EFFECTS OF AN ACUTE EXPOSURE TO SIMULATED OR REAL ALTITUDE ON ORGAN TRANSPLANT RECIPIENTS: THE “MONTE ROSA” PROJECT

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Tranplant recipients and Physical Exercise

Exercise training appears to be beneficial for patients BEFORE and AFTER lung transplantation

Waiting list times can average 326 days in the UK
it is important to maintain functional capacity and prevent further physical deterioration in patients

Hume, 2020, Eur Respir Rev

Tranplant recipients and Physical Exercise

Recommendations for Exercise in Adult Solid Organ Tranplant Recipients

- Exercise training improves maximal exercise capacity, lower extremity muscle strength, and health-related quality of life in lung, heart, kidney, and liver recipients

- Exercise training in the **posttransplant** phase is safe and should consist of **aerobic training or combined aerobic plus resistance training**. To obtain benefits early or late posttransplant, exercise training should be of a **moderate-to vigorous intensity level, 3–5 times a week for a minimum of 8 weeks**.

- Early posttransplant (1–6 mo) and/or in case of medical instability, exercise programs should be supervised and can be offered in an outpatient setting or at home.

- Late posttransplant (>6 mo), structured exercise programs, or physical activities can be unsupervised and offered at home or in private fitness centers.

Janaudis-Ferreira, 2019, Transplantation

Effects of high altitude

Therapeutic Use of Exercising in Hypoxia

Millet GP, 2016; Hobbins, 2017; Kim 2021; Jung 2021

Residency at high (better moderate) altitudes is associated with lower mortality from cardiovascular diseases, stroke and certain types of cancer

Burtscher M, 2013; Burtscher J 2021

Why high altitude?

1) studying the effects of hypoxia, similar to different pathology

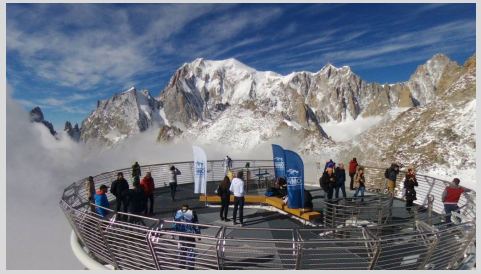
2) WHO reports 35 mln people/year @>3000 m asl
3) Estimated more than 100 mln people/year @>2500 m asl

(Netzer et al., 2013)

“Progressive” hypoxia

Balance, safety and exercise tolerance at acute high-altitude exposure in patient

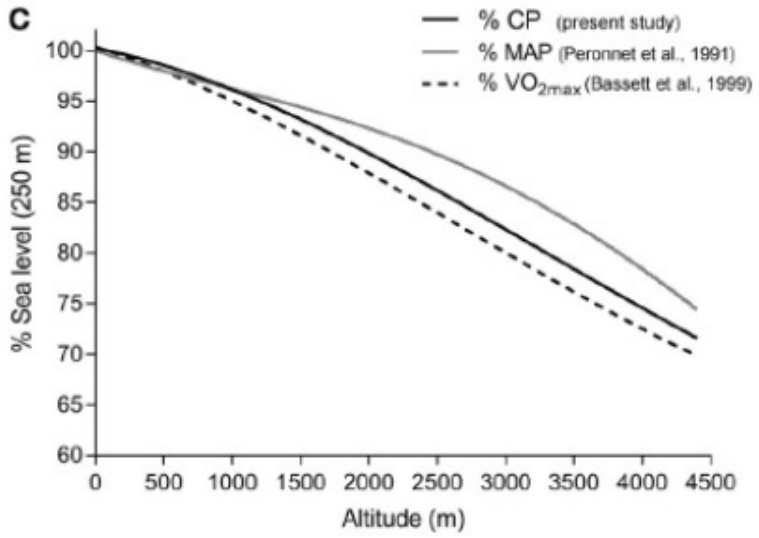
(Bruyneel et al., 2017; Schmid et al., 2006; Schmid et al., 2015)

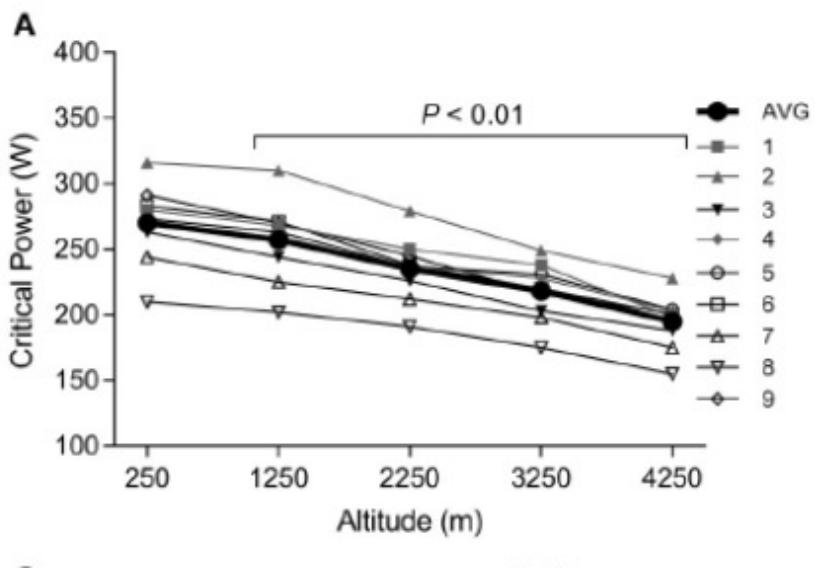


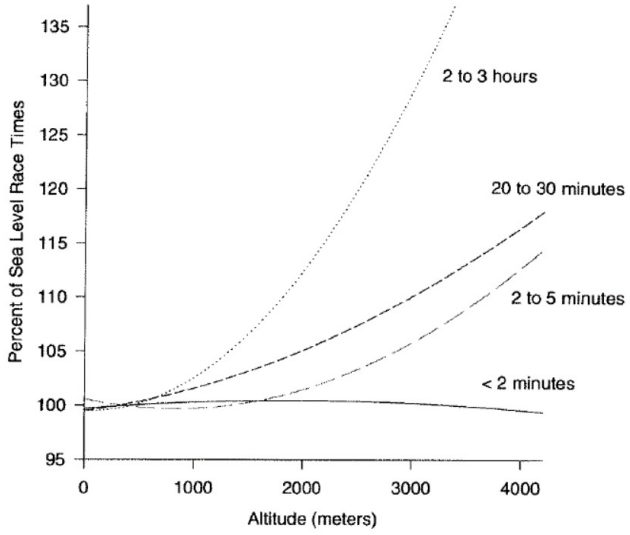
Passive gain of altitude	Climb uphill Speed (m/s)	
Schmid et al., 2006; 3.5h from Bern 540 m to Jungfraujoch 3454m public transport => patients	0.23	
1546 m -3000 (col du Pillon, Glacier 3000m) by cable car	1.63	
20 min 1035 to 3842 (Chamonix - Aiguille du Midi) by cable car	2.34	
8 min from 2,356 m to 3,555 m (Tenerife Mt Teide) by cable car	2.50	
Loeb Pike's Peak **by car**	2.99	
4 minutes 1300m-2200m (Pontal d'Entrèves - Pavillon du Mont Fréty) by cable car	3.75	← 13500 m/h
5 min 2200m- 3466m (Pavillon du Mont Fréty - Punta Helbronner) by cable car	4.22	
Zhang, 2015 - Lab	6.00	

Active gain of altitude	Climb uphill Speed (m/s)	
Record Kilian Jornet - Advanced base camp to Everest	0.04	
Red Fox Elbrus	0.25	← 900 m/h
Re Stelvio - by bike	0.40	
Red Bull K3 - record - Anthamatten - Rocciamelone 3538 m asl	0.40	
VK 100 athletes time	0.42	
VK world record - Philip Goetsch	0.58	← 2088 m/h!!!!

Effects of high altitude exposure on physical exercise



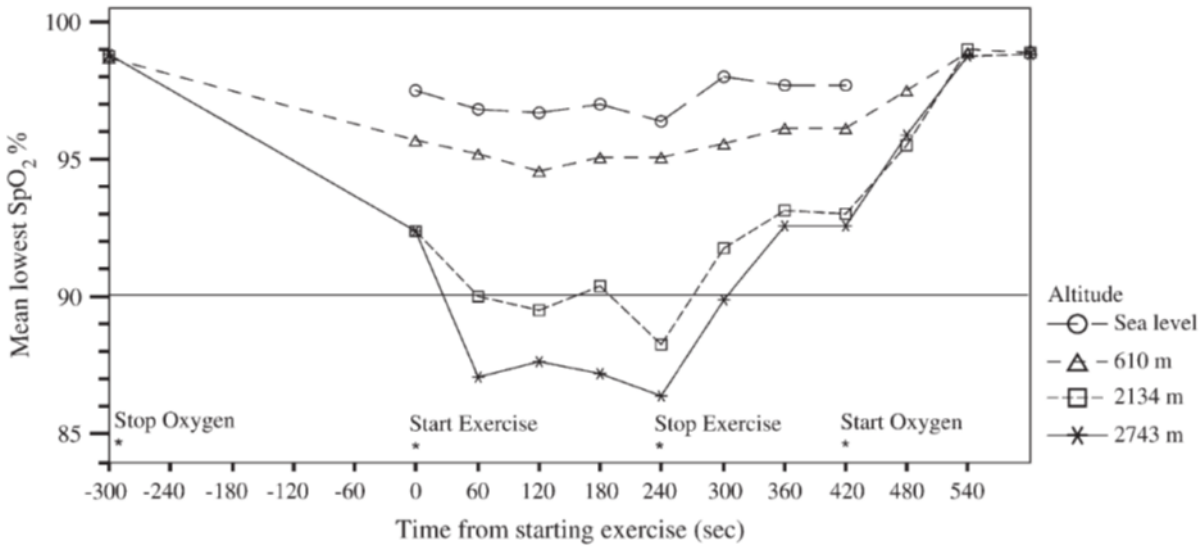




Townsend, 2017

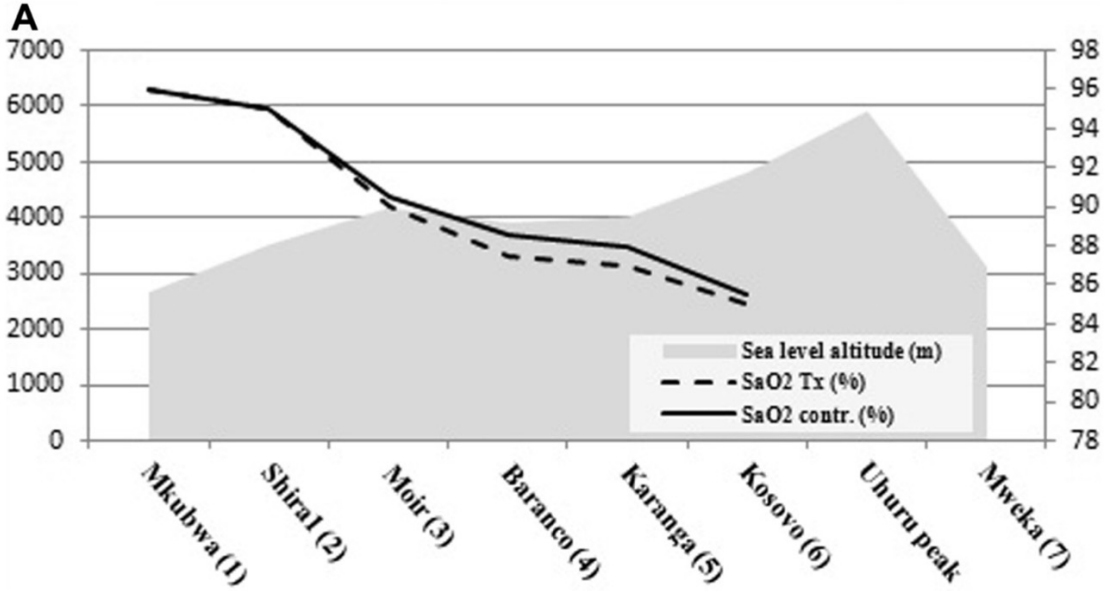
Effects of hypoxia and exercise on SpO_2

Typical SpO_2 response at 3048 m asl



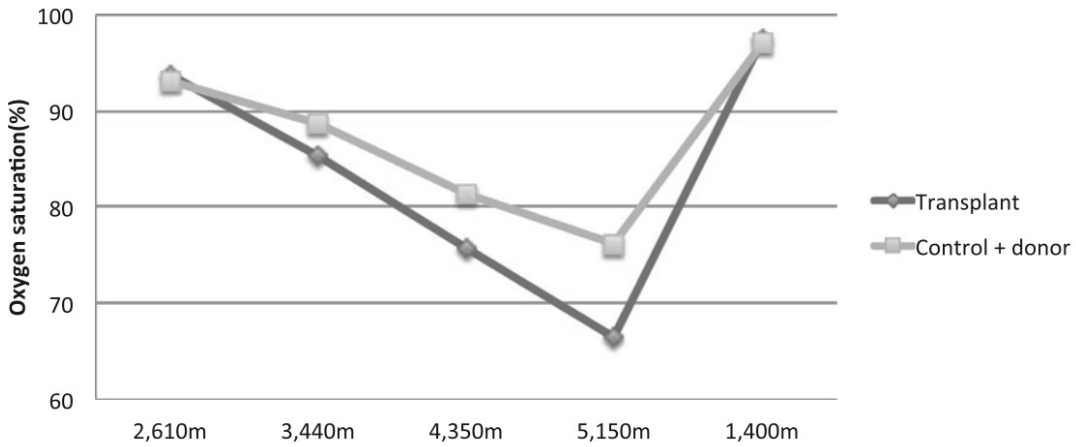
Smith, 2007

Tranplant recipients and high altitude



Lung Transplant Patients on Kilimanjaro

Gieszer, 2019, Transplantation



Tranplsant patients and live donors on Island Peak

Suh, 2015, Clin Transplant

Aim

Can we provide some evidence predicting the feasibility of a high altitude trek?

How physical performance and cardiopulmonary parameters of transplant recipients change during both real and simulated acute exposure to high altitude?

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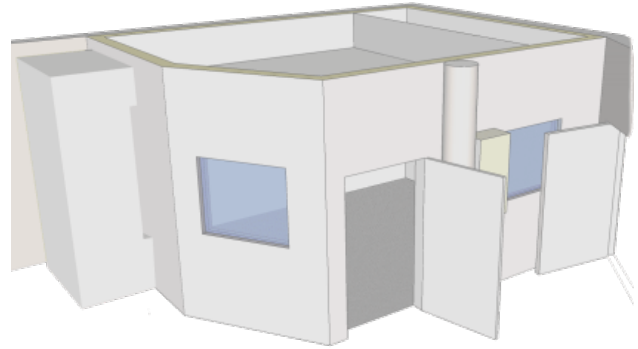
research center - Rovereto (TN) CeRiSM sport mountain health

Methods

5 subjects (3 F, 2 M)

4 transplant (3 lung and 1 kidney) recipients
1 cystic fibrosis patient

	Age (y)	Weight (kg)	Height (cm)
mean	41.1	63.5	166.7
s.d.	7.0	4.0	5.5



Acute Mountain Sickness susceptibility

rate of ascent, preexposure and **individual susceptibility** are the major, independent determinants for prevalence of AMS

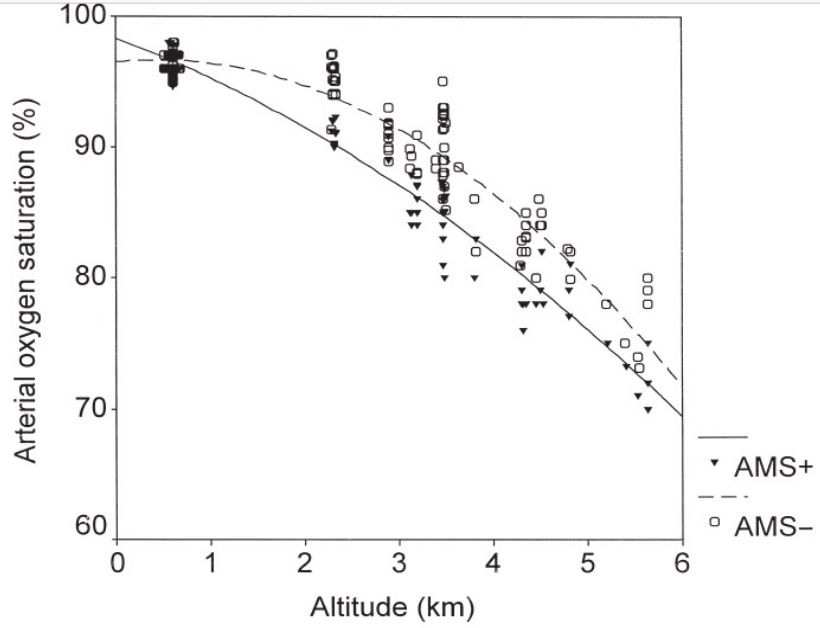
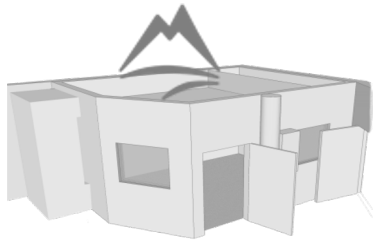
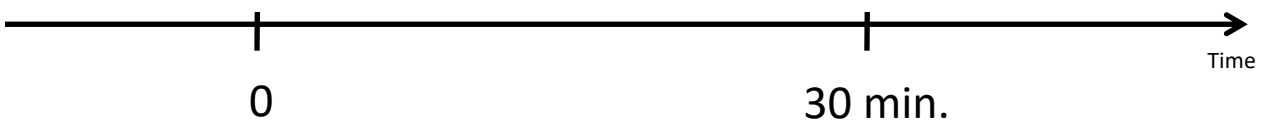


FIG. 1. Altitude-dependent Sa_{O_2} values in AMS-susceptible (AMS+) and nonsusceptible (AMS−) subjects.
Regression equation for AMS+: $Sa_{O_2} = 98.34 - 2.72alt - 0.35alt^2$ ($R^2 = 0.96$)
Regression equation for AMS−: $Sa_{O_2} = 96.51 + 0.68alt - 0.80alt^2$ ($R^2 = 0.92$)
Sa_{O_2}, arterial oxygen saturation (%); alt, altitude (km).

Burtscher M, 2008

FiO2 range 12.1%-12.9% (3827-4333 m)





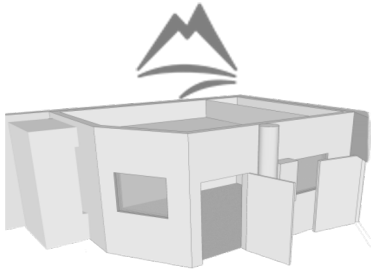
SpO2 drop in 30 min acute exposure

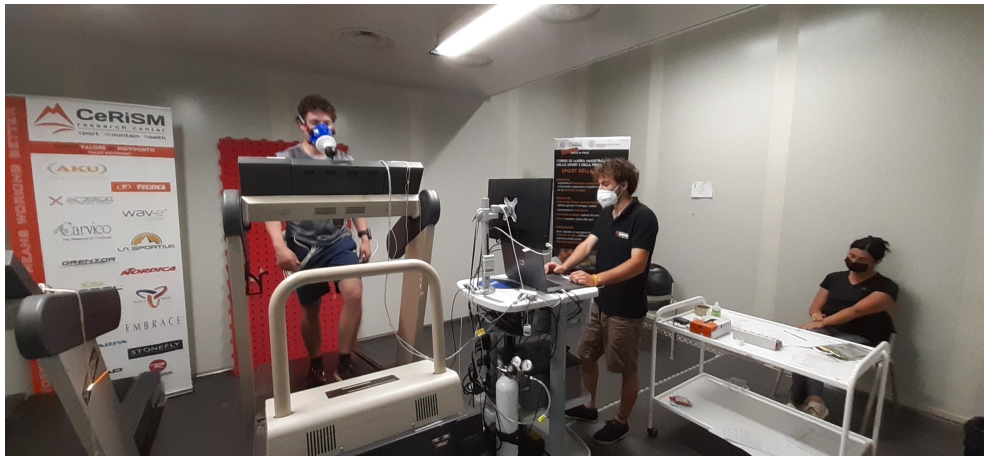
Physical performance and cardiopulmonary parameters

CPET Normoxia and Hypoxia (FiO_2 0.12%)

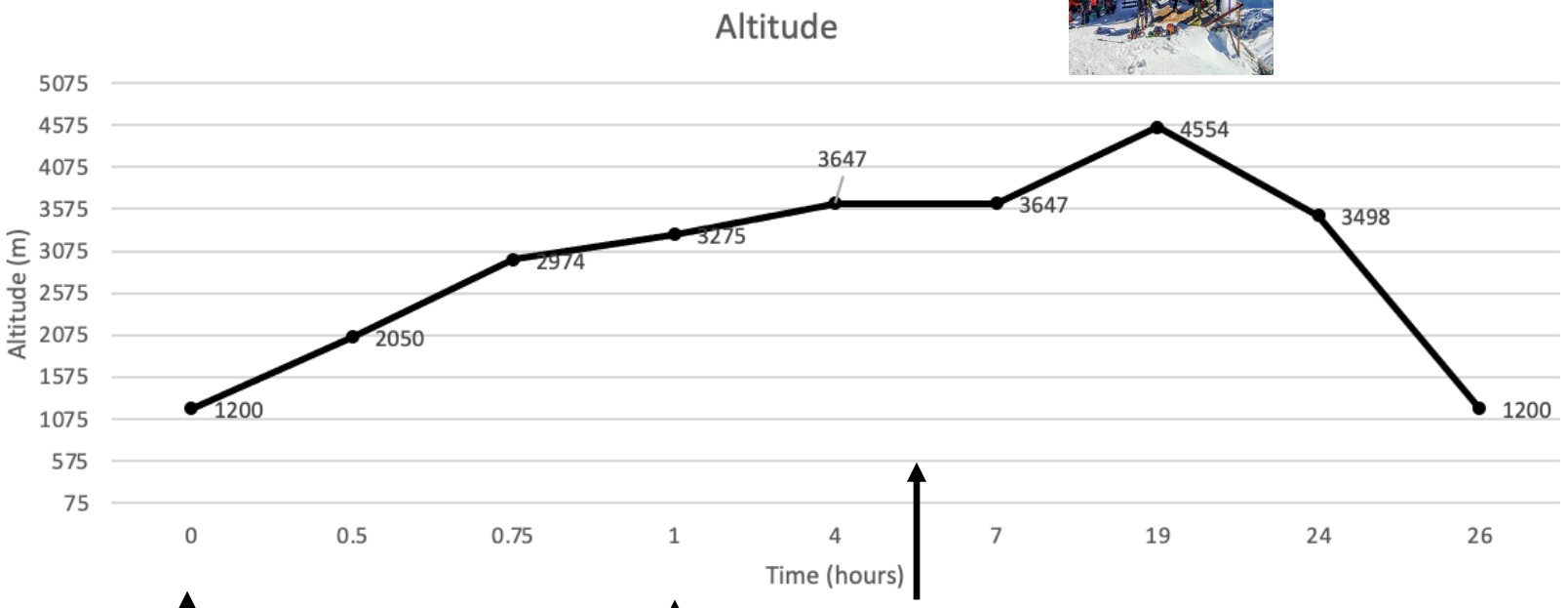
25% slope

+0.5 km/h (3' step) ⟶ -VO_2
-RPE
-La^-
-SpO_2





Real altitude trek: Monte Rosa ascent



Alagna

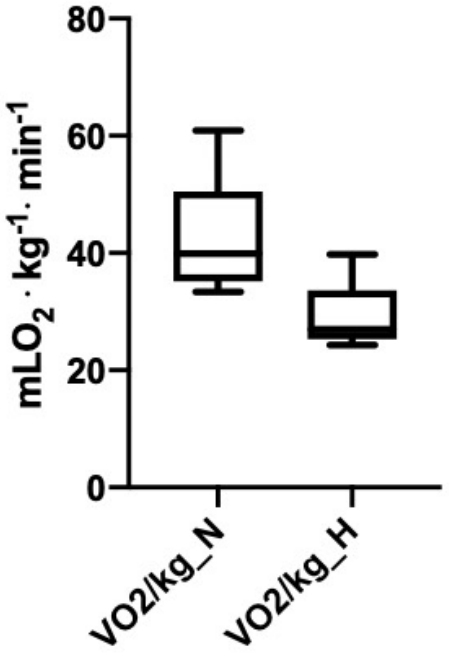
Indrent

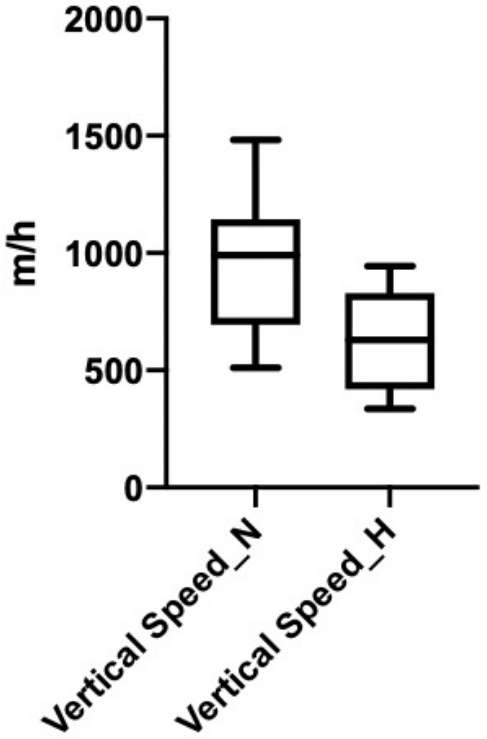
Results: Acute Mountain Sickness susceptibility in trasplant recipients

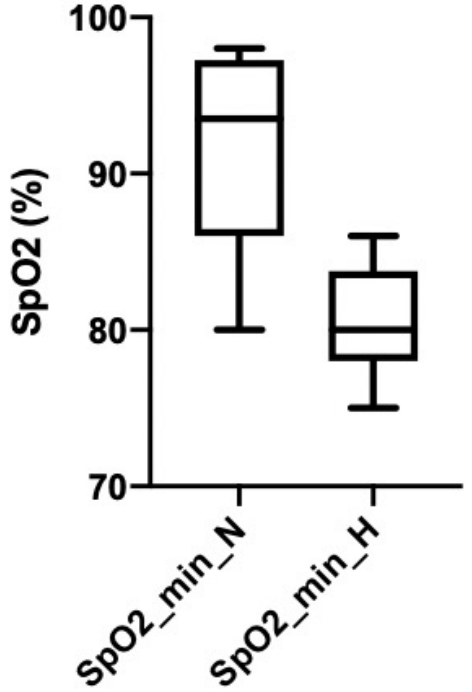
FiO_2 range 12.1%-12.9% (3827-4333 m)					
	SpO_2 after 30 min (%)	FiO2 (%)	Simulated Altitude (m)	AMS +	AMS -
C.S.	79	12.9	3827	83	87
T.A.	90	12.7	3950	82	87
L.V.	87	12.8	3888	82	87
Z.G.	80	12.3	4204	81	85
D.M.	83	12.4	4139	81	86

Individual susceptibility, rate of ascent, and preexposure are the major, independent determinants for prevalence of AMS

Results: Physical performance and cardiopulmonary parameters





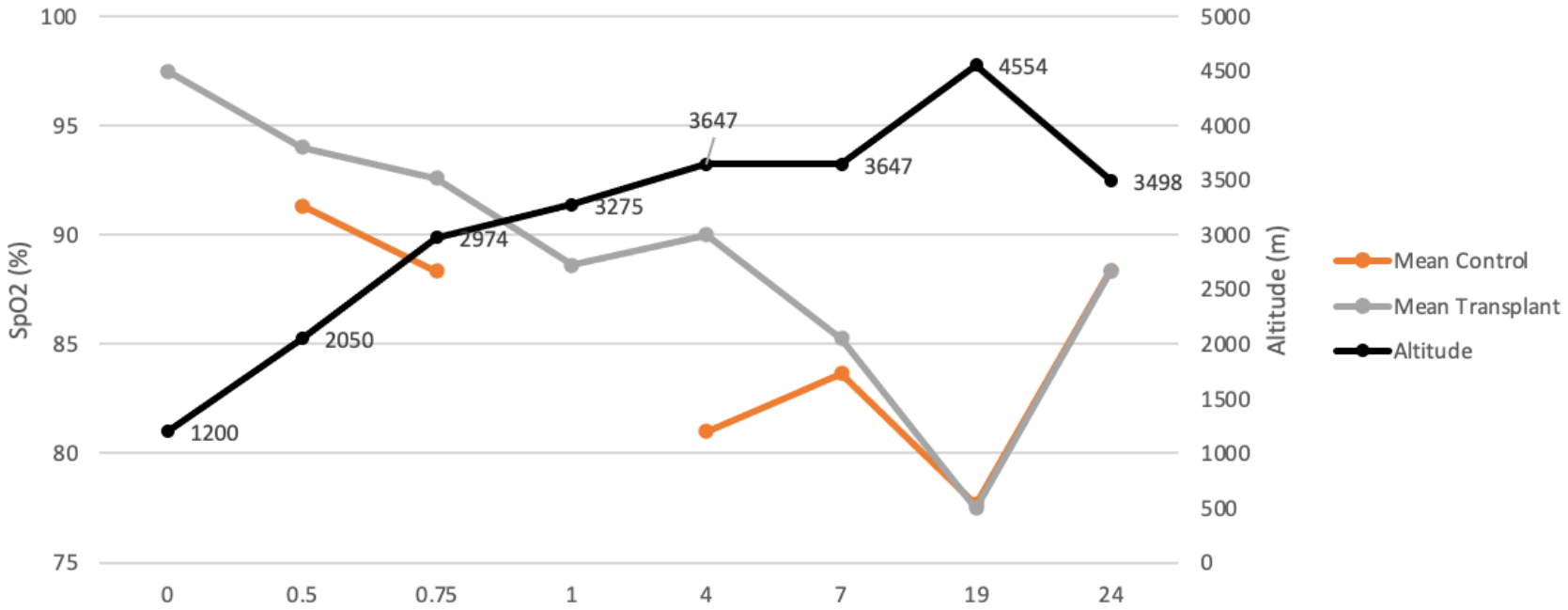


-45% P<0.01 ES 1.6

-54% P<0.01 ES 1.5

-14% P<0.01 ES 1.9

Results: SpO2 during the real altitude trek

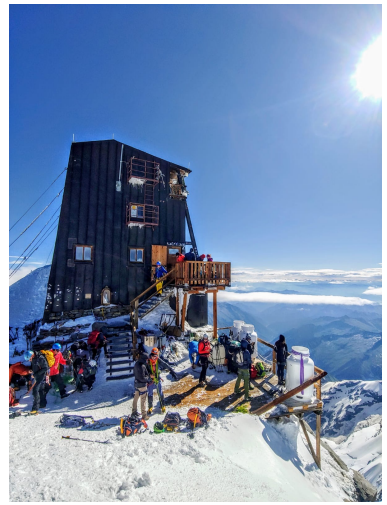


Summit attempt/success

5 subjects (3 F, 2 M)

4 transplant (3 lung and 1 kidney) recipients
1 cystic fibrosis patient

2 x



fitness level?

3 x
AMS+

	SpO_2 after 30 min (%)
C.S.	79
T.A.	90
L.V.	87
Z.G.	80
D.M.	83

3 x

Conclusion

CPET and performance in hypoxia decreased more than in NON tranplant recipients

VO2peak -45% VS *hypotetical* -24%

Contrary to other studies on transplant recipients with longer time of adaptations to high altitude, **we observed a lower rate of success during a two-days expedition**

We can speculate that **a stable patient** with cystic fibrosis or after an organ transplantation **IF PROPERLY TRAINED can achieve high altitude even with an ACUTE EXPOSURE**

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Grazie!

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