -0,008 (Fig. 2).

Name:		**date:**			
Location:			altitude:	m ft	
SpO_2:	% ;	barometric pressure		mbar;	
Pulse:	/ min				
		non	mild	moderate	severe
1. I feel sick		**0**	**1**	**2**	**3**
2. I feel weak / tired		**0**	**1**	**2**	**3**
3. I couldn't sleep well		**0**	**1**	**2**	**3**
4. Headache		**0**	**1**	**2**	**3**
5. Shortness of breath / Dyspnea		**0**	**1**	**2**	**3**
6. irregular Breathing (periodic Breathing)		**0**	**1**	**2**	**3**
7. Change in mental status (irritable, nervous, uncertain, euphoric, confused...)		**0**	**1**	**2**	**3**
8. Pulse at rest:		≤79 ⇒ **0**	80-99 ⇒ **1**	100-119 ⇒ **2**	>120 ⇒ **3**
9. Appetite		good ⇒ **0**	none ⇒ **1**	nausea ⇒**2**	vomiting ⇒**3**
10. Urine:		frequent/ ⇒ **0**	**1**	**2**	rare/concentrated ⇒**3**
Something else:					

Fig. 1. *High altitude symptoms questionnaire that is used in the German Armed Forces [9]*

A preceding altitude exposure (8 subjects reported one stay at similar altitude within the last week) had no influence on performance, SpO_2 (median 90%; 82–94%) and I.S. (median 4; 1 - 12)

Discussion

The latency of AMS of 6-36 hours [10] is the most likely reason for the moderate AMS-symptomatology among this group of skiers at Pitztal glacier ski resort despite of their low SpO_2. The short stay of 6-8 hours makes skiing at high altitude enjoyable (nearly) without altitude symptoms. During an expedition to Broad Peak [7] (altitude profile: Fig. 3) at a comparable altitude of 3600 m and similar barometric pressure the SpO_2 was higher 90% (88 – 91%) and I.S. was lower 2 (0 – 7) (Fig. 4 and 5). The striking difference is that it took 12 days during the expedition to reach that altitude, enough time for a profound acclimatization process. Despite that, even during the expedition, the subjects were not completely free of symptoms but no one suffered from AMS (I.S. ≤ 9). In addition the symptom "I couldn't sleep well" counted for the I.S.-Score during the expedition but not at Pitztal glacier because the skiers had no overnight stay. This applies in particular for the symptom "irregular/periodic breathing" as this occurs typical at night. For these reasons, the I.S. of the skiers compared to the expedition members might be underestimated. If the skiers had to stay for a longer time at that altitude, especially overnight, stronger AMS-Symptoms would (conditional) have to be expected.

In addition, more than 20% of the skiers had a SpO_2 below 85% and were not adapted to this hypoxemia. As skiing is a demanding exercise, a further significant decrease in SpO_2 must be expected [11] during the ski-run. Therefore, the measured SpO_2 most likely represents the upper margin of the SpO_2-range of the skiers during this day of skiing.

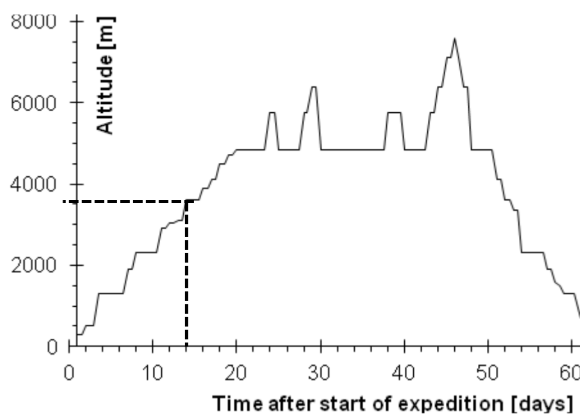

Fig. 3. *Altitude profile of the expedition to Broad Peak (8047 m) [7]. The dotted line marks the12th day of the ascent with similar altitude compared to the study among skiers at Pitztalglacier ski resort.*

Up to now, there are no investigations about the specific influence of altitude on the risk of accidents during skiing, but it is well known that most ski accidents occur in the afternoon [12]. AMS and hypoxemia might be additional risk factors besides of fatigue and alcohol [13,14].

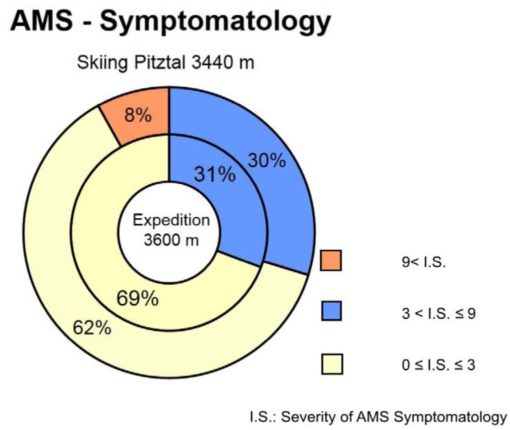

Fig. 4. *AMS-Symptomatology skiing at Pitztalglacier (outer circle) compared to an Expedition (inner circle) at comparable altitudes*

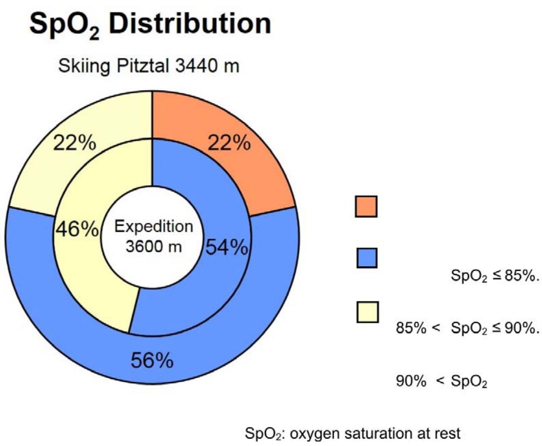

Fig. 5. *Oxygen saturation at rest of skiers at Pitztalglacier (outer circle) compared to an Expedition (inner circle) at comparable altitudes*

Conclusions

Despite of a notable hypoxia the skiers displayed only weak, primarily not agonizing AMS-symptoms after 4-5 hours at an altitude between 2800 – 3440 m. Because of the latency of the high altitude illness, single-day glacier skiing at middle/high altitude is possible even in not acclimatized condition. With an increase in time spent on the glacier, a worsening of high altitude symptoms has to be expected. This can contribute to the risk of afternoon ski accidents, besides muscular fatigue.

Declaration of interest

The authors report no conflicts of interest.

References

1. Brandt S, Brugger H. [High altitude lung edema in the East Alps]. *Wien Klin Wochenschr* 1994; 106: 742-5.
2. Ladner E, Schobersberger W, Sparr H, et al. [High altitude pulmonary edema at a medium height. A case report]. *Anaesthesist* 1994; 43: 183-6.
3. Gabry AL, Ledoux X, Mozziconacci M, et al. High-altitude pulmonary edema at moderate altitude (< 2,400 m; 7,870 feet): a series of 52 patients. *Chest* 2003; 123: 49-53.
4. Honigman B, Theis MK, Koziol-McLain J, et al. Acute mountain sickness in a general tourist population at moderate altitudes. *Ann Intern Med* 1993; 118: 587-92.
5. Hultgren HN, Honigman B, Theis K, et al. High-altitude pulmonary edema at a ski resort. *West J Med* 1996; 164: 222-7.
6. Sophocles AM, Jr. High-altitude pulmonary edema in Vail, Colorado, 1975-1982. West J Med 1986; 144: 569-73.
7. Tannheimer M, Thomas A, Gerngross H. Oxygen saturation course and altitude symptomatology during an expedition to Broad Peak (8047 m). *Int J Sports Med* 2002; 23: 329-5.
8. Roach RC, Greene ER, Schoene RB, et al. Arterial oxygen saturation for prediction of acute mountain sickness. *Aviat Space Environ Med* 1998; 69: 1182-5.
9. Tannheimer M, Thomas A, Gerngross H. [Self-test to assess high altitude symptomatology]. *Wehrmed Mschr* 2000; 44: 138-41.
10. Savourey G, Guinet A, Besnard Y, et al. Evaluation of the Lake Louise acute mountain sickness scoring system in a hypobaric chamber. *Aviat Space Environ Med* 1995; 66: 963-7.
11. Tannheimer M, Albertini N, Ulmer HV, et al. Testing individual risk of acute mountain sickness at greater altitudes. *Mil Med* 2009; 174: 363-9.
12. Greier K. [Skiing injuries in school sport and possibilioties to prevent them]. Sportverletzung Sportschaden : *Organ der Gesellschaft fur Orthopadisch-Traumatologische Sportmedizin* 2011; 25: 216-21.
13. Cherpitel CJ, Meyers AR, Perrine M. Alcohol consumption, sensation seeking and ski injury: a case-control study. *Journal of Studies on Alcohol and Drugs* 1998; 59: 216
14. Burkner A, Eichbichler A, Simmen HP. [Safety requirements and risk factors of skiers and snowboarders]. Sportverletzung Sportschaden : *Organ der Gesellschaft fur Orthopadisch-Traumatologische Sportmedizin* 2009; 23: 41-6.

Accepted: August 1, 2014
Published: September 10, 2014

Address for correspondence:
Markus Tannheimer
Department of Sport and Rehabilitation Medicine
University of Ulm
Leimgrubenweg 12-14
89070 Ulm, Germany
Markus.Tannheimer@arcor.de

Raimund Lechner: Raimund.Lechner@googlemail.com
Marcel Stahl: Marcel.Stahl@arcor.de
Jürgen Steinacker: Juergen.Steinacker@uniklinik-ulm.de

Authors' contribution
A – Study Design
B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection