



MOUNT EVEREST FOUNDATION

Patron: HRH The Duke of Edinburgh KG KT



BRITISH MOUNTAINEERING COUNCIL

Final Report

Widening participation for children; understanding cardiopulmonary and cerebrovascular acclimatisation to high altitude

Expedition Leader/Organiser: Dr Mike Stembridge

Address: Cardiff Metropolitan University, Cyncoed Road, Cardiff, CF23 6XD

Telephone number: 07977 440839

e-mail address: mstembridge@cardiffmet.ac.uk

Country/Region: White Mountain Research Station, CA, USA

Names of all expedition members, indicating leader, climbing members, and support:

- Dr Mike Stembridge (33) UK – Principle Investigator, Reader in Cardiovascular and Environmental Physiology
- Dr Joseph Donnelly (31) – New Zealand – Collaborator, Senior Lecturer in Anaesthesiology
- Dr Ali McManus (48) Canada, UK – Collaborator, Professor Paediatric Exercise Science
- Prof. Philip Ainslie (44) – Canada, UK – Collaborator, Professor Cerebrovascular Physiology

Original objective(s) of expedition:

The [Union Internationale des Associations d'Alpinisme \(UIAA\)](#) medical commission [consensus statement](#) proposes that high-altitude travel is safe for children >14 weeks old (Meijer & Jean, 2008). However, guidelines for safe daily ascent rates (i.e. 300-500 meters a day) have been based solely on adult trekkers, and the commission acknowledges that there are no scientific data to support safe ascents in children. Our objective is to investigate ventilatory, cardiac, pulmonary, and cerebrovascular acclimatization to high altitude in children. The findings will help travellers, guides and doctors understand acclimatization in children, and identify considerations and precautions for families planning trips to high-altitude.

Overall dates of expedition:

Fieldwork start date: August 1, 2019

Fieldwork end date: August 11, 2019

Location(s):

Baseline data collection was conducted at University of California Irvine before the expedition team travelled to Crooked Creek Station (3050 m) for two nights. The researchers then ascended to The Barcroft Laboratory and established the field laboratory, before being joined by the remainder of the expedition party. The group resided at The Barcroft for 5 nights and performed daily hikes to keep active including to the summit of Mt Barcroft and White Mountain.

Outline of expedition

A total of 26 people participated in the expedition, including 12 children, accompanied by one or both parents, and seven research scientists. The expedition team consisted of members from around the globe, including the UK, Canada and the US. The first stage of scientific work was completed in collaboration with Professor Dan Cooper at the University of California, Irvine. Here, baseline testing of all 12 children and their parents was completed over the course of two days, before the expedition team departed on the 9-hour drive to the Crooked Creek station at 3090 m above sea level. The first day after arrival, full physiological assessments were completed including brain blood flow, pulmonary pressure, cardiac function and peripheral blood vessel function. These tests were further complimented by cognitive assessments and tests of exercise capacity. Whilst the majority of the expedition team spent two nights at Crooked Creek, members of the scientific team ascended to the Barcroft Laboratory at 3800 m to establish the laboratory at the higher station. The main group when ascended the additional 710 m and spent the next 5 nights at The Barcroft facility. Whilst there, physiological testing was completed on alternate days to map the acclimatisation response in the children and their parents.



A careful balance was struck between the scientific testing and more enjoyable mountain activities to maintain the children's engagement with the programme of work. Two members of the expedition acted as activity leaders, and led daily hikes to local peaks and nature trails in the surrounding areas. Some of the older children were also able to ascend to the summit of White Mountain (4342 m) along with their parents and members of the research team to take in the views over the Sierra Nevada. After five nights at The Barcroft Station, the team descended back to Orange County where they stayed for one further night before departing to their respective destinations.



Preliminary Results

As with all scientific expeditions of this nature, an enormous amount of data was captured to maximise the knowledge learnt whilst in the field. The research team are currently making their way through the ultrasound images of each of the components of the cardiovascular system assessed, and we are pleased to share the first conference abstract we had published earlier this year as part of the Okanagan Cardiorespiratory Symposium:

High altitude travel is becoming increasingly popular with families, yet the impact of altitude on cerebrovascular exercise responses in children is unknown. Children have elevated resting cerebral blood velocity (CBFv) compared to adults and altered sensitivities to changes in arterial oxygen and carbon dioxide in comparison to adults. The purpose was to compare cerebrovascular responses to exercise in children and adults at 3800m elevation. 10 children (7-14years) and 10 sex-matched adults (23-44 years) performed a graded exercise test to exhaustion on the 4th day of acclimatization at White Mountain Research Center. Peripheral oxygen saturation (SPO₂), PETCO₂, PETO₂, and blood velocities (middle (MCAv) and posterior (PCAv) cerebral arteries) were continuously monitored. At ventilatory threshold, MCAv increased to a greater extent in adults (+23% vs +12% above baseline, $P=0.01$) and remained elevated compared to children at peak exercise (18% vs 4.9%, $P=0.047$). A similar trend was observed in the PCA, however significant child-adult differences were only evident at peak exercise (+17.4% in adults vs. +3.7% in children, $P=0.035$). PETCO₂ was below baseline during peak exercise in children (-5mmHg, $P<0.01$) and adults (-6.5mmHg, $P<0.001$) and a

significant positive linear relation between ΔPETCO_2 and ΔMCAv was observed in both groups ($P=0.021$). While both groups demonstrated similar changes in PETO_2 throughout the test, the reduction in SPO_2 during peak exercise was larger in adults (-11% vs -5.9%, $P=0.027$). The differences in CBFv between children and adults may in part be attributed to better maintenance of SPO_2 during exercise to maximum at high altitude in children.

We believe that these findings demonstrate a better ability to maintain blood oxygen levels in children during exercise at high altitude, which allows cerebral blood flow to be lower. Both of these factors are implicated in the development of acute mountain sickness (AMS), and these findings may mean that children are less susceptible to high altitude headache.

The conference abstract above is currently being prepared into a manuscript for submission, and analysis work has turned to the pulmonary vascular and cardiac response to altitude. The Mount Everest Foundation will be acknowledged in each of the publications to come from the expedition.

Budget and Expenditure

The Mount Everest Foundation kindly contributed £3250 to the expedition. This amount equated to ~15% of the total cost, with the remainder funded by a combination of other sources including Research Councils (NSERC), the Wilderness Medical Society and the North American Society of Pediatric Exercise Medicine. The funding from the MEF was used on travel (return flights to and from the UK) for Dr Stembridge and to contribute to the overall cost of lodging at the Crooked Creek and Barcroft Research Stations. E-receipts for these items are provided below.

Your StudentUniverse Order - May 29, 2019

StudentUniverse confirmation number: **19149-NYQLCI3EUK3**

Total Cost: **£983.22**



Traveller: **Michael Robert Stembridge**

Date of birth: **11 Jul 1985**

Contact Email: mstembridge@cardiffmet.ac.uk

Phone Number: **7977440839**



London, United Kingdom, London Heathrow (LHR) -
Orange County, CA, John Wayne (SNA) Thu 01 Aug -
Sat 10 Aug



StudentUniverse reservation code: **TWXHCM**

Airline reservation code: **Iberia: NFF5OF American Airlines: TWXHCM**

Return Flight:

Orange County, CA, John Wayne (SNA) , Sat 10 Aug



American Airlines	departs SNA	arrives PHX	1hr
Flight 1476	Sat, Aug 10, 2019	Sat, Aug 10, 2019	26min
(operated by OPERATED BY AMERICAN AIRLINE)			
Eqpt. type: Boeing 737-800			

Connection in Phoenix, US for 1hr 35min



Iberia	departs PHX	arrives LHR	9hr
Flight 7446	Sat, Aug 10, 2019	Sun, Aug 11, 2019	55min
(operated by OPERATED BY BRITISH AIRWAY)			
Eqpt. type: Boeing 747-400			

London, United Kingdom, London Heathrow (LHR) , Sun 11 Aug

Departure Flight:

London, United Kingdom, London Heathrow (LHR) , Thu 1 Aug



Iberia	departs LHR	arrives DFW	10hr
Flight 4193	Thu, Aug 1, 2019	Thu, Aug 1, 2019	5min
(operated by OPERATED BY AMERICAN AIRLINE)			
Eqpt. type: Boeing 777-300ER			

Connection in Dallas, US for 1hr 59min



American Airlines	departs DFW	arrives SNA	3hr
Flight 0769	Thu, Aug 1, 2019	Thu, Aug 1, 2019	5min
(operated by OPERATED BY AMERICAN AIRLINE)			
Eqpt. type: Boeing 737-800			

Orange County, CA, John Wayne (SNA) , Thu 1 Aug



INVOICE

Invoice date: August 23, 2019
Invoice #: 18591-2
Application #: 41198
Description: Cardio-respiratory Acclimatization to High Altitude in Children
Reservation #: 58245
Purpose: With the development of modern transit systems to once-remote places, the number of families travelling to high-altitude increases each year. Current travel guidelines for safe ascent rates are based on acclimatization profiles observed in adults, yet little research has focused on the safety of the child. Control mechanisms of ventilation and blood flow differ between children and adults, which likely create developmental differences in the rate and trajectory of acclimatization to high alti...

Bill To

Matt Rieger
University of British Columbia - Okanagan

mrieger@ualberta.ca

Phil Ainslie
University of British Columbia - Okanagan

painslie@mail.ubc.ca

Reserve Resource	Begin	End	Units	Count	Rate	Subtotal
Barcroft Station- Room and Board-per person/per night (Per person per night)	August 05, 2019	August 09, 2019	24 people	4 nights	\$60.00	\$5,760.00
Barcroft Station- Room and Board-per person/per night (Per person per night)	August 05, 2019	August 09, 2019	2 people	4 nights	\$60.00	\$480.00
CCR-Crooked Creek Station-Room and Board per person/per night (Per person per night)	August 03, 2019	August 05, 2019	26 people	2 nights	\$60.00	\$3,120.00

Total reserve resources provided: **\$9,360.00**

Payment	Payor	Payment Type	Note	Amount
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Total payment(s) or credit: **\$0.00**

Invoice Note:

Billing person per reservation: Audrey Kirby; audrey.kirby@ucb.ca; 250-807-9366

Balance: \$9,360.00

BILLING ADDRESS

White Mountain Research Center
3000 East Line Street
Bishop CA, 93514
U.S.A.

NOTES

Make Check Payable TO: Regents, Univ. of California
 Tax ID: Regents, Univ. of CA
 > PLEASE REMIT PAYMENT WITHIN 30 DAYS OF RECEIPT
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 > UC departments will be recharged.
 > If you have questions about the invoice, please e-mail: Denise Waterbury at : wmcinfo@ucla.edu
 Elizabeth Sally at : esally@ioes.ucla.edu