Field Monitoring of Neuroendocrine and Cardiovascular Alterations during a Himalayan Expedition to High Altitude

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Introduction

High altitude (HA) environments are characterized by reduced atmospheric pressure, lowered oxygen availability, and extreme temperature fluctuations, among other challenges. Specifically, ascending to HA challenges metabolic homeostasis resulting in altered neuroendocrine and cardiovascular control. Some evidence suggests such changes are linked to the development of acute mountain sickness (AMS),[1,2] which if left undetected can progress to life-threatening HA cerebral edema and/or HA pulmonary edema. Effective monitoring of individual physiological responses during ascent to HA is essential for improving early detection of altitude illness; however, there are currently no clinical biomarkers used to monitor such changes in individuals sojourning to HA.

Purpose

To test the feasibility and sensitivity of several self-collected biomarkers during a 21-day expedition to remote regions of the Greater Himalayan Range as part of the Himalayan Health Exchange venture. We aimed to characterize changes in urinary neurotransmitters (NTs) and heart rate variability (HRV) with ascent to moderate altitude (MA; ~2,400-2,800 m) and HA (~3,600-4,400 m).

Methods

Eleven medical professionals, 8 medical students from the UK, South Africa and the USA and 3 attending physicians from the USA and UK (6 males, 5 females, BMI = 22.4 ± 2.3 kg/m2, age = 29 ± 14 yr.) set out on a 21-day expedition to remote regions of the Greater Himalayan Range, with the goal of summitting and traversing the Pimu La Pass. Along the sojourn visits were made to many remote villages where medical care was provided to the villagers that otherwise have no access to health care except by multiple day travel (3-5 days) to the nearest city or by airlift. After visits to the villages, they conducted a completely self-contained remote trek with minimal external support on a trail that is used by local shepherds. The trek consisted of had a steep ascent through a high pastureland and an unmarked trail through a large boulder field which ended at the base of Pimu La near the Zanskar Range. Figure 1 displays the elevation changes across the complete expedition. Based on the changes in elevation, pre-expedition (Pre) was defined as ~2,000 m followed by 6 days at MA (~2,400-2,800 m) and 3 days at HA (~3,600-4400 m).

HRV: Daily 60-s, post-waking HRV measures were self-recorded supine and standing using the Elite HRV smartphone application for analysis of R-R intervals (RR) and the root mean square of successive differences (RMSSD).

Urinary NTs: Dried urine samples were taken once at Pre, MA, and HA immediately after waking up and stored in plastic bags with desiccant until analyses could be completed via liquid chromatography-mass spectrometry.

AMS Questionnaire: Lake Louise AMS Score was taken each morning. Participants were instructed to record a daily score for each symptom (e.g., headache = 3, GI symptoms = 0, etc.) and total score (sum of all 5 symptom scores).

Fitbit: Participants were asked to wear a Fitbit provided to them as long as possible each day excluding travel days (day 3-18). Fitbit activity tracking measured step count.

Statistical Analyses

Differences were assessed by linear mixed models fitted using restricted maximum likelihood with Greenhouse-Geisser correction and Tukey post-hoc testing. Data are presented as means ± SD.

Figure. 1 Elevation changes across the 21-day expedition.

Results

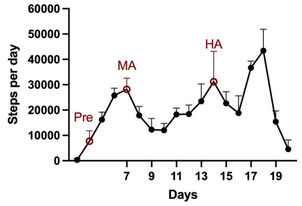

Figure 2. Daily step count across the 21-day expedition

Table 1. Average Lake Louise scores taken at the first day of ascent to moderate (MA) and high altitude (HA)

	MA	HA
AMS Score	0.5 ± 0.7	2.2 ± 2.5

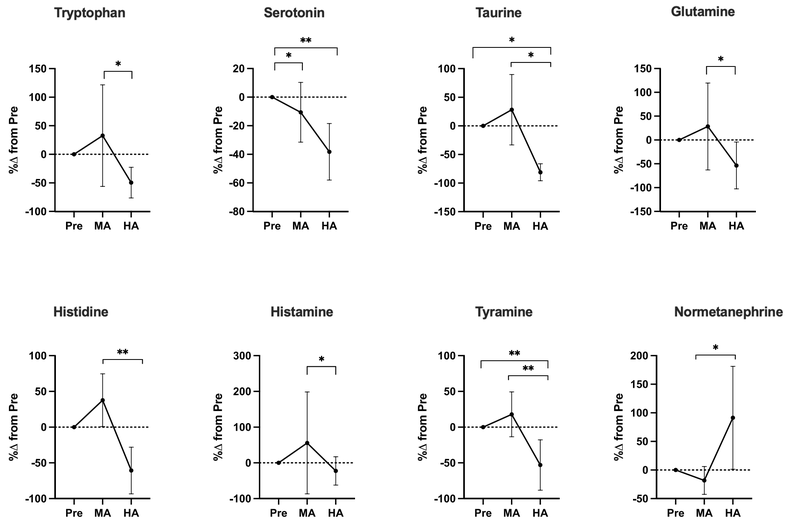

Figure 3. Group means and standard deviations for the relative change in concentrations of urinary neurotransmitters with ascent to moderate (MA) and high altitude (HA). * = P < 0.05, * = P < 0.01

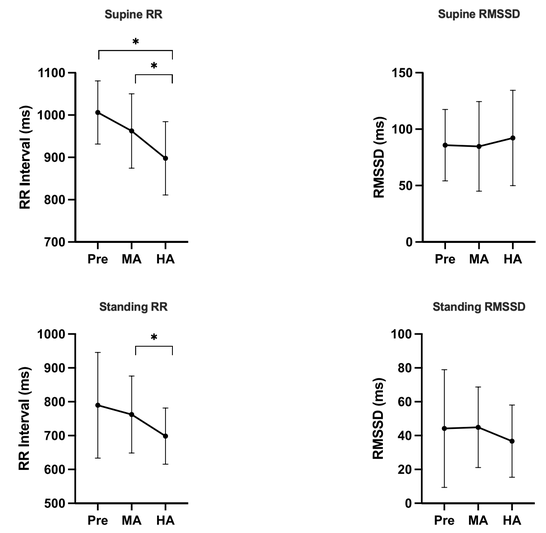

Figure 4. Group means and standard deviations for R-R intervals (RR) and root mean square of successive differences (RMSSD) with progressive exposure to moderate (MA) and high altitude (HA). * = P < 0.05

Conclusions

- Self-collected urinary and HR measures were sensitive to alterations in neuroendocrine signaling and cardiovascular control with ascent to HA; however, ultra-short HRV profiles may not be sensitive enough to detect changes in RMSSD.
- Due to the nature of this as a field study, we lose a certain amount of control that would not be found in a laboratory setting. However, even given these constraints, we demonstrate there may be field measures that are both feasible and sensitive to detect physiological changes in individuals sojourning to HA, even in remote regions.
- Since such few participants developed AMS during the expedition, perhaps due to taking prophylactic medications (i.e., acetazolamide) or a slow ascent, it was not possible for us to make conclusions regarding possible relationships between changes in neuroendocrine and HR control with AMS.
- Future research should focus on exploring relationships between these measures and AMS development or severity in individuals ascending to HA.

References

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