From Bench to Tentside: Altitude Sickness Study on Kilimanjaro

At Uhuru Peak. Top (left to right): Allen, Erika, Braden, Pam, Uzi, Ally, Dafang. Bottom: Ellicott, Bariki, Paulo, and Captain Jaguar.

(Rapoport Cont...)

his running experience following the race. Every year since, Rapoport has returned to Dr. Kettyle's class to give a talk on the physiology of endurance running.

Over time, Rapoport developed an increasingly clear understanding of the sport and a sense of what was missing from the scientific and popular literature on endurance running. Rapoport's experiments developed into a set of methodical calculations that can enable runners to calculate the amount of energy (kcal) they need to sustain their target paces for a marathon. Rapoport based his model on aerobic capacity (VO2max) and the amount of glycogen stored in the leg muscles. VO2max is a measurement of the maximum rate at which an individual can transport oxygen to the muscles for use during exercise. The more oxygen the body is able to uptake and transport during exercise, the more glucose it can break down for energy. Rapoport submitted his findings to *PLoS Computational Biology*, and the journal accepted his paper just in time for fall marathon season. (Rapoport BI (2010) Metabolic Factors Limiting Performance in Marathon Runners. PLoS Comput Biol 6(10): e1000960. doi: 10.1371/journal.pcbi.100096).

After publishing his work, Rapoport launched a web calculator that makes it easy for any runner to apply the model. At endurancecalculator.com, runners can enter their weight, age, resting heart rate, and target marathon finishing time; based on that information, the calculator provides an estimated number of carbohydrate calories the runner would need to consume before the race. While Rapoport's calculator is for marathoners, he notes that it could be adapted to other sports, such as cycling, in time.

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-Alal Eran, Erika Williams, Dafang Zhang, and Pamela Basto

A mile and a half from Uhuru Peak—The Roof of Africa—a merciless wind blew in icy gusts. In the pitch black hours before sunrise, the only sound was the panting of our team mates, struggling to suck a rare molecule of oxygen. Too exhausted to speak, we shared a collective thought: "How the hell did we get here?"

It all started at HST.100 Respiratory Pathophysiology, when Prof. Drazen notified us, "You have 48 hours to submit your writing assignment." One member of our group had an idea for her assignment. As is the case with many good ideas, it was the product of a near-tragedy. Two years prior, she was honeymooning on Kilimanjaro in Tanzania, Africa when her husband discovered—the hard way—how pulmonary and cerebral edema feel. After class that April night, we pieced together a plan to apply our new respiratory knowledge to Kilimanjaro, studying the physiology and risk factors of altitude sickness. Our HST.100 writing assignments were nowhere near finished, but our Kili 2010 research project had begun.

Our HST.100 professors were quick to offer their help and recruited their most adventurous friends to mentor us. The all-volunteer steering committee included Dr. Stuart Harris, Chief of the Division of Wilderness Medicine at MGH, Dr. Stephen Muza, Mountain Medicine Team Leader in the US Army, and Dr. Gary Strangman, Director of the Neural Systems Group at MGH. With their extensive knowledge and experience, they guided us in experimental design, provided specialized equipment, and obtained IRB approval. On July 30, 2010, following three months of planning, seven of us headed to Tanzania to carry out our study.

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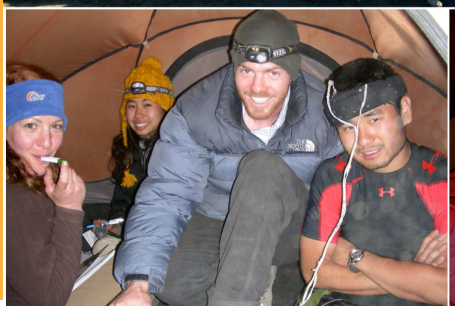
Daily experience on Kili. Top: 28 men catering for our every need. Bottom left: Braden measures Dafang's cerebral hemodynamics while Pam is taking Ally's vital signs. Bottom right: Erika does it all – NIN, EKG, temperature, SaO2. In the back of her head she's proving Fermat's Last Theorem.



(Kilimanjaro cont...)
Our study was designed to test the relative contributions of cerebral hemodynamic alterations, peripheral oxygenation, and sleep desaturation to acute mountain sickness (AMS). We self-monitored relevant physiological parameters associated with ascent and descent during a 6-day Machame Route ascent to 19,341 ft, 1-day descent and several days of recovery. We used near-infrared neuroimaging (NIN) to monitor cerebral hemodynamics, with daily measurements of a 22-minute standardized task battery (rest, serial sevens, Valsalva maneuvers, Mueller maneuvers, breath-hold, and CO2-rebreathing). EKG was monitored simultaneously. We continuously collected actigraphy and peripheral oxygen saturation (SaO2). During sleep, we measured movement, SaO2, breath rate, breath volume and EEG using the Alice PDx Portable Sleep System. Twice a day, we filled a qualitative questionnaire for the diagnosis of AMS (Lake Louise Questionnaire), and once a day we measured blood pressure, temperature, and urine pH. These measurements provide an unusually complete physiological profile of individuals during ascent, descent, and recovery.

Our schedule was demanding: climb all day, experiment half the night. The rest of the night, we tried to sleep while chained to recording devices, tickled by cannulas up our noses, and glued to our sleeping bags by the goo holding the EEG electrodes in place. We filled our days ogling amazing scenery, servicing our equipment and team mates, eating trail mix, brushing up on our Swahili, eating more trail mix, and amassing a repertoire of inside jokes. Our shared training in nearly all study aspects and logistics, and a strong collective desire to meet daily protocol goals, created a highly flexible and productive team able to adjust rapidly to the changing task demands.

At 6 a.m. on August 5, 2010, all seven of us—wearing our specialized HST Kili 2010 gear—reached Uhuru Peak. As we stood above Africa, overlooking the Kili glaciers (19341 ft), the view and our oxygen levels were breathtaking. Six days of climbing, five climate zones, four ibuprofen pills a day, three months of preparations, two feet and one HST course brought us to this moment. We are still analyzing our data, but one thing is clear: a follow-up study is in order – Himalaya here we come!