MEDEX 2015: Is fitness important for an individual's performance and health at altitude?

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Introduction

High altitude illness, poor exercise capacity, and fatigue present major risk factors for injury and fatality at altitude (Firth *et al*., 2008; Oliver *et al*., 2012).

Greater sea level fitness may increase altitude exercise capacity but also increase acute mountain sickness (AMS).

The influence of hypoxic sensitivity (cardiac, ventilatory, and arterial oxygen saturation responses to acute hypoxia) on altitude exercise capacity and AMS is also unclear.

Determining these relationships is necessary before fitness assessment can be recommended to appraise individuals' readiness for altitude.

Aims

1) To determine the effect of sea level fitness (VO_{2max}) on altitude exercise capacity and AMS during chronic altitude exposure.

2) To investigate the role of physiological responses to acute and chronic hypoxia in exercise capacity and AMS during chronic altitude exposure.

Methods

Forty-four trekkers, 26 men and 18 women (mean ± SD: age 39 ± 14 yr, body mass 69.0 ± 14.5 kg, height 172 ± 10 cm, $\dot{V}O_{2max}$, 45 ± 8 mL·min-1·kg-1) from the MEDEX Manaslu trek volunteered for this cohort observational study that received ethical approval from the North West Wales Research Ethics Committee. All volunteers provided written informed consent.

Participants completed a loaded walking test to determine fitness ($\dot{V}O_{2max}$). A hypoxic exercise test (FiO_2 = 0.112) was then used to determine hypoxic sensitivity.

One month later participants completed a three-week trek to 5085m, with AMS recorded daily.

Exercise capacity was determined by three tests: rating of perceived exertion (RPE) on ascent to 5085m (RPE_{ascent}), RPE on a fixed workload step test at 5085m (RPE_{fixed}), and self-selected stepping rate at 5085m.

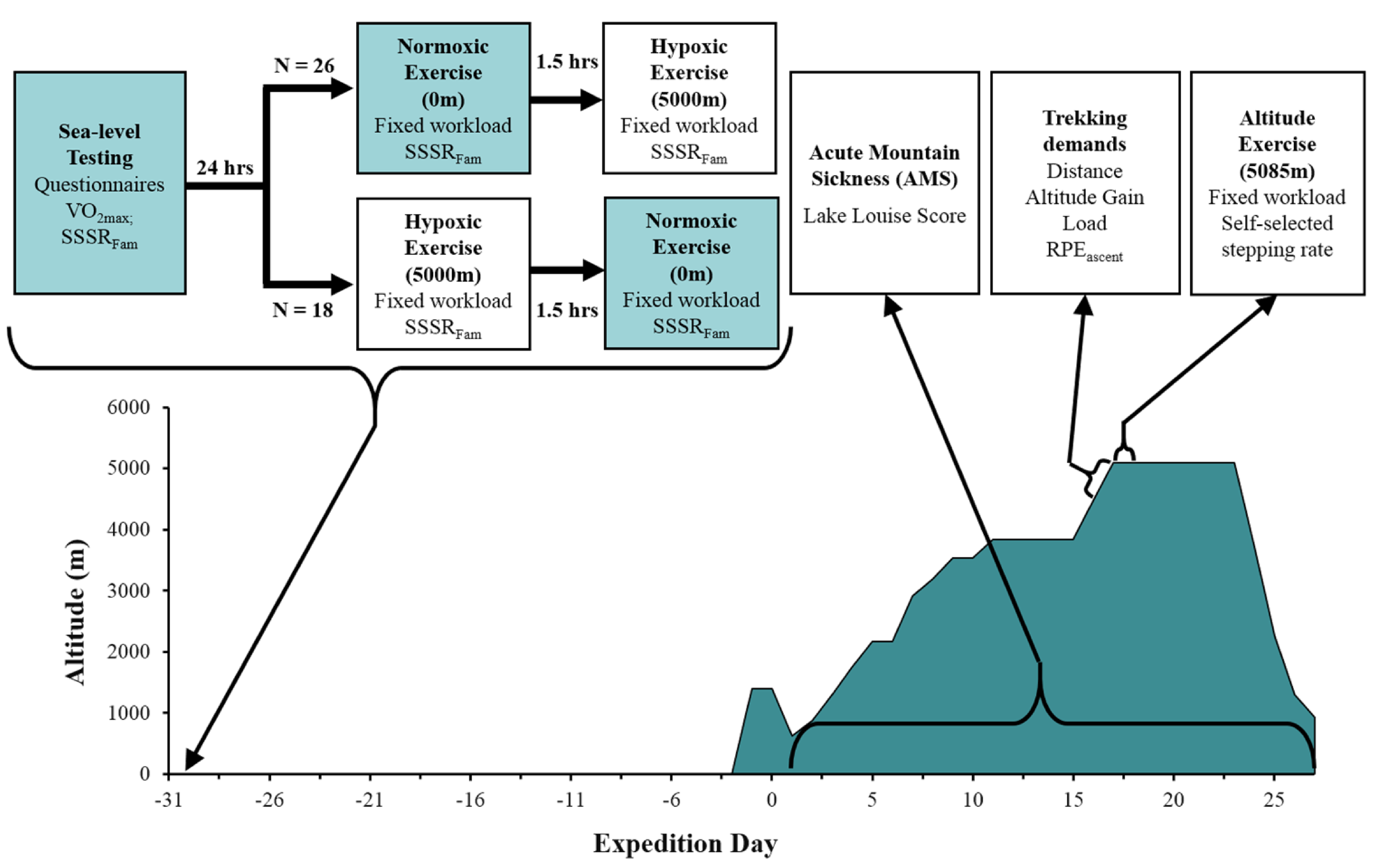


Figure 1. Schematic representation of study protocol. Coloured boxes indicate procedures undertaken in normoxia, white boxes indicate procedures undertaken in hypoxia. $SSSR_{Fam}$, Self-selected stepping rate test familiarization; LLS, Lake Louise Score; Load, External load for the trekking session (kg); RPE_{ascent}, Rating of perceived exertion on ascent to base camp.

Results

Figure 2. Relationship between sea level fitness ($\dot{V}O_{2max}$) and exercise capacity at altitude. Greater sea level fitness was associated with reduced (A) RPE at a fixed workload (RPE_{fixed}; r=-0.69; p<0.001) and (B) Session RPE from ascent to base camp (RPE_{ascent}; r=-0.43; p=0.005), and greater (C) Self-selected stepping rate (r=0.62; p<0.001).

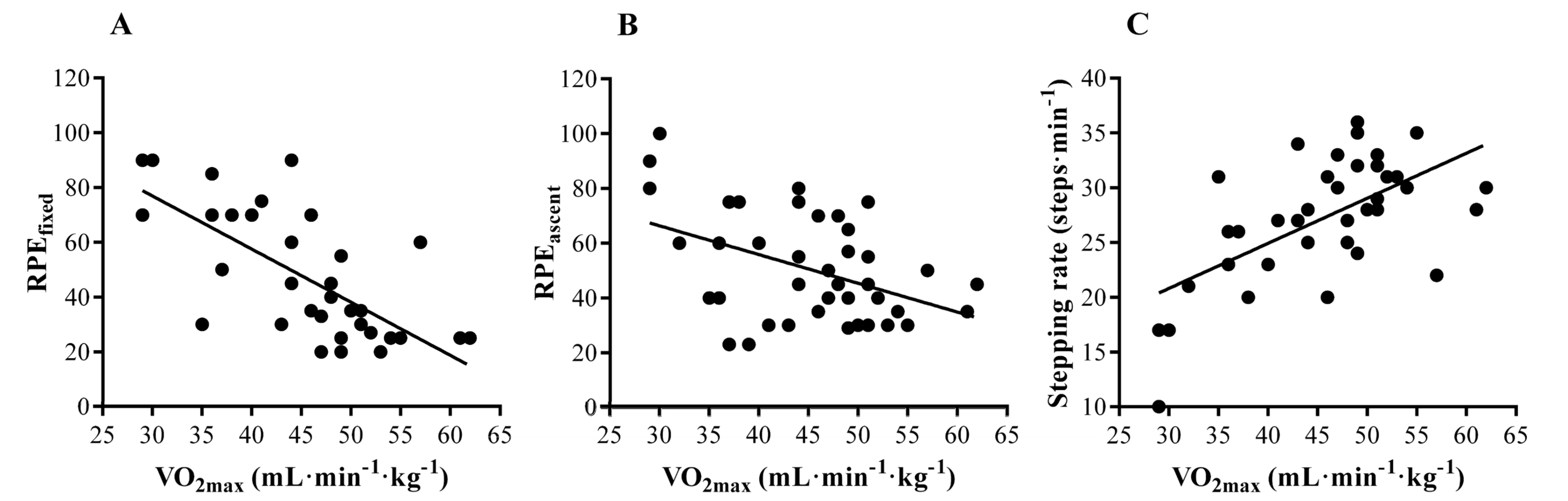


Figure 3. Sea level fitness ($\dot{V}O_{2max}$) was not related to (A) Percent of trekking days with clinically defined AMS (r=0.13; p=0.41), (B) Peak AMS score (r=-0.05; p=0.74), or (C) Oxygen saturation during fixed workload step test (SpO_2e; r=0.07; p=0.67).

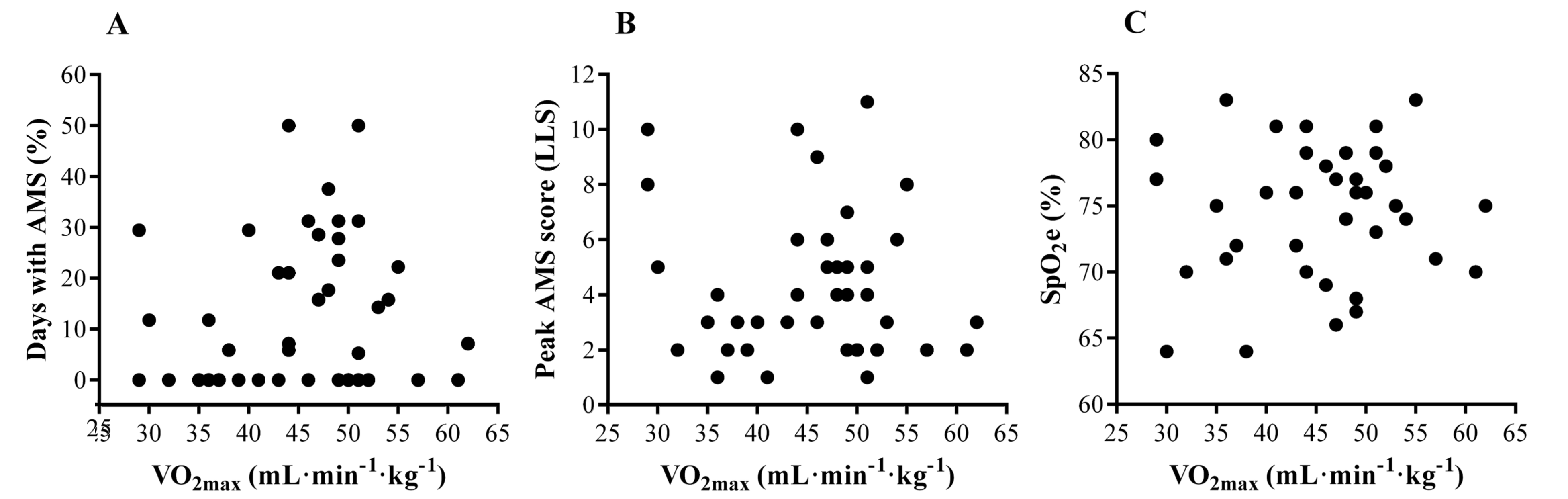
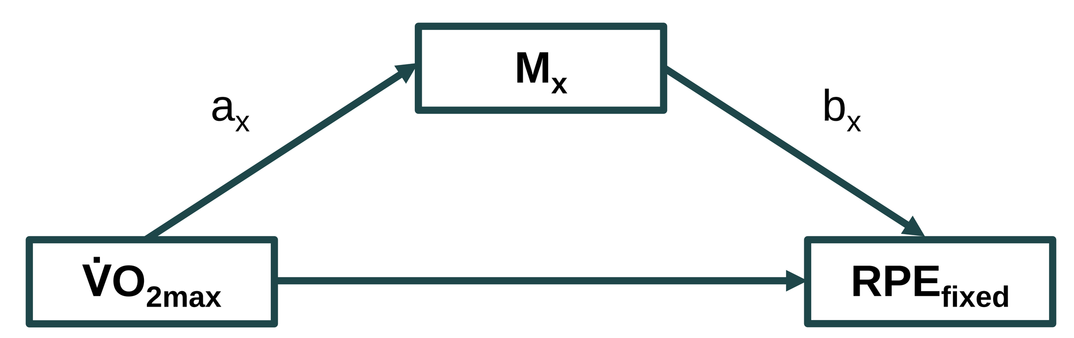


Table 1. Mediation analysis summary for acute normobaric hypoxia and chronic high altitude cardiac and ventilatory parameters.

Values are standardized regression coefficients and 95% confidence intervals (lower limit; upper limit) for direct effects of $\dot{V}O_{2max}$ on mediators (a_x), direct effects of mediators on RPE_{fixed} (b_x), and indirect effects of $\dot{V}O_{2max}$ on RPE_{fixed} through mediators (ab_x). *p < 0.05; **p < 0.01.



Variable (M_x)	a_x ($\dot{V}O_{2max} \rightarrow M_x$)	b_x ($M_x \rightarrow RPE_{fixed}$)	Indirect effect (ab_x)
Acute normobaric hypoxia			
Hypoxic ventilatory response	-0.27 (-0.58; 0.04)	0.21 (-0.07; 0.49)	-0.06 (-0.25; 0.01)
Hypoxic cardiac response	0.37 (0.06; 0.69)*	-0.05 (-0.34; 0.23)	-0.02 (-0.18; 0.08)
Chronic high altitude exposure			
Ventilatory reserve	0.85 (0.60; 1.10)**	-0.29 (-0.72; 0.13)	-0.25 (-0.55; 0.33)
Ventilatory efficiency	0.59 (0.25; 0.93)**	-0.14 (-0.46; 0.18)	-0.08 (-0.28; 0.11)
Chronic change in heart rate	0.42 (0.12; 0.72)*	-0.23 (-0.51; 0.05)	-0.10 (-0.32; 0.00)

Conclusions

This study provides the first empirical evidence that greater sea level fitness is related to superior exercise capacity at altitude without exacerbating AMS.

Individuals with high sea level fitness maintained SpO_2 equal to less fit individuals despite a higher absolute workload. This was accompanied by an elevated heart rate response and a lower ventilatory response to acute hypoxia and chronic altitude exposure.

Given that poor exercise capacity and fatigue are major risk factors for injury and fatality at altitude, sea level fitness assessment should be considered as part of the screening process to appraise an individual's readiness to perform at altitude.

References

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