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Human Kinetics
BRIEF REPORT

On Top to the Top—Acclimatization Strategy for the "Fastest Known Time" to Mount Everest

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Purpose: To present the acclimatization strategy employed by an elite athlete prior to 2 successful ascents to Mount Everest (including a "fastest known time") in 1 wk. ***Methods:*** Training volume, training content, and altitude exposure were recorded daily. Vertical velocity was recorded by GPS (global positioning system) heart-rate monitor. ***Results:*** The subject first used a live high–train low and high preacclimatization method in normobaric hypoxia (NH). Daily, he combined sleeping in a hypoxic tent (total hours: ~260) and exercising "as usual" in normoxia but also in NH (altitude >6000 m: 30 h), including at high intensity. The hypoxic sessions were performed at the second threshold on treadmill in NH at 6000 m, and the pulse saturation increased from 70% to 85% over 1 mo. Then, the subject was progressively exposed to hypobaric hypoxia, first in the Alps and then in the Himalayas. On day 18, he reached for the second time an altitude >8000 m with the fastest vertical velocity (350 m/h) ever measured between 6300 and 8400 m. Afterward, he climbed twice in a week to the summit of Mount Everest (8848 m, including a "fastest known time" of 26.5 h from Rongbuk Monastery, 5100 m). ***Conclusion:*** Overall, this acclimatization was successful and in line with the most recent recommendations: first, using live high–train low and high, and second, using hypobaric hypoxia at increasing altitudes for a better translation of the NH benefits to hypobaric hypoxia. This case study reports the preparation for the most outstanding performance ever acheived at an extreme altitude.

Keywords: high-altitude, normobaric hypoxia, hypobaric hypoxia, acclimatization, mountaineering

Exposure to high altitudes (>2500 m) triggers a series of physiological responses including maladaptive responses that cause 3 forms of acute altitude illness: acute mountain sickness, high-altitude cerebral edema, and high-altitude pulmonary edema.[1] Slow ascent (<500 m/d above 2500 m)[1,2] and preacclimatization (ie, spending time in hypoxia before ascending to the target altitude, described as "staged ascent")[1] are generally recommended as effective preventive measures, by increasing the positive adaptations and/or decreasing the prevalence and severity of acute altitude illness.

Regarding the speed of ascent, beyond general recommendations, it is likely that due to the large interindividual variability in susceptibility to altitude illness, some individuals can tolerate faster ascents.[3] This point is poorly investigated, but contradictory to the common beliefs, intense aerobic training is not a protective factor because regular physical activity is positively associated to altitude illness.[2] Moreover, high value of maximal oxygen uptake is not a predictor of success in high-altitude expeditions.[4] One reason is that elite endurance athletes, even in sports practiced in altitude as ski mountaineering, present more severe desaturation during exercise in hypoxia than their lower level counterparts.[5] Therefore, these subjects with more pronounced hypoxemia and/or larger desaturation during exercise in hypoxia will be more prone to develop severe high altitude–related disorders.[2]

Regarding preacclimatization, several physiological differences have been reported between normobaric hypoxia (NH; "simulated altitude"; reduction of the inspired fraction of oxygen <20.93%) and hypobaric hypoxia (HH; "real altitude"; reduction of the barometric pressure),[6] and it is now well established that "*NH is not a complete surrogate to HH.*"[7] Although possibly providing minimal benefits for reduction in acute mountain sickness symptoms or ventilatory acclimatization,[8] it seems that NH preacclimatization strategy (eg, by using hypoxic tents) is less effective than HH.[8] Therefore, disentangling hypoxia and hypobaria is of importance for mountaineers who use NH to prepare for expeditions.[7]

Of interest is also the potential benefit of exercising in hypoxia during the preacclimatization. First, it was shown that high-intensity training in hypoxia (at the second ventilatory threshold and above) induces larger endurance performance enhancement and specific transcriptional muscle adaptations than the same training performed in normoxia.[9,10] Second, the combination of residence in NH and high-intensity hypoxic exercise induces large specific muscle adaptations not observed without the hypoxic exercise.[10] However, this LHTLH (Living High Training Low and High) method is not usual in mountaineering.

This case study aimed to report the acclimatization strategy performed by an elite athlete prior his successful attempts to Mount Everest and the most outstanding performance (uphill velocity) ever performed at extreme altitude.

Methods

Subject

The subject is an elite professional endurance athlete (age: 30 y, weight: 56 kg, and height: 172 cm) who practices ski mountaineering (7 × world champion, mainly in vertical race); sky running (5 × world champion); ultra-trail running (winner of Western State, 3 × Ultra-Trail du Mont-Blanc, 6 × Sierre-Zinal, and 4 × Hardrock 100 among others); and mountaineering (record of MontBlanc: 4 h 57 min, Cervin: 2 h 52 min, Denali: 11 h 40 min, and Aconcagua: 12 h 49 min among others). His maximal oxygen consumption was 92 mL/kg/min

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(measured on May 8, 2010, CAR Sant Cugat, Spain, using a cycle ergometer) with maximal heart rate (HR) = 199 beats·min^{-1} and maximal minute ventilation = 199 L/min. He has been training full time since he was 13 years and is self-coached since he was 17 years. His yearly training volume increased progressively from 600 hours in 2002 to 1140 hours in 2017, with 33% to 40% at moderate (2000–3000 m) altitude.[11]

Data Collection

He is recording his training volume and content daily in a homemade Excel (Microsoft Corp, Redmond, WA) log. His training sessions are also available online (http://www.movescount.com/members/member1018-kilianjornet) as he is using a global positioning system HR monitor (Spartan Ultra; Suunto, Vantaa, Finland). During the preacclimatization period prior traveling to the Himalayas, he used a hypoxic tent (Hypoxico, New York, NY) for sleeping and a mask system (Hypoxico) for indoor training in NH either on ergocycle or on treadmill. He measured his HR and finger pulse saturation (Oxypad Pro; Colson, Chicago, IL), and recorded the higher HR and lower saturation values. The saturation was measured during the high-intensity sessions and for 1 hour postexercise. It took about 1 hour to come back to the basal values of 98%, and the subject reported regularly "dizziness symptoms."

The training volumes/contents as well as the duration of NH or HH exposures were calculated from his training diary. The times and uphill velocities were calculated from his GPS online data.

Results

The details of the activity (running/mountaineering vs ski mountaineering), the duration, and the vertical elevation of the morning and afternoon sessions of each day are displayed in Figure 1.

Living at sea level, the subject used first a LHTLH preacclimatization method in NH. Daily, he combined sleeping in a hypoxic tent at increasing altitudes (total hours: ~260 h; altitude: 4000–5000 m), and his "usual" normoxic training combined with daily treadmill running in NH (total hours: ~90 h; altitude: 4000–6000 m) starting with low-intensity training (ie, altitude: 4000 m; 1 h at HR ~140 beats·min^{-1}; saturation: ~80%) and progressively increasing altitude (total hours >6000 m: 30 h) and intensity.

The high-intensity sessions were performed on treadmill in NH at 6000 m as follows: 10-minute warm-up at 10 km/h, 4 × (5 min at 15 km/h – 5 min at 10 km/h), 5 minutes at 10 km/h with a 15% slope, 5-minute cooldown. The relative intensity was self-estimated at 85% and 75% of maximal oxygen uptake for the 5-minute exercise and recovery intervals, respectively. The relative intensity was estimated at 65% to 70% for the aerobic running sessions. Pulse saturation measured was progressively increased from 70% to 85% over 1 month.

The subject started to use NH on February 25. He slept occasionally 2 to 3 times a week in his hypoxic tent during 1 month. Then, on March 24, he started to use NH on a daily basis: sleeping every night and exercising every day in hypoxia. Overall, in February–March, he slept 46 days in NH. NH was used

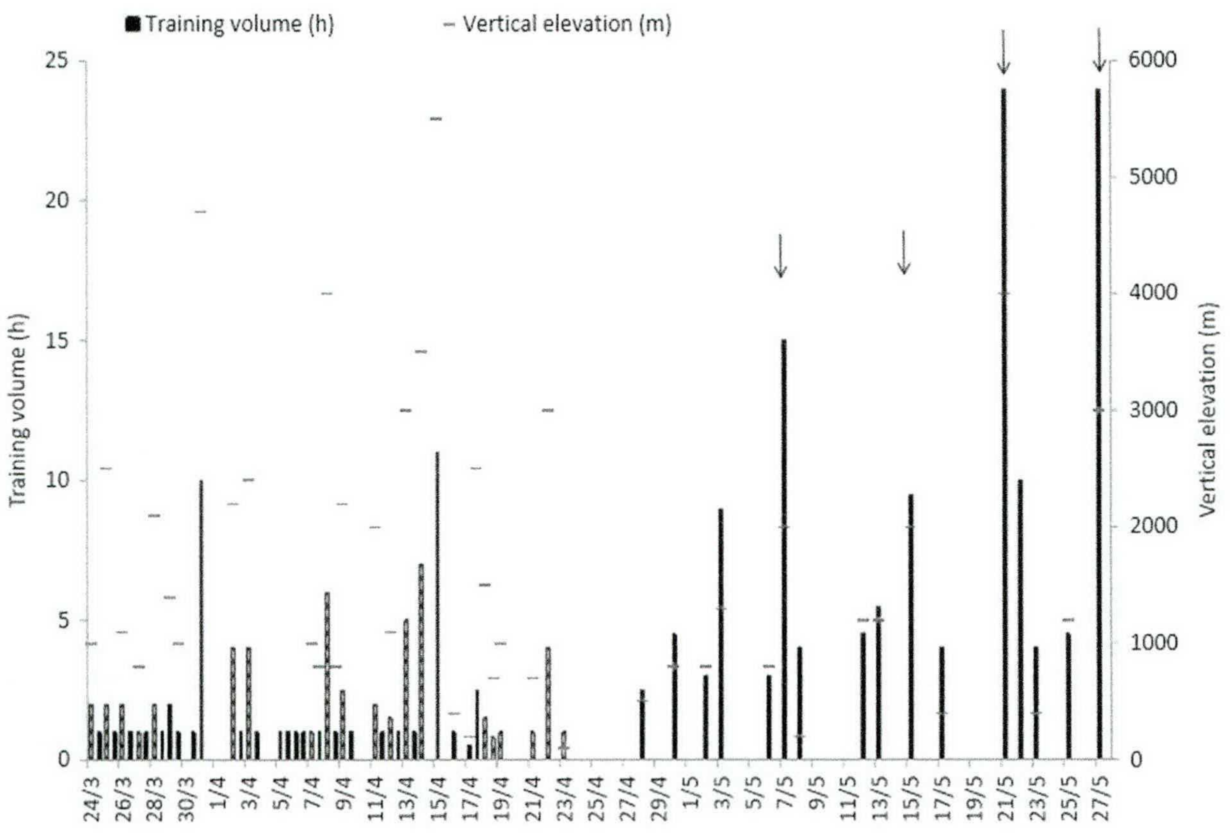

Figure 1 — Training duration (in hours), type of activity, and vertical elevation (in meters) of the morning and afternoon sessions during the last 2 months of the acclimatization period. Dashed bar indicates ski mountaineering; undashed bar, running/mountaineering. All 1-hour running sessions performed until April 17 were performed in normobaric hypoxia. After this date, all sessions were performed in hypobaric hypoxia. Arrows indicate 4 times when the subject reached an altitude above 8000 m.

for both sleeping and training until April 17. Between this date and his departure to the Himalayas on April 24, the subject moved to the Alps and used exclusively HH. He arrived on base camp at 5100 m on April 27.

During the last 4 weeks, the subject was progressively exposed to HH first in the Alps (100 h by adding sleeping and ski mountaineering up to 4200 m) and after in the Himalayas with the shortest delay as possible between exposure at 4000 m in the Alps and 5000 m in the Cho Oyu Mount Everest base camp. He reached an altitude of 7500 m after only 5 days in the Himalayas and reached an altitude >8000 m for the first time on May 7 (summit plateau of Cho Oyu, ~8200 m) after 10 days. All climbs in the Himalayas were performed without supplemental oxygen or fixed ropes.

On day 18 (May 15) in the Himalayas, he reached an altitude >8000 m (8400 m) for the second time with an average vertical velocity of 350 m/h for 6 hours between 6300 and 8400 m. His velocity between 8000 and 8400 m was >200 m/h (http://www.movescount.com/moves/move159296004#table-year=2018).

He climbed to summit of Mount Everest (8848 m) twice in a week (May 20, 2017 and May 27, 2017) including a record or "fastest known time," 26.5 hours, from Rongbuk Monastery, 5100 m. His velocity during these 2 days was lower than on May 15 due to gastrointestinal troubles on May 20 and due to the fatigue of the first summiting on May 27. For his first ascent to Mount Everest (May 20, 2017), the subject started from Rongbuk at 5100 m. The route is a long moraine for 20 km followed by snowy/icy slopes up to 40°. The ridge is 3 km long over 8400 m, with 3 technical sections that were climbed without the use of fixed ropes, except the second steep one with the use of the last of the 3 ladders. The subject did not use any fixed ropes or external help. In the second ascent (May 27, 2017), the route was exactly the same but starting from advanced based camp at 6300 m. The subject carried a 6- to 7-kg backpack, including 2 L of water and 5 to 10 energy gels. He was always climbing alone.

Discussion

This case study shows unique data of acclimatization of an elite athlete who reached 4 times altitude >8000 m in 20 days and performed the "fastest known time" to Mount Everest. These data are not comparable with previous studies because of the outstanding fitness level of the subject and the novelty of his approach in the traditional world of mountaineering.

Regarding his general training volume/content, it is of interest to emphasize 3 similarities between his training[11] and the data published on the world's most successful female cross-country skier (Marit Bjørgen, 15 × Olympic medals including 8 × Gold medals)[12]: a high annual training volume (1140 h for Kilian Jornet vs 940 h for Marit Bjorgen); a polarized training (75% vs 92% of training at low intensity), and an important training volume performed at 1800 to 3500 m altitude (40% vs 18–25%).

To our knowledge, this is the first report of acclimatization using both NH and HH and integrating high-intensity training in hypoxia. Only one report of preacclimatization with elite athletes is available[13]: After 1 week in the Alps at 4350 to 4807 m and 4 nights in the hypobaric chamber (38 h, progressively increased from 5000 to 8500 m), the subject reached 7800 m in just 5 days after leaving the base camp. This study, after the LHTLH preacclimatization, the subject needed only 5 days to reach 7500 m and 10 days to achieve the summit of Cho Oyu (8200 m). To our knowledge, this is the shortest period known in the Himalayas for an 8000-m summit. In addition, the use of hypoxic tent is more accessible than a hypobaric chamber for most of climbers who would like to replicate similar LHTLH strategy.

His average vertical velocity of ~350 m/h for 6 hours between 6300 and 8400 m on day 18 is, to our knowledge, the best performance ever measured in such extreme conditions and is another indicator of an efficient acclimatization. The environmental conditions (ie, snow, wind, temperature) affect to a large extent the way and velocity with which climbers move up, and therefore, it is difficult to compare performances in mountaineering. However, anecdotal reports on elite climbers at altitudes above 8000 m give the best vertical velocity values at 240 m/h (Andrzej Bargiel on Manaslu, September 25, 2014, between 4800 and 8163 m) or 250 m/h (Russell Brice on Cho Oyu, May 16, 1996, between 5400 and 8188 m).

KJ commented his acclimatization as follows: "In four weeks I have reached 4 times an altitude above 8000 m (8200, 8400, 8848 × 2) so it seems our acclimatization has worked."

Another point of interest is the use of high-intensity hypoxic training during the preacclimatization period. A previous study[13] reported only low-intensity exercise. This novel approach is in line with recent studies showing specific peripheral adaptations not observed with passive hypoxic exposure only.[10] However, because of the extraordinary characteristics of the athlete, it might be very difficult (if not impossible) to reproduce such program. Therefore, this should be considered as a limitation to the external validity (generalizability) of the present results. Further research on the usefulness of this LHTLH strategy is required.

Some limitations have to be acknowledged. There is no report of saturation or HR during the different climbs above 8000 m. The subject tried to be as light as possible and chose not to lose time to record these data in such extreme conditions. To date, except laboratory studies in hypobaric chamber as Mount Everest II or Mount Everest III, there are very few physiological measurements at altitude >7000 m and none measured in elite mountaineers.

Practical Application

Altogether, the performance data reported above testify for acclimatization extremely efficient. Combining NH and HH appears therefore as a practical strategy, more accessible than using a hypobaric chamber. It is impossible to postulate on the effects of a strategy that would use only NH exposure prior traveling to the base camp, but the literature suggests that a HH component is necessary for a better translation of the very low transfer of the benefits induced by the NH acclimatization to the HH condition.[7,8]

Conclusion

By reporting the acclimatization strategy employed by an elite mountaineer during the 4 months prior 2 successful ascents to summit of Mount Everest without supplemental oxygen or fixed ropes in 1 week (including a "fastest known time"), this case study emphasizes that this acclimatization was successful, innovative, and in line with the most recent recommendations: first, using LHTLH (ie, sleeping in NH and exercising in both normoxic and NH, including at high intensity for preacclimatization) and second, using HH at increasing altitudes during the final part of the preparation for a better translation of the NH benefits to extreme HH conditions. This case study reports the most outstanding performance ever performed at these extreme altitudes and opens door for further investigation.

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