

Assessment of hypoxemia while climbing Mount Kilimanjaro (5895 m)*



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*Progress-report from a Dissertation with the working title „Ausmaß der Hypoxämie bei der Besteigung des Mount Kilimandscharo (5895 m)“ by Thomas Orlovius, supervised by Prof. Dr. med. Markus Tannheimer



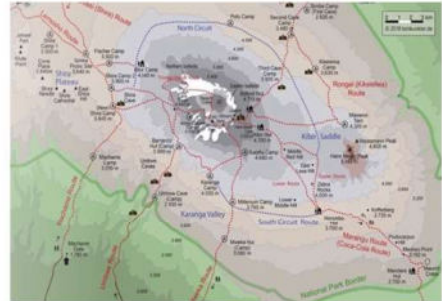
Mount Kilimanjaro (5895 m) (19,341 ft)

- Tallest freestanding Mountain in the world
- 4th topographical dominance worldwide
- 4th in prominence worldwide
- Part of the Seven Summits as Africa's tallest mountain
- Highest point 5895 m on Uhuru Peak as the summit of Kibo
- Kilimanjaro National Park (KINAPA) under UNESCO protection since 1973



Mount Kilimanjaro (5895 m) (19,341 ft)

- Ideal conditions for trekking
 - Climate
 - Geographical/Geological features
 - Wide well prepared hiking paths
 - Camps with huts/shelters
- Several routes to reach the summit
- 45.000-50.000 trekkers annually



Acute Mountain Sickness on Mount Kilimanjaro

- Summit success rate 30-88% depending on study, route, ascend profile and success criteria
- Incidence of AMS 52-86% (Lake Louise Score)
- Symptoms reported by > 90%
- Annually 8-10 deaths on Mount Kilimanjaro
- Common routes show elevation gain of up to 1000 m per day
- Protective factors:
 - Slower ascend profile / Extra acclimatisation day
 - Use of acetazolamide
 - High altitude experience/ porters / prior acclimatisation

1,2,3,4,5,6



- Lack of comparability to other alpine regions
- Lack of data on the hypoxemia for a regular ascend on Mount Kilimanjaro

Assessment of hypoxemia while climbing Mount Kilimanjaro (5895 m) - Methods

- Study population: Travel group of five men (age 25-43)
- 6-Day Trekking along Marangu-Route with an acclimatization day at 3720 m
 - Group travelled with guide, porters, cook
 - Daypack for trekking
 - Nights spend in Huts in the Camps along the Marangu-route



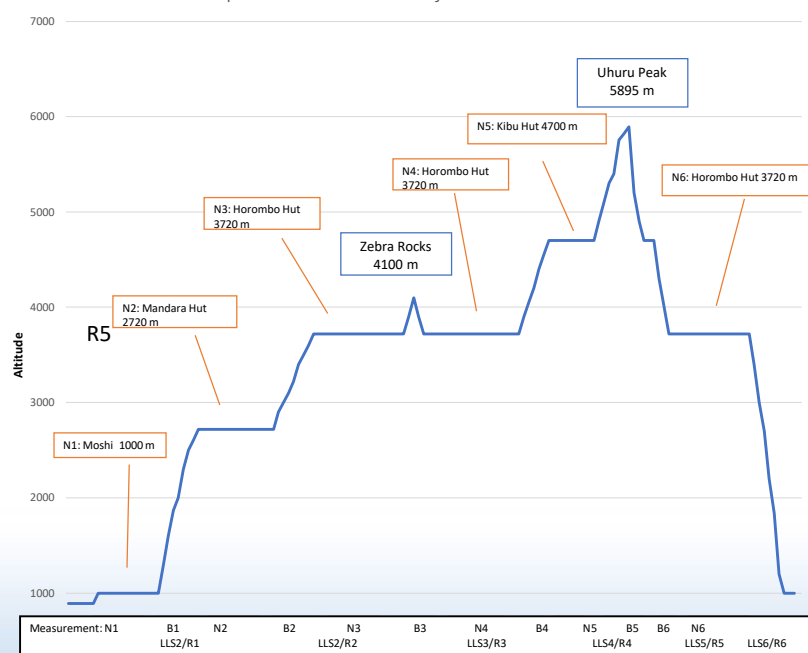
Primary Data:

- Continuous SpO₂-measurement (every 4s) during trekking and while at sleep

Additional Data:

- "Conventional" SpO₂-measurements in the morning at rest (2min.)
- Daily LLS-Score before Trekking
- Daily Journal entries (Symptoms, Sleep, Disturbances, Medication)

Ascendprofile Mount Kilimanjaro and measurement-intervalls



Assessment of hypoxemia while climbing Mount Kilimanjaro (5895 m) – Data & Statistics

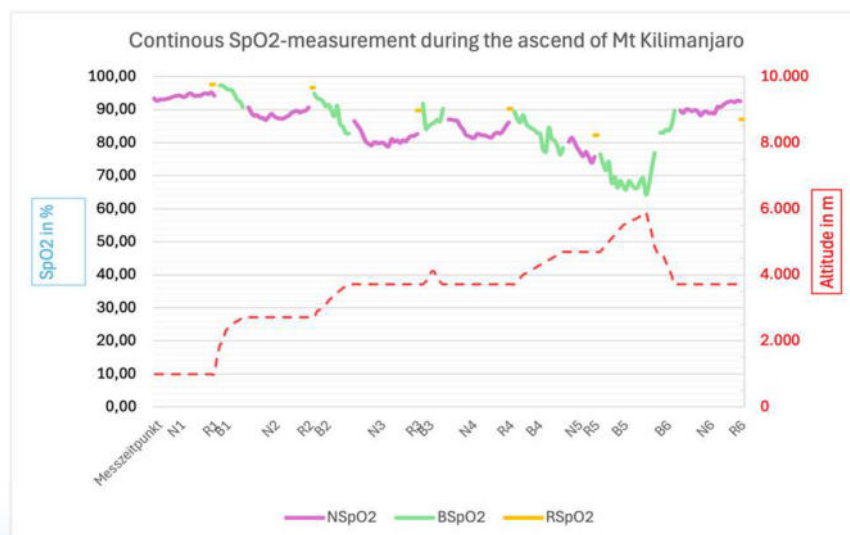
Datamanagement

- Datasets:
 - All five Participants completed all measurements (P_1 - P_5)
 - Six sleep measurements (N_1 - N_6)
 - Six Trekking measurements (B_1 - B_6)
 - Five 2-Minute Measurements at rest (R_1 - R_6)
- Datapoints: 359.327 SpO_2 -measurements
- Errors/Errormanagement
 - 14.830 Recorded Errors (Value 500) were excluded (4,13%)
 - 3.728 (1,03%) Measurements excluded after outlieranalysis

Statistics

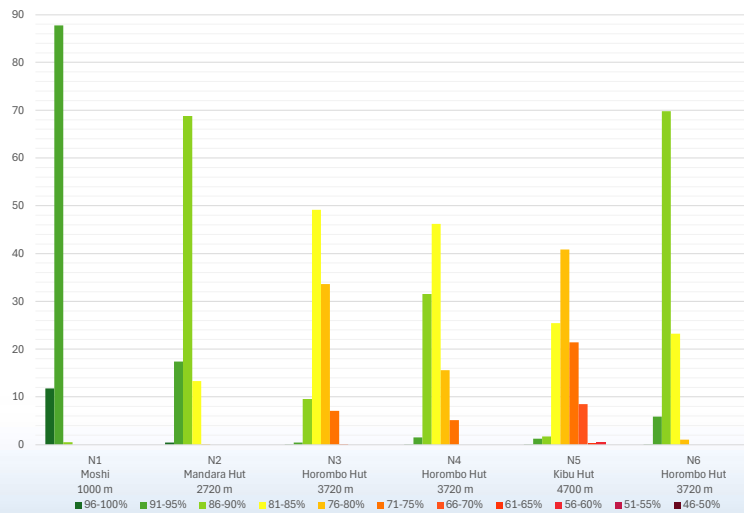
- Descriptive statistics and analysis of SpO_2 -measurements
- Graphical depiction of linear SpO_2 -progress and cumulative data
- Quantitative and qualitative analysis of Lake Louise Score & Journal entries
- Statistical comparisons:
 - Nights spent at same altitude
 - Night-measurements vs. Rest-measurement at same altitude

Assessment of hypoxemia while climbing Mount Kilimanjaro (5895 m) – Results



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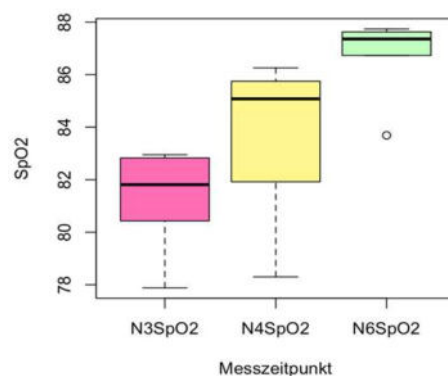
Sleep-Measurements



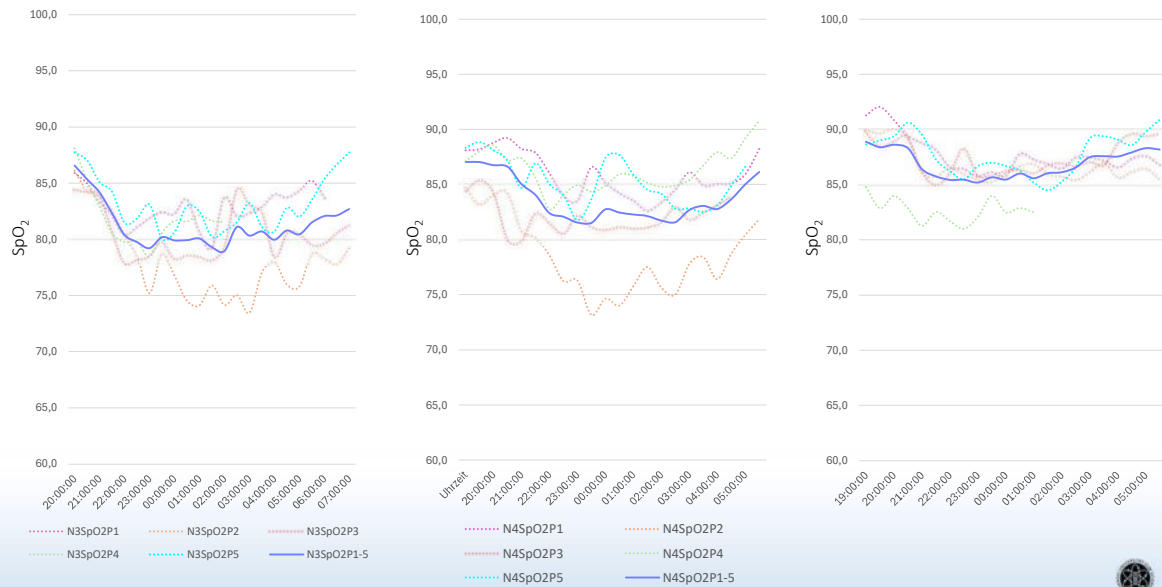
| | N ₁ | N ₂ | N ₃ | N ₄ | N ₅ | N ₆ |
|--------------------------------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Altitude | 1000 m | 2720 m | 3720 m | 3720 m | 4700 m | 3720 m |
| Mean N _i SpO ₂ | 93,7% | 88,5% | 81,2% | 83,5% | 77,6% | 86,6% |
| SD | 1,3 % | 2,4 % | 3,7 % | 4,1 % | 5,1 % | 2,5 % |
| minSpO ₂ | 83% / 99% | 71% / 98% | 68% / 97% | 68% / 97% | 56% / 96% | 75% / 97% |
| maxSpO ₂ | | | | | | |

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Nights spent at Horombu (Hut 3720 m)

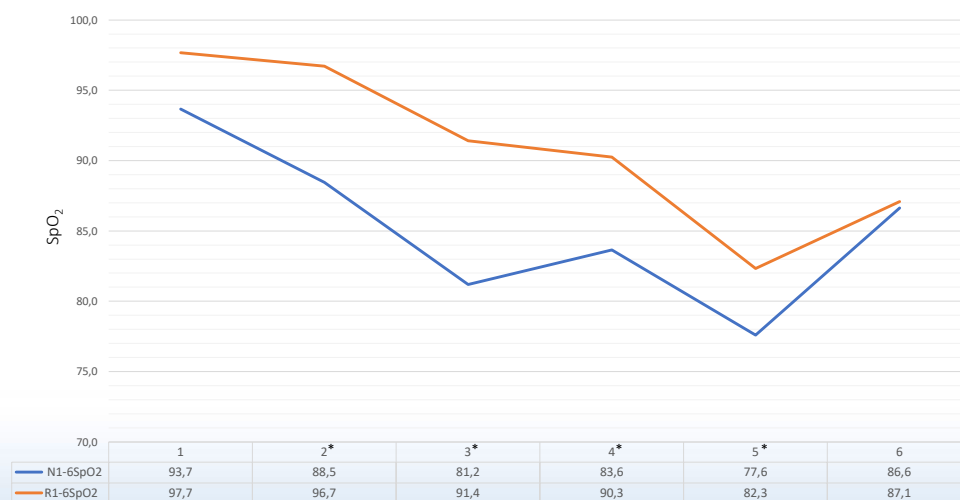


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Comparison of Sleep and Rest-measurements

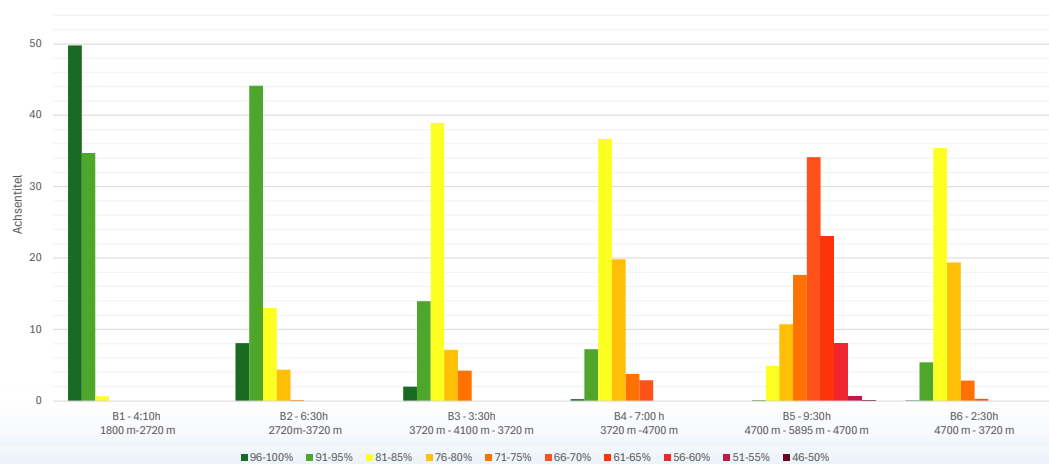


Assessment of hypoxemia while climbing Mount Kilimanjaro (5895 m) – Results

Trekking-measurements

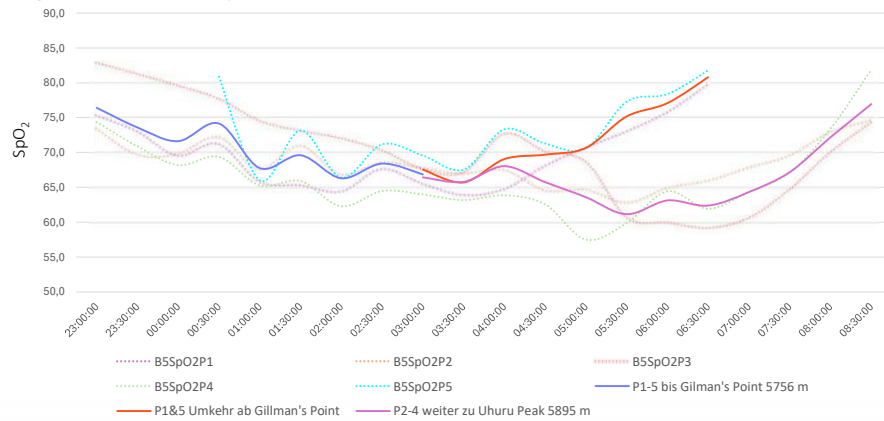
| | B1 | B2 | B3 | B4 | B5 | B6 |
|---|-----------------------|----------------------|---|----------------------|---------------------------------|----------------------|
| Start (Altitude) | Marangu Gate (1800 m) | Mandara Hut (2720 m) | Horombu Hut (3720 m) | Horombu Hut (3720 m) | Kibo Hut (4700 m) | Kibo Hut (4700 m) |
| Destination (Altitude)/ Endpoint | Mandara Hut (2720 m) | Horombu Hut (3720 m) | Zebra Rocks (4100m) Horombu Hut (3720 m) | Kibo Hut (4700 m) | Uhuru Peak (5895 m) | Horombu Hut (3720 m) |
| Duration in h:min | 4:10 | 6:30 | 3:30 | 7:00 | 9:40 | 3:00 |
| Altitude-gain | 920 m | 1000m | 380m | 980 m | 1195 m | -980 m |
| VAM (hm/h) | 221 hm/h | 154 hm/h | 190 hm/h | 140 hm/h | 180 hm/h | |
| Distance in km | 7,7 km | 12,7 km | 4,1 km | 9,5 km | 4,7 km ascend 4,7 km descend | 9,5 km descend |
| Mean (SpO ₂) | 94,6 | 89,9 | 86,3 | 83,4 | 68,8 | 84,0 |
| SD | 3,4 | 4,6 | 4,6 | 5,3 | 6,6 | 4,5 |
| minSpO ₂ / maxSpO ₂ | 81% / 100 % | 74% / 99% | 70% / 98% | 65% / 98% | 47% / 93% | 68% / 95% |
| Mean (Puls) | 115 | 115 | 110 | 108 | 124 | 117 |
| (+/- SD) | (+/- 18) | (+/- 16) | (+/- 17) | (+/- 17) | (+/- 15) | (+/- 13) |

Assessment of hypoxemia while climbing Mount Kilimanjaro (5895 m) – Results



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SpO₂ during the Summit attempt:



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| | LLS ₁ | LLS ₂ | LLS ₃ | LLS ₄ | LLS ₅ | LLS ₆ |
|----------|------------------|------------------|------------------|------------------|------------------|------------------|
| Location | Moshi | Mandara Hut | Horombo Hut | Horombo Hut | Kibo Hut | Horombo Hut |
| Altitude | 1035 m | 2750 m | 3700 m | 3700 m | 4700 m | 3700 m |
| P1 | 0 | 0 | 0 | 0 | 1 [#] | 0 |
| P2 | 1 | 4 [*] | 3 [*] | 2 | 6 [*] | x |
| P3 | 0 | 0 | 1 | 0 | 1 | 0 |
| P4 | 0 | 0 | 1 | 1 | 2 | 0 |
| P5 | 1 | 2 | 4 [*] | 0 | 3 [#] | 0 |

* Met LLS-Criteria for Acute Mountain Sickness

[#] No summit success, Return at Gilman's Point

Assessment of hypoxemia while climbing Mount Kilimanjaro (5895 m) – Discussion



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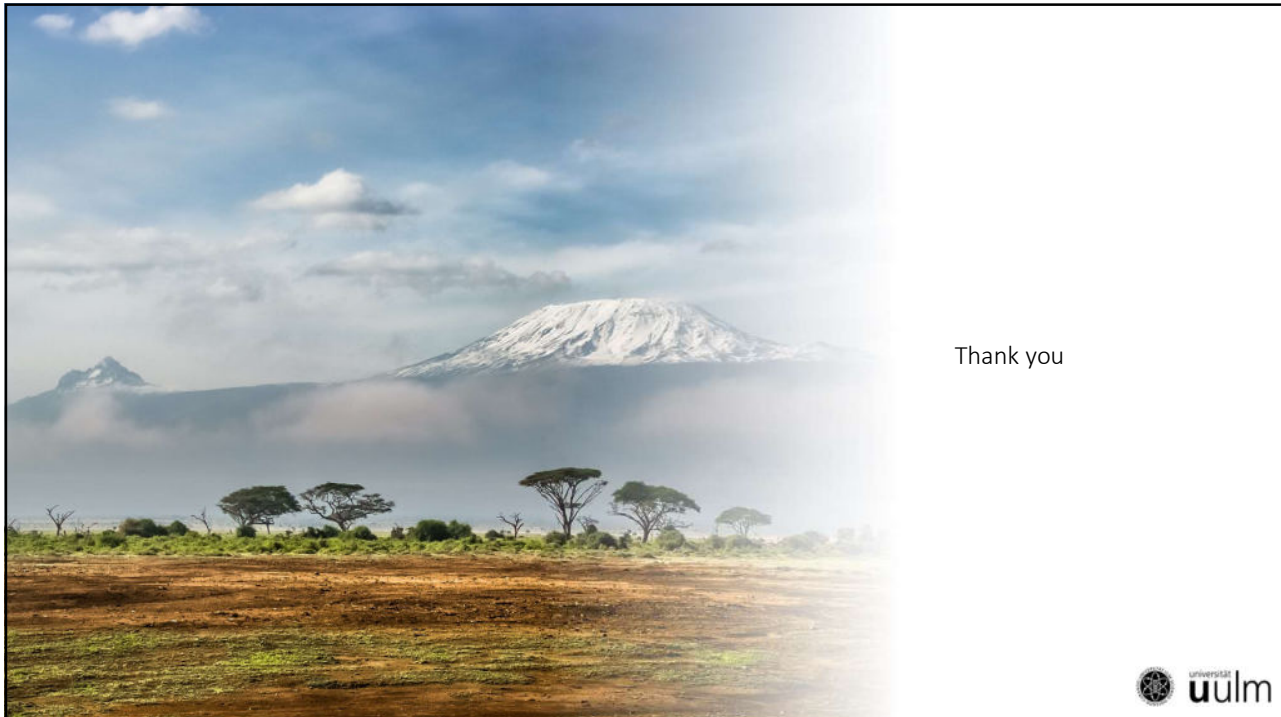


Sample Size

Large Datasets, additional benefits
from continuous data?

Measurements at rest,
overestimation of acclimatization?

Timing of LLS-questionnaire and
validity for rapid ascends?



Thank you



Sources

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⁴Karinen H., Peltonen J., Tikkanen H.: Prevalence of acute mountain sickness among Finnish trekkers on Mount Kilimanjaro, Tanzania: an observational study. *High Alt Med Biol* 9: 301-306 (2008)

⁵Lawrence James S., Reid Stephen A.: Risk Determinants of Acute Mountain Sickness and Summit Success on a 6-Day Ascent of Mount Kilimanjaro (5895 m). *Wilderness & Environmental Medicine* 27: 78-84 (2016)

⁶Meyer J.: Twice-daily assessment of trekkers on Kilimanjaro's Machame route to evaluate the incidence and time-course of acute mountain sickness. *High Alt Med Biol* 13: 281-284 (2012)

Pictures:

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²<https://www.namibia-forum.ch/forum/158-diverses/29962-29-lodge-tage-im-norden-von-tanzania-gnus-satt.html?start=90>

³https://www.google.com/maps/place/Kilimandscharo/@-3.1143254,37.2747737,11.36z/data=!4m6!3m5!1s0x1839fc5a396ea805:0x8e741c478eea6c0118m2!3d-.067424714d37.3556273!16zL20vMDE1MTN?entry=ttu&g_ep=EgoyMDI1MDxhNy4wKXMDSoASAFQAw%3D%3D

⁴<https://www.climbing-kilimanjaro.com/uhuru-peak/>

⁵<https://www.nonin.com/products/palmsat-2500/>

