Selected Abstracts From the Wilderness Medical Society's 2014 Winter Scientific Conference

Walk High, Sleep Low: An Observational Cohort Study of Altitude Symptoms and Physiological Profiles Over a 6 Day Ascent of Mount Kilimanjaro

Introduction.—Acute mountain sickness (AMS) is a potentially life threatening complication of high altitude trekking. Several ascent profiles of Mount Kilimanjaro have been criticized for rapid ascent allowing little acclimatization time. The 7 day Lemosho route is one of the longest treks, allowing 2 days for acclimatization (day 3 & 4) and more time for rest which should improve the success rate of trekkers reaching the summit as well as decreasing the incidence of potentially fatal complications of AMS such as high altitude cerebral edema (HACE).

Objective.—To evaluate symptom profiles of trekkers on Lemosho route to determine whether this route enhances acclimatization.

Methods.—Daily measurement of oxygen saturation, heart rate, and Lake Louise Symptom Score (LLSS), plus clinical assessment score (CAS) recorded days 1–4, summit day for 25 subjects.

Results.—Median LLSS + CAS day 1 = 0.56, incidence of AMS 4% ; median LLSS + CAS day 2 = 2.24, incidence of AMS 40%; median LLSS + CAS day 3 = 1.72, incidence of AMS 36%; median LLSS + CAS day 5 = 1.84 incidence of AMS 24%; median LLSS + CAS summit day = 2.4 incidence of AMS 40%. Incidence of AMS/HAPE in smokers (12%; $n = 3$) = 0; incidence of AMS/HAPE in non-smokers (88%; $n = 24$) = 48% ($n = 12$); incidence of AMS/HAPE without acetazolamide (24%; $n = 6$) = 8% ($n = 2$); incidence of AMS/HAPE with acetazolamide (76%; $n = 19$) = 10.

Conclusions.—Incidence of AMS has been reported to range between 47 and 75% on Mount Kilimanjaro. Our results show a significantly lower rate with symptom scores and heart rate highest at day 2 but improved following the subsequent acclimatization day demonstrating benefits of the longer route and the value of time to acclimatize.

Laura G. Nicol
Hannah E. Evans
Inverness, United Kingdom

altitude by ultrasound measurements and correlate this with summit success (SS).

Methods.—A prospective observational cohort study enrolled climbers between the ages of 18 and 65 who had been at 14,000 ft (4267 m) for less than 24 hours on Mount McKinley, Alaska during June 2013. Participants completed a survey about water-carrying capacity and intake and had state of hydration evaluation determined by urine specific gravity (SG) and ultrasound measurements of the inferior vena cava (IVC) collapsibility index. Upon returning to 14,000 ft after their summit attempt, climbers reported maximum elevation gained. An independent two-sample *t* test was performed for independent variables with binary logistic regression for the identified significant predictors.

Results.—One-hundred twenty-one participants enrolled, with 100 (86%) complete data sets and 67% successful summiters. There was no significant association with SS and IVC collapsibility (50.4% vs 52.4% $\pm$ 1.9%, $P = .52$), IVC size (0.96 cm vs 0.99 cm $\pm$ 0.03 cm, $P = .63$), or SG (1.02 vs 1.02 $\pm$ 0.001, $P = .64$). Successful summiters estimated they consumed more water (3.4 L/day vs 3 L/day $\pm$ 0.4 L/day, $P = .049$) than non-summiters, though this significance was not seen in the regression analysis.

Conclusions.—Ultrasound measurements did not appear to have a diagnostic role in predicting dehydration or high-altitude performance by summit success. While ultrasound measurements indicated that climbers were dehydrated, specific gravity measurements suggested climbers were euvoletic (average SG 1.02). A trend was seen that greater water consumption might have increased chances for SS. Increasing water-carrying capacity is an inexpensive and easy intervention that may improve SS in climbers ascending to high altitudes.

Eric R. Ladd, MD
Katherine M. Shea, MD
Grant S. Lipman, MD
Patrick Bagley
Elizabeth Pirrotta
Hurnan Vongsachang
N. Ewen Wang, MD
Paul S. Auerbach, MD
Stanford, CA, USA

Hydration Status as Predictor of Summit Success on Mount McKinley

Background.—As thousands of people attempt high-altitude peaks each year, euhydration is promoted for optimal climbing performance and dehydration is viewed as a potential detriment. This study was the first to define hydration status at high

Incidence of Illness and Sick-Cell Trait at Altitude: Data from the Marine Mountain Warfare Training Center

Introduction.—Sickle-cell trait (SCT) has been associated with an increased risk of injury and death among otherwise

fit athletes training at both lower elevations and elevations greater than 5000 feet. Military population rates of injury have been consistently lower than civilian sectors in previous studies. Nevertheless, no large-scale studies of this type have looked at altitude and the effects of hydration on SCT-related complications. The military uses an aggressive hydration and work/rest protocol for all soldiers.

Objective.—The investigators hypothesized that hydration and work/rest protocols may have led to lower rates of injury in soldiers with SCT exposed to altitude.

Methods.—We conducted a retrospective review of a 2800 soldier cohort using blinded data of injuries occurring in participants with pre-identified SCT during a series of 28-day Marine Mountain Warfare training events conducted in Bridgeport, CA from May 2010–Feb 2012. All soldiers with SCT enrolled in the course were included in the study and their injury patterns followed. We compared their patterns with those of the non-SCT population.

Results.—Out of the 2800 soldiers, 25 had SCT, but only 1 of the SCT group had an altitude-related complication (acute mountain sickness). Surprisingly, despite a reported clear predilection for complications secondary to SCT, altitude-specific illnesses were rare and only occurred once out of 25 participants (4%). The rate of injuries was much lower than previous civilian studies. There were no deaths in either the study group or the control group.

Conclusions.—Medical providers must be prepared to recognize possible SCT-related complications at elevations above 5–10,000 feet, but also recognize that it may be far more likely that their soldiers with SCT will more likely have a wide range of routine illnesses and injuries that are not altitude related.

Ian C. May, MD
Garrett Ripoll, DO
Ian Wedmore, MD
Carl Skinner, MD
Darren Thomas, MD
Owen McGrane, MD
San Diego, CA, USA

6-Minute Walk Test as a Predictor of Summit Success on Denali

Introduction.—A growing number of climbers attempts mountains over 5,500 meters each year. The rescue of climbers from these elevations is dangerous and expensive, with each rescue on Denali averaging over \$20,000. The 6-minute walk test (6MWT), previously tested on Aconcagua, is an inexpensive and easily reproducible screening test for summit success that may provide early detection for those requiring rescue.

Objective.—The purpose of this study was to validate the 6MWT at 14,000 ft (4,267 m) on Denali, Alaska.

Methods.—This was a prospective observational cohort study of healthy adults between the ages of 18 and 65 who had been at 14,000 ft for less than 24 hours in June, 2013. Vital signs (VS) were measured before and after the 6MWT.

Subjects attempted to summit at their own pace and, at the time of descent, returned to the study tent and completed a Lake Louise AMS Questionnaire (LLQ) and reported maximum elevation reached.

Results.—One hundred and twenty-one participants enrolled in the study. Complete data was collected on 100 subjects (86% response rate) of whom 62% summited. Univariate analysis revealed that there was no association between any resting or post-exercise VS and summit success. Specifically, there was no significant difference between the post-exercise oxygen saturation in summiters (S, 74.6%) and non-summiters (NS, 74.05%), which differed by -0.54% (95% CI: -0.93% to -0.13% , $P = .53$). The 6-minute walk test distance (6MWT) revealed marginal significance with 2025 ft (S) and 1855 ft (NS) for a difference of -170 feet (95% CI: -247.6 ft to -91.39 ft, $P = .048$; OR: 1.000; 95% CI: 1.000 to 1.002).

Conclusions.—This study showed that the post-exercise oxygen saturation does not correlate with summit success. The distance a subject covered in 6 minutes, however, may be a better measure of functional status at altitude.

Katherine M. Shea, MD
Eric R. Ladd, MD
Grant S. Lipman, MD
Patrick Bagley
Elizabeth Pirrotta
Human Vongsachang
N Ewen Wang, MD
Paul S. Auerbach, MD
Stanford, CA, USA

Effectiveness of Preventive Search and Rescue: Illness and Injury Prevention and Fiscal Impact

Introduction.—Grand Canyon National Park Rangers respond frequently to calls for assistance in the backcountry. The Preventive Search and Rescue Team (PSAR) seeks to educate the hiking public in Grand Canyon and reduce the number of hikers requiring assistance.

Objectives.—This study investigates the effectiveness of the PSAR Team by examining its impact on heat-related search and rescues (SARs) and non-heat-related SARs, in addition to its fiscal impact.

Methods.—Historical data collected on heat-related and non-heat-related SARs was used to develop predictive models about pre-PSAR SAR rates. These models were then compared to recent data collected by the PSAR Team on heat-related and non-heat-related SARs that occurred after the inception of the PSAR Team.

Results.—A 42% reduction in heat-related SARs, 21% reduction in non-heat-related SARs, and an annual fiscal savings of at least \$300,000 were observed after the implementation of the PSAR Team.

Conclusions.—The PSAR Team has a great impact on the occurrence of SARs, both heat and non-heat related. By