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Effect of Simulated Tree-Well vs Avalanche Snow Burial on Core Temperature Cooling Rate

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Introduction.—An increasing number of skiers and snowboarders are caught in nonavalanche tree-well snow immersions. Given the lighter density of snow and inverted position of burial, this emerging injury pattern may have different victim physiology and associated rescue considerations compared with avalanche-related burials.

Objective.—This study aimed to measure the differential effect of burial type (tree-well vs avalanche) on victim physiology related to survival.

Methods.—Eleven volunteers participated in 2 paired 60-minute snow burials: avalanche and tree-well scenarios simulated by controlling burial position and snowpack densities. Minute-by-minute physiologic parameters were monitored for safety and recorded, including core temperature, respiratory rate, minute ventilation, end-tidal carbon dioxide, oxygen saturation, and heart rate.

Results.—Using a quasi-Bayesian generalized linear mixed model, we found the subject-specific average rate of core temperature cooling in avalanche conditions was –0.017°C/min. (95% CI –0.023 to –0.011; $P = .001$); in tree-well conditions, it was –0.013°C/min. (95% CI –0.019 to –0.005; $P < .001$). The subject-level average expected time to hypothermia (35°C) was 185 minutes in avalanche and 250 minutes in tree-well conditions. Upon limiting the false discovery rate to 5%, secondary analyses revealed no statistically significant difference between burial types for respiratory rate, minute ventilation, end-tidal carbon dioxide, oxygen saturation, or pulse.

Conclusions.—The lower density of snowpack in tree-well snow immersions is likely to result in the 24% slower rate of cooling observed and thus in longer expected time to hypothermia compared with higher snow density avalanche conditions. These implications may lead to allocating extended search and rescue efforts to accommodate for longer time to hypothermia when looking for tree-well burial victims compared to avalanche victims.

Reduced Acetazolamide Dosing for Acute Mountain Sickness Prevention Study: A Comparison of 62.5 vs 125 mg BID (the RAD AMS prevention study)

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Objective.—Acetazolamide is the standard agent of choice for medical prophylaxis against acute mountain sickness (AMS). The current North American guidelines propose 125 mg twice daily (BID) as the recommended prophylactic dose. To our knowledge, a dose lower than 125 mg twice daily has not been studied. We sought to determine whether 62.5 mg twice daily was as effective as 125 mg twice daily for the prevention of AMS. In addition, we sought to measure the number and severity of side effects experienced by users of each dose.

Methods.—We conducted a prospective double-blind randomized noninferiority trial of healthy trekkers and climbers traveling to Everest Basecamp in Nepal or those ascending Denali in Alaska. Participants received either the reduced dose of acetazolamide at 62.5 mg twice daily or the standard dose of 125 mg twice daily before and during ascent. Outcome measures included the incidence and severity of AMS in each group as well as the prevalence of common side effects of the medication.

Results.—Ninety participants had data sufficient to be included in the analysis. The incidence of AMS did not vary significantly between the 2 groups; the mean Lake Louise Score

was 0.966 for the 125 mg BID dose group and 1.014 for the 62.5 mg BID dose group (CI, 0.885–1.144). Side effects experienced by the 62.5 mg BID group were, curiously, slightly higher than those of 125 mg BID dose group, but these differences diminished when controlling for participant weight.

Conclusions.—A reduced dose of acetazolamide 62.5 mg BID is as effective as the currently recommended dose of 125 mg BID for the prevention of AMS. These results could influence future recommendations for climbers and trekkers with ascent profiles similar to those seen in our study.

Sleep Characterization at High Altitude

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Introduction.—Poor sleep at high altitude is a well-described phenomenon and is associated with acute mountain sickness (AMS); however, large comprehensive studies characterizing sleep are lacking.

Objective.—This study aims to better understand factors contributing to the observed poor-quality sleep.

Methods.—We completed a descriptive analysis of the SLEEP-AID randomized controlled trial limited to the placebo arm (n=104 using resistance-free nasal strip, mean LLQ=1.86, 17% AMS incidence) and analyzed 52 participants with complete data. Minute-by-minute sleep data and oxygen saturation were acquired with WatchPAT-200 sleep monitors on the first night of trekking to 4371 to 4530 m altitude in Nepal.

Results.—Participants were 70% male with an average age of 37 years (interquartile range [IQR] 27–48), and had mean 24-hour elevation gain of 448 m (IQR 380–550). Participants slept on average 477 minutes (IQR 442–517) with 11 awakening events (IQR 6–14). Their average sleep was 68% light sleep (IQR 63–78), 11% deep sleep (IQR 6–17), and 20% rapid eye movement (REM) sleep (IQR 15–24). Average sleep latency was 22 minutes (IQR 19–26) with REM latency of 104 minutes (IQR 63–119). They experienced an average of 275 desaturation events (IQR 105–399), in which oxygen saturation dropped below 80%, and spent 46% of the night below that threshold (IQR 11–84). All calculated sleep quality indices were profoundly abnormal: Respiratory Disturbance Index (mean 53, IQR 32–74), Apnea Hypopnea Index (mean 51, IQR 27–73), and Oxygen Desaturation Index (mean 37, IQR 14–54). All of these metrics (except % REM sleep) were significantly worse in participants with AMS prior to sleep than in those who did not have AMS ($P < .05$).

Conclusions.—This study more accurately describes altitude-related sleep metrics contributing to poor sleep. There were a large number of nocturnal desaturation and awakening events likely contributing to the hypobaric hypoxic insult of sleeping at high altitude and accounting for the profoundly abnormal sleep indices.

Oral L-Tyrosine Supplementation Improved Core Temperature Maintenance to Whole-Body Cold Exposure in Older Adults

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Introduction.—During cold exposure, an immediate and sustained increase in sympathetic nerve activity evokes vasoconstriction (VC) of cutaneous vessels to minimize heat loss and maintain body core temperature. In older adults, this reflex VC response is impaired, thereby increasing their susceptibility to excess heat loss and hypothermia. This may be explained in part by reduced bioavailability of the amino acid substrate, L-tyrosine, for catecholamine production. Thus, the thermoregulatory benefit of tyrosine supplementation in older adults is unknown.

Objective.—We hypothesize that oral L-tyrosine ingestion will augment the cutaneous VC response and thereby attenuate the decline in core temperature resulting from prolonged whole-body cooling in older adults.

Methods.—In a randomized, double-blind design, 8 older participants (aged 68±4 years) ingested either 150 mg/kg of L-tyrosine or placebo before commencing 90 minutes of whole-body cooling to decrease skin temperature to ~30°C. Esophageal temperature (TES) and forearm laser Doppler flux was measured continuously throughout the protocol to provide an index of core temperature and skin blood flow, respectively. Cutaneous vascular conductance (CVC) was calculated as CVC = laser Doppler flux / mean arterial pressure and expressed as a percent change from baseline (%ΔCVC). The change in esophageal temperature (ΔTES) was the difference in temperature at the end of cooling subtracted from baseline. Data were analyzed using 2-way (drug by cooling time) analysis of variance with repeated measures with Bonferroni post hoc analysis.

Results.—Oral tyrosine supplementation improved the reflex cutaneous VC response to cooling in older adults (placebo = 15.0±0.9, tyrosine = 29.6±0.7 %ΔCVC; $P < .05$). Additionally, tyrosine maintained body core temperature throughout cooling (placebo = –0.31±0.04, tyrosine = –0.09±0.03 ΔTES; $P < .05$).

Conclusions.—These results indicate that L-tyrosine supplementation may improve thermoregulatory function in response to acute cold exposure in an older population.