FORM 2 – FULL RESEARCH PROPOSAL

Principal Investigator[1] Dr.; Samuel James Oliver; Lecturer; School of Sport, Health and Exercise Sciences; Bangor University; George Building, Bangor, Gwynedd, LL57 2PZ, UK; +44 1248 383965; s.j.oliver@bangor.ac.uk

Collaborators[2] Dr.; Jamie Hugo Macdonald; School of Sport, Health and Exercise Sciences; Bangor University; j.h.macdonald@bangor.ac.uk

Research title[3] Testing the relationship between fitness and expedition success: Is being fitter associated with less illness, more enjoyment and better performance?

Lay summary[4] Success on expeditions can be defined in various ways including whether a summit is climbed or how enjoyable the expedition is. The influence of physical and mental fitness on summit success and expedition enjoyment is not clear. Scientific data and expert opinion suggests that summit success is very dependent on ascent rate and the mountaineer making choices to continue climbing rather than abandon their attempt. Thus people may be more likely to summit by being fitter to allow ascent at a faster rate and by having more confidence to continue ascending despite threats to success and safety such as benightment. Expedition mood may also be dependent on fitness because fitter people may find physical tasks and the arduous nature of expeditions easier. Surprisingly, no studies have assessed fitness and related it to ascent rate, confidence in summiting, or expedition mood. This study will test participant's fitness at sea level before a high altitude expedition. Participant's summit/high pass success, actual and self-selected ascent rate, physiological responses to typical mountaineering exercise, self-confidence, and mood at rest and during exercise will then be assessed during the expedition. This study will thus determine the importance of fitness for high altitude expedition success.

Scientific proposal, background[5]

In the European Alps alone, tourism exceeds 100 million visitor days per year, with alpinists spending more than 90,000 nights annually in huts located above 2500 m (Maggiorini et al., 1990). The majority of trekkers and mountaineers sojourn to high altitude for non-competitive reasons. This can make high altitude performance difficult to define and study. For example, it is rarely possible to rank participants' performance against one another and maximum speed *per se* may be of little importance to trekkers and mountaineers. However, generally in altitude expeditions some form of journey is completed and thus many participants wish to get from point a to point b. Point b is very often a summit of a mountain or a high pass that requires arduous physical activity to be attained. Success and safety is also often dependent on speed to avoid threats such as benightment or adverse weather. Still, some people participate in high altitude expeditions with a primary goal of enjoyment and attaining a summit is of lesser importance. Thus when studying high altitude trekking and mountaineering expedition success it is necessary to account for participants' variable reasons for participation.

For the purpose of this proposal we operationally define altitude performance in the terms of physiological and psychological capability to attain a summit or high pass, and define expedition enjoyment as participating in an activity that enhances mood. Mood itself is defined as how an individual generally feels at a particular moment of time on a continuum from pleasurable to unpleasurable affective states (positive and negative affect: Berger & Motl, 2000). By assessing factors important for altitude performance and mood during expedition the authors believe that expedition success is also more broadly assessed.

Of course there are many factors that influence whether a trekker or mountaineer will successfully attain a summit or high pass, for example, environmental conditions. We however are interested in physiological and psychological factors within the trekker or mountaineer's own control. After a review of the literature and a debate with two expert mountain guides, the most important variables influencing success to reach a summit were chosen as ascent rate (to ensure the summit or pass is reached before time runs out) and confidence (to control behaviours when making decisions about whether to continue or to abandon the attempt).

Ascent rates have been recorded on summit attempts and consistently predict summit success (Billet et al., 2010; Wagner et al., 2008). For example, increases in the rate of ascent were associated with greater odds for summit success on Mt. Whitney (odds ratio of a 50 m/h increment in ascent rate = 1.13, Wagner et al., 2008). Ascent rates range from an average of 170 m/h (Wagner et al., 2008) to 440 m/h (Billet et al., 2010), dependent on altitude, length of ascent, gradient, and terrain under foot.

Scientific evidence for an influence of confidence (self-efficacy) on summit success is currently lacking. However self-efficacy is concerned with perceived capability and is known to influence behaviour. It can influence effort and how long a person perseveres in the face of obstacles and their resilience to adversity (Bandura, 2006). Thus it makes conceptual sense that self-efficacy could influence decision making when performing arduous physical mountaineering activities. In this regard, previous authors (Wagner et al., 2008; Pesce et al., 2005) have found a strong relationship between past experience and summit success. Wagner et al (2008) thus speculated that enhanced self-efficacy increased odds of reaching the summit however neither self-confidence nor self-efficacy were assessed directly.

Theoretically, ascent rates are related to power output and thus also physical fitness. However the role of physical fitness on altitude performance and expedition mood is not clear. A common perception of trekkers and mountaineers is that fitness is relatively unimportant for altitude performance or more broad expedition success. Conversely scientific evidence (albeit indirect) contradicts this perception. For example, Wagner et al. (2008) studied 886 attempts on Mt. Whitney (4419 m) and showed that training hours per week influenced the odds ratios of summit success, consistent with an important role for physical fitness. Age was also identified as an important predictor of success, with older persons less likely to summit, a finding confirmed on Mt. Aconcagua (6962 m) in 64 attempts studied by Lazio et al. (2010). As cardiovascular and muscular fitness declines with age by 1% per year over the age of 30 years (Brooks et al., 2005), these data further support a role for physical fitness on summit success.

Limited direct evidence exists to suggest how physical fitness relates to altitude performance. Mountaineering and trekking is characterized by prolonged submaximal exercise and therefore physical fitness, in particular aerobic fitness variables (maximal aerobic capacity, fractional utilisation (percentage of maximal aerobic capacity at anaerobic/lactate threshold), and economy), can be intuitively hypothesized to be important for altitude performance (Bassett & Howley, 2000). Nonetheless, little direct evidence exists to support this hypothesis. Maximal aerobic capacity is well known to decrease with increasing altitude and is the main reason for reduced physical performance at altitude (Wehrlin & Hallen, 2006). Still whether maximal aerobic fitness is important for altitude performance is unclear as elite mountaineers do not have a particularly high aerobic capacity (Pugh, 1972; Oelz et al., 1986) although in a small study of eight mountaineers the four that summited Mt Cho-Oyu (8201 m) had the highest sea level maximal aerobic capacity (Horii et al., 1994). Unfortunately these studies have been with small samples and maximal aerobic capacity and other measures of aerobic fitness have not been examined simultaneously. This is important as although maximal aerobic capacity may predict performance outcome between people of very different maximal aerobic capacity it is fractional utilisation and economy that better predict performance when maximal aerobic capacities are similar (Coyle et al., 1988). Interestingly, experienced mountaineers have been reported to be more economical (lower oxygen cost of exercise) during summit attempts (Billet et al., 2010). Further, heart rate (a measure of cardiovascular strain) has been shown to be lower in summiteers than non-summiteers (Tsianos et al., 2006; Wagner et al., 2012). Further investigation is clearly required to determine the relationship between altitude performance and these fitness variables, in particular fractional utilisation, which is an important predictor of sea level endurance performance (Bassett & Howley, 2000).

Another key variable influencing ascent rate is pacing. At sea level sub-maximal pacing is determined by rating of perceived exertion (RPE, Eston, 2012), which is influenced by physical fitness (Ekkekakis & Petruzzello, 1999). Thus at altitude RPE is likely to mediate the relationship between physical fitness and ascent rate. RPE is indirectly related to physiological variables including arterial oxygen saturation and blood lactate accumulation. The role of RPE and fitness is potentially amplified at altitude because when exercising in a hypoxic environment respiratory rate is increased yet oxygen delivery remains compromised. These phenomena cause greater locomotor and respiratory muscle fatigue (Amman & Calbet, 2008) leading to an elevated RPE (Marcora et al., 2008; Romer et al., 2008). Although the relationship between fitness and RPE has not been specifically investigated at altitude, during acclimatisation to hypoxia (when maximal aerobic capacity increases), RPE also decreases (Fulco et al., 2009), which is consistent with a role for fitness on RPE during altitude expeditions. Recent development in assessment of session RPE now also allow RPE measures to be made for an entire trekking or mountaineering day (Foster et al., 2001).

Residing at high altitude and exercising in hypoxia can lead to poor mood (i.e. increased anger, depression and fatigue Bahrke & Shukitt-Hale, 1993; Lane et al., 2005). For trekkers and mountaineers whose primary goal is not summit success but expedition enjoyment (mood), the role of physical fitness should not be underestimated. Indeed, those persons with lower fitness report higher RPE and poorer mood during exercise at sea level (Ekkekakis & Petruzzello 1999). The relationship between fitness and expedition mood has not been investigated. However it is conceivable that during a high altitude expedition, particularly whilst exercising, fitter persons will report less negative affect (e.g. anger) and greater positive affect (e.g. enjoyment), which subsequently may also alter altitude performance (summit success, ascent rate) and overall expedition success.

Altitude illness may also influence altitude performance (summit success, ascent rate) and expedition enjoyment. Anecdotal evidence suggests that physical fitness does not protect against acute mountain sickness (AMS). Indeed, recent scientific evidence suggested that participants with AMS had increased aerobic capacity compared to participants without illness (Karinin et al., 2010), and a risk equation for severe altitude illness developed on 1326 participants included baseline physical activity level as a predictor variable (Richalet et al., 2012). However, not all studies concur (Milledge et al., 1991) and a theoretical rationale for a link between fitness and illness is currently lacking. A possible explanation for these disparate findings is that relationships between fitness and altitude illness are confounded by other variables such as age. Alternatively, fitter individuals may complete more physical activity at altitude, by gaining greater height per day, walking at a faster speed, or voluntarily completing more habitual physical activity during free time. Such increased physical activity has been shown to increase acute mountain sickness (Roach et al., 2000). No studies have investigated whether level of daily physical activity on expeditions mediates the relationship between fitness and illness. Furthermore, although studies have attempted to determine physiological variables that may predict altitude illness susceptibility (such as arterial oxygen desaturation response to a hypoxic environment: Basnyat et al., 1999; Burtscher, 2008; Douglas & Schoene, 2010; Karinen et al., 2010; Koehle et al., 2010; Modesti et al., 2011), few have attempted to explain whether such physiological variables can predict altitude performance (summit success, ascent rate) or expedition mood.

The role of altitude illness on altitude performance and expedition enjoyment is also not clear. Surprisingly, AMS scores do not predict summit success (Lazio et al., 2010; Wagner et al., 2008) or physical activity level (Maggiorini et al., 1998). However these studies highlight the lack of appreciation within the literature of psychological influences on summit success. For example, although Wagner could find no difference in AMS scores between successful and unsuccessful summit attempts, the most commonly reported reason for an unsuccessful attempt was acute mountain sickness! Presumably how trekkers and mountaineers interpret their symptoms and how these symptoms then influence behaviour is critical rather than the symptom severity *per se*. No known studies have directly assessed the influence of illness on self-efficacy or expedition mood but participants with higher acute mountain sickness scores report higher state anxiety (Oliver et al., 2012) which may decrease confidence, positive affect and increase negative affect.

In summary, previous research has failed to directly assess the relationship between fitness (aerobic capacity, fractional utilisation and economy) and altitude performance (summit success, ascent rate, self-efficacy) or expedition mood. Further research is required to prospectively and directly obtain these parameters to determine whether increasing fitness could enhance future expedition success.

Scientific proposal, aims and hypotheses[6]

Primary aim

To determine whether higher sea level fitness leads to better altitude performance and better expedition mood at rest and during exercise.

Secondary aims

To determine whether better hypoxic fitness leads to better altitude performance and expedition mood at rest and during exercise.

To determine whether hypoxic fitness and RPE obtained during fixed workload exercise performed in hypoxia mediates the relationship between sea level fitness and altitude performance and expedition mood.

To determine whether daily physical activity mediates the relationship between sea level and hypoxic fitness and AMS scores during a high altitude expedition.

Hypotheses

i) It is hypothesised that higher sea level fitness (maximal aerobic capacity, fractional utilisation and economy standardized to z scores and then averaged) will lead to better altitude performance and expedition mood as evidenced by:

- more summit/high pass success (altitude performance);
- greater actual ascent rates on summit and high pass expedition days (altitude performance);
- higher self-selected ascent rate on a step test after arduous and rested expedition days (altitude performance);
- increased self-confidence and perceived self-efficacy to attain a summit/high pass (altitude performance);
- lower expedition RPE assessed during acute fixed workload exercise (altitude performance);
- lower RPE 30 minutes after arriving from an arduous expedition day (altitude performance);
- higher positive affect and lower negative affect at rest and during acute exercise (expedition mood); and
- lower expedition AMS scores when adjustment for daily physical activity.

ii) It is further hypothesised that higher hypoxic fitness (higher oxygen saturation and lower RPE during fixed workload exercise in hypoxia and lower blood lactate concentration after fixed workload exercise in hypoxia) will lead to better altitude performance and expedition mood as evidenced by:

- more summit/high pass success (altitude performance);
- greater actual ascent rates on summit and high pass expedition days (altitude performance);
- higher self-selected ascent rate on a step test after arduous and rested expedition days (altitude performance);
- increased self-confidence and perceived self-efficacy to attain a summit/high pass (altitude performance);
- lower expedition RPE assessed during acute fixed workload exercise (altitude performance);
- lower RPE 30 minutes after arriving from an arduous expedition day (altitude performance);
- higher positive affect and lower negative affect at rest and during acute exercise (expedition mood); and
- lower expedition AMS scores when adjustment for daily physical activity.

iii) It is further hypothesised that RPE obtained during fixed workload exercise performed in hypoxia will mediate the relationships between sea level and hypoxic fitness with altitude performance (assessed by higher self-selected ascent rate) and expedition enjoyment (assessed by higher positive affect and lower negative affect).

iv) It is further hypothesised that the relationship between fitness and AMS will be mediated by daily physical activity (both obtained on the day of peak incidence of acute mountain sickness).

Scientific proposal, methods[7]

Research Design

A prospective cross sectional study with independent variables (sea level and hypoxic fitness) assessed before expedition departure and dependent variables (altitude performance and expedition mood) assessed during a high altitude expedition.

Study schematic

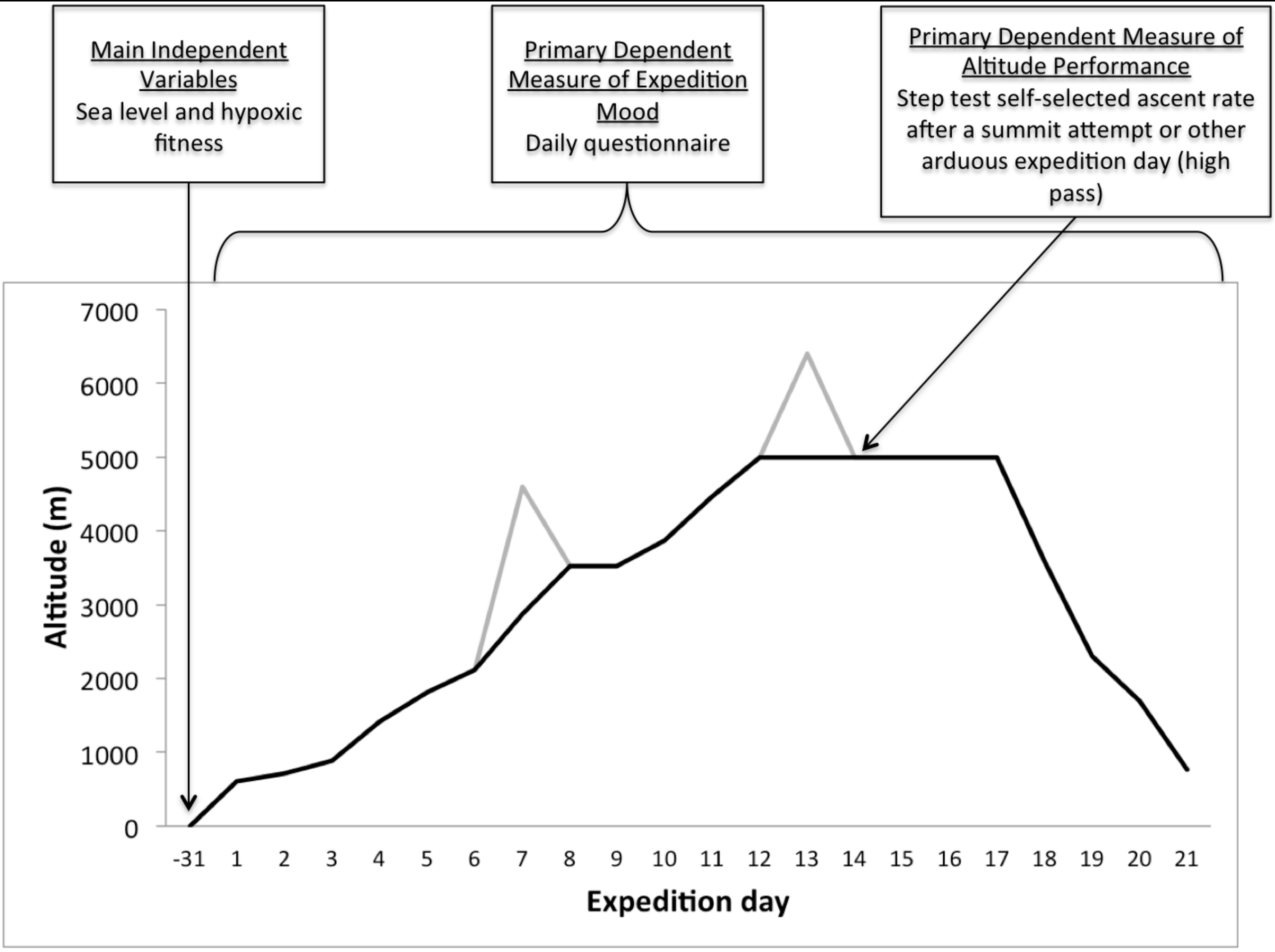

Figure 1. Study schematic highlighting the main independent (fitness) and dependent measures (altitude performance and expedition mood). The dark figure line indicates sleeping altitude where as the grey line indicates peak altitudes.

Procedures

Pre-Expedition (Bangor) Experimental Procedures

Before expedition departure, each participant's sea level fitness (maximal aerobic capacity (VO_2 max), fractional utilisation and economy) will be determined by a graded exercise test on a motorised treadmill. The exercise protocol will be confirmed with pilot testing but is envisaged to involve the participant walking beginning at 2 km/h with a 5% gradient with subsequent increases until exhaustion by a ramped protocol. During the exercise heart rate, blood oxygen saturation and overall RPE will be determined every minute by remote transmitter, fingertip pulse oximetry and CR100 RPE scale (Borg & Borg, 2010). Blood lactate concentration will be determined every two minutes via ear lobe capillary sampling and a portable analyser. Breath-by-breath gas analysis by metabolic cart will be recorded continuously during the protocol. VO_2 max will be determined as the highest 30 s average of oxygen consumption at any given time point. To ensure VO_2 max has been correctly identified verification will also be completed where the participant repeats a workload above that which elicited VO_2 max. Other sea-level fitness variables (fractional utilisation and economy) will be determined off-line by standard exercise testing procedures (Gaskill et al., 2001; Winter et al., 2007). Maximal aerobic capacity, fractional utilisation and economy will then be standardized to z scores and averaged to determine sea level fitness as a single variable.

At this visit participants will complete a general questionnaire on demographic variables such as age, gender, expedition and altitude experience, prior altitude illnesses and training load. They will also be familiarised with AMS and mood questionnaires to be used during the expedition at rest. These are the 5 item Lake Louise Questionnaire (LLQ, Roach et al., 1993) to determine AMS and the two 10 item scales for Positive and Negative Affect (PANAS, Watson, Clark & Tellegen, 1988) to determine mood. To determine mood during exercise participants will also be familiarised at this visit to the Feeling Scale (FS) and Felt Arousal Scale (FAS), which are measures of the affective dimension of pleasure–displeasure (FS, Hardy & Rejeski, 1989) and perceived activation/arousal (FAS, Svebak & Murgatroyd, 1985). The FS scale is an 11-point single-item bipolar rating scale. The scale ranges from - 5 to +5. Anchors are provided at the 0 point (''neutral'') and at all odd integers, ranging from ''very good'' (+5) to ''very bad'' (-5). Participants will also be asked to rate how they felt at that particular moment. The FAS is a six-point, single-item measure of perceived activation/arousal. The scale ranges from 1 to 6, with anchors at 1 (''low arousal'') and 6 (''high arousal''). Both the FS and FAS have the advantage of most other self-report mood scales of being easily administered during exercise. The FS and FAS have been commonly used for the assessment of affective responses during exercise and have been used in prior exercise studies (Hall et al., 2002; Backhouse et al., 2007).

On a separate day participants will complete a hypoxic fitness test in a normobaric hypoxia (Fraction of inspired oxygen 0.115). The fitness test will be similar to previously described methods (Richalet et al., 2012) but will be completed using a step test for the exercise mode. Briefly the test will consist of four 4-minute stages: rest in normoxia, rest in hypoxia, exercise in hypoxia, and exercise in normoxia. Power output during the exercise test will be set to that equivalent to approximately 3 METs and will be regulated by participants stepping in time to a metronome. Heart rate, blood oxygen saturation, RPE and blood lactate concentration will be determined every two minutes as previously described. Hypoxic fitness will be assessed by blood oxygen desaturation at rest and to exercise as calculated previously (Richalet et al., 2012). We also intend to determine hypoxic fitness from final RPE and blood lactate concentration after fixed workload exercise in hypoxia.

Finally, each participant will complete a newly developed perceived self-efficacy scale (see appendix 1 for the first draft of this scale). Before expedition departure this scale will be assessed for face validity by interview of expert mountaineers and experienced trekkers and will be evaluated for internal consistency assessed using Cronbach's alpha. Construct validity of the scale will be assessed by determining differences in those who successfully summit Larkya Peak and those who choose not to attempt it or who attempt it but do not succeed.

High Altitude Expedition Procedures

The main outcome measure of altitude performance will be self-selected ascent rate (stepping rate) as determined from a step test after an arduous expedition day (after a summit (Larkya peak) or other high pass day: See **Figure 1**). The step test will be completed after an arduous expedition day as we wish to determine the effect of fitness on self-selected ascent rate when persons are fatigued as this better represents high altitude summit and high pass attempts and as it is not feasible to complete long duration exercise protocols whilst at expedition basecamp. Ascent rate on actual summit and high pass days will also be determined however these measures are considered as secondary outcome measures as other extraneous factors may affect these ascent rates (e.g. terrain under foot, weather). This is selected as the main altitude performance dependent outcome measure as it is the most rigorous method to determine the effect of fitness on the most important controllable factor (ascent rate), which is related to summit or high pass success.

Before completing a simulated ascent step test participants will rest for four minutes and have resting heart rate, blood oxygen saturation, RPE and blood lactate concentration determined as previously described in the final minute. Participants will then complete four minutes of stepping exercise at a fixed intensity equivalent to 3 METs as previously described for the hypoxic fitness test. In the final minute heart rate, blood oxygen saturation, RPE, blood lactate concentration and mood (FS & FAS) will be determined. After two minutes rest, participants will then exercise at an intensity of their choice (self-selected), with the verbal instruction: "Please select an exercise intensity by stepping at a rate that you would choose if you were attempting to ascend Larkya Peak today". The stepping rate will be recorded after four minutes for one minute. At five minutes participants will stop exercising.

On the days of ascent of Larkya Peak and of a high pass, immediately before morning departure, participants will complete the Competitive State Anxiety Index II (revised edition). Actual ascent rate and physical activity will then be recorded by diary and global positioning system. Physical activity will be later analysed using the compendium of physical activity codes to determine activity METs (Ainsworth et al., 2000). After these arduous days, session RPE will also be recorded 30 minutes after arriving to camp (Foster et al., 2001). Finally, AMS and mood will also be determined that evening by LLQ and PANAS.

At expedition basecamp on a morning when participants are acclimatized (as defined by an absence of acute mountain sickness by Lake Louise scale) and not fatigued (no arduous physical activity within 24 hours) the simulated ascent step test will be repeated.

The main outcome measure expedition mood will be determined daily during the expedition by participants recording mood by PANAS questionnaire in a waterproof personal diary at breakfast similar to previous MEDEX high-altitude expeditions (Oliver et al., 2012). Additionally, AMS will also be recorded by LLQ at this time.

Statistical analyses

The primary analysis will be a comparison of between fit and unfit participants (independent variable) and self-selected ascent rate and expedition mood (dependent variables). Maximal aerobic capacity, fractional utilisation and economy will then be standardized to z scores and averaged to determine sea level fitness as a single variable. A dichotomous split will then select participants into two groups (fit and unfit groups). Self-selected ascent rate will be obtained from the simulated ascent step test after an arduous expedition day. Expedition mood will be averaged for positive and negative affect and compared between fit and unfit participants.

The main outcome measure in this study will be self-selected ascent rate during a simulated ascent step test. The minimum important difference in ascent rate is chosen as 50 m/h (associated with an increased odds ratio of summit success of 1.13 (Wagner et al., 2008). The pooled SD is 70 m/h (Wagner et al., 2008; Billet et al., 2010; Tsiano et al., 2006). Using a one tailed t test, 25 participants per group are required to detect a difference of 50 m/h with a power of 80% and a type I error rate of 5% between fit and unfit participants. The one sided test is justified because we hypothesize that increased fitness can only have a positive or null effect on ascent rate. Furthermore, unlike many drug interventions, increased fitness is a relative cheap and safe intervention, and hence risks from making a type I error (when a null hypothesis is incorrectly rejected) are of lesser importance. This philosophy is supported by current statistical thinking (e.g. Knottnerus & Bouter, 2001).

Scientific proposal, expected results[8]

The expected findings for the main outcome self-selected ascent rate after an arduous expedition day are included in Figure 2 below. This is selected as the main dependent outcome measure as it is likely the most important controllable factor that determines altitude performance (summit or high pass success).

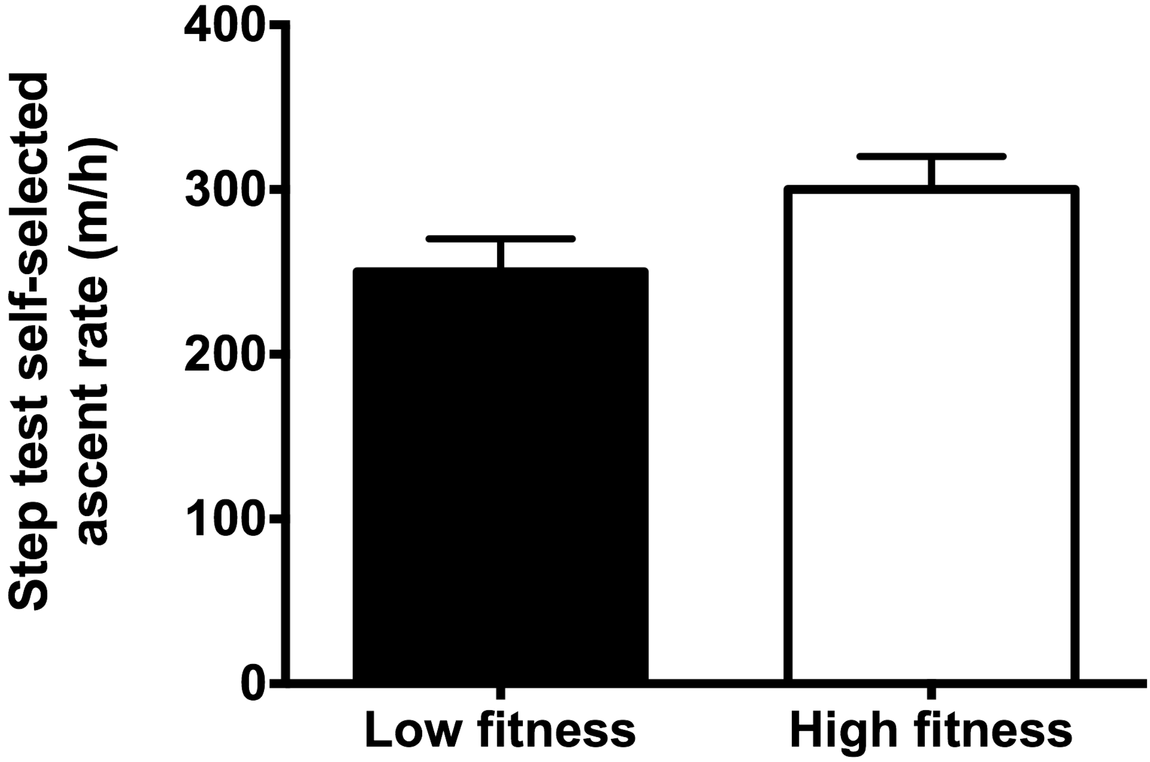

Figure 2. The proposed effect of fitness on self-selected ascent rate at basecamp after an arduous expedition day.

Dissemination plan, target journal(s)[9]

First submission to Medicine and Science in Sports and Exercise. Second submission if unsuccessful to European Journal of Applied Physiology or High Altitude Medicine and Biology.

Dissemination plan, timeline[10]

May - August 2015 - Data analysis

July – August 2015 – Draft methods

September – October 2015 – Data interpretation and draft results

November 2015 – Draft introduction and discussion

December 2015 – Presentation at a UK hypoxia conference (BMRES/Oxford meeting)

January - February 2016 incorporate UK conference feedback into 1st draft

March 2016 – Submit manuscript to Journal

Research requirements, participants[11]

Total research time required per volunteer: approximately 4.5 hours.

Pre-expedition (Bangor): two fitness tests (sea level ~45 min, hypoxic ~30 min) and questionnaire familiarisation (~15 min) and Expedition: daily data collection (~5 min), two step tests (~40 min) and CSAI-IIR questionnaire (~10 min).

Risks

Rare (1 to 10% chance)

- Some individuals experience feelings of light-headedness, headache and nausea when exercising in hypoxia. The chance of experiencing such symptoms is estimated to be 1 in 10. This risk will be mitigated by systematically monitoring each participant of symptoms when in hypoxic environments.

Very rare (less than 1% chance)

- Risks of infection from blood sampling. This risk will be mitigated by using trained personnel and standard Bangor University techniques.
- Risk of musculoskeletal injury. This risk will be mitigated by using warm up and cool down exercise.

Very rare but serious (less than 1% chance)

- Risks of performing maximal exercise. The chance of death during a graded exercise tests is estimated to be 2-5 in 100,000 (ATS, 2003). This risk will be mitigated by using the PARQ pre exercise assessment questionnaire with participants identified as at risk being asked to obtain doctor consent before participation. In addition trained first aid (inc. AED) will be available in the building during baseline testing.

Research requirements, personnel[12]

Pre-expedition (Bangor): Eight staff trained to complete graded exercise tests plus one technician for problems. This will enable two sea level fitness tests and two hypoxic fitness tests to be run simultaneously (Four fitness test stations with two staff required per test).

Expedition: One staff member per trekking group to facilitate daily data collection. Two staff trained to complete step tests to facilitate basecamp data collection.

Research requirements, equipment[13]

All equipment is available and will be sourced from Bangor University. Mains power required at pre-expedition (Bangor). Battery power (AA size or watch battery size) required only on expedition.

Pre-expedition (Bangor): Treadmill x 2 (h/p/cosmos, Nussdorf, Germany), metabolic cart x 2 (Metalyser, Cortex, Leipzig, Germany), masks (S, M, L x 2), heart rate monitors x 4 (FT3, Polar, Kempele, Finland), calibration gas, blood lactate analyzers x 8 (Lactate Pro, Ark Ray Inc, Kyoto, Japan), stopwatches x 4, arterial oxygen saturation monitors x 4 (7500, Nonin Medical Inc., Minnesota, USA), steps x 2, metronome, Competitive State Anxiety Index (CSAI-IIR), self-efficacy, PANAS, FS, FAS and LLQ questionnaires. All equipment and questionnaires from Bangor University.

Expedition: Steps x 6, metronome x 2, blood lactate analyzers x 6, Stopwatches x 6, heart rate monitors x 6, blood lactate analyzers x 8, stopwatches x 6, arterial oxygen saturation monitors x 6, clipboards and pens x 12. All from Bangor University.

Research requirements, consumables[14]

Blood lactate testing for approximately 700 tests. Per test requires gloves, alcohol swab, lancet, lactate strip, and a plaster. Data collection sheets and questionnaires.

Research requirements, logistics[15]

No sample transport required.

Total weight of equipment: approximately 30 kg.
6 steps for step test = 24 kg (~4 kg per step); Blood lactate pro x 6 = ~1 kg total; metronome, heart rate monitors, clipboards, paper, pens, stopwatches = ~2 kg total.

Laboratory requirements: flat area 10 m x 10 m; 5 L sharps bins x 2; yellow bin bags x 2.

Research requirements, research cost[16] Costs will be met by an application to the grants committee of Bangor University and are approximately £1000. The majority of this is for blood lactate testing (~700 tests at ~£1 per test including lactate strips, gloves, lancets).		
[17]Samuel James Oliver Jamie Hugo Macdonald		21.12.13

Suggested Reviewers

1. Dr. Doug Thake, Senior Lecturer, Department of Biomolecular and Sport Science, Coventry University, UK, d.thake@coventry.ac.uk, +44 (0) 24 7688 8372.

2. Dr. Dale Wagner, Associate Professor, Human Movement Science Program, Health, Physical Education Recreation Department, Utah State University, Logan, UT, USA, dale.wagner@usu.edu, +1 (435) 797 8253.

3. Professor Martin Burtscher, MD, PhD, Department of Sport Science, University of Innsbruck, Fürstenweg 185, A-6020 Innsbruck, Austria, martin.burtscher@uibk.ac.at, (+43) 0512 507 45896.

4. Dr. Charles Fulco, Thermal and Mountain Medicine Division, United States Army Research Institute of Environmental Medicine, Natick, MA 01760, USA. Charles.fulco@us.army.mil

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1Title, full name, current post, department, institution, contact postal address, email address, telephone (including country and area code)
2Title, full name, department, institution, email address
3Max 20 words
4Project summary in simple English. Max 200 word
5Provide rationale for study
6Concise; specific and directional hypotheses
7Participants; research design; study schematic; procedures; statistical analyses; identification of main outcome measure; justification of sample size
8 Graphs as likely to be presented in manuscript depicting theoretical relationships but correct units and physiologically plausible absolute values; explanatory text to justify relationships (based on previous literature)
9Target journal(s)
10Timeline from research proposal to submission of, manuscript to target journal (including conference presentations and 1st draft of introduction/methods/results/discussion sections)
11Total time participants will spend on study; Risk to participants and how risks will be mitigated
12Staff required to run project successfully
13Make, model, where equipment will be sourced from, rough estimate of power requirements
14Plastics, paper, disposable accessories for equipment, etc
15Rough estimates of: sample transport (if required); equipment total weights; laboratory requirements (space, environmental conditions, services (water, electric, light, waste disposal)
16Direct expenditure related to project and explanation of how these costs will be met. Do not include expedition fees or logistics, or indirect salaries
17Principal Investigator and Collaborators must provide consent to submit proposal. This can be done with either physical or electronic signatures on the research proposal, or alternatively each researcher may email j.h.macdonald@bangor.ac.uk the following text: “I [INSERT NAME] approve the full research proposal entitled [INSERT TITLE]”

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Appendix 1

Practice Rating
To familiarize yourself with the rating form, please complete this practice item first.

If you were asked to lift objects of different weights **right now**, how certain are you that you can lift each of the weights described below?

Rate your degree of confidence by recording a number from 0 to 100 using the scale given below:

0 10 20 30 40 50 60 70 80 90 100
Cannot
do at all

Moderately
can do

Highly certain
can do

Physical Strength Confidence (0-100)

Lift a **5** kilogram object _____
" **10** " " _____
" **25** " " _____
" **40** " " _____
" **50** " " _____
" **75** " " _____
" **100** " " _____
" **200** " " _____

Appraisal inventory

A number of situations are described below that can make it hard to complete physical tasks when on an expedition. Please rate in each of the blanks in the column how certain you are that you can complete physical tasks in the situations described below.

Rate your degree of confidence by recording a number from 0 to 100 using the scale given below:

0 10 20 30 40 50 60 70 80 90 100

Cannot
do at all

Moderately
can do

Highly certain
can do

Confidence (0-100)

When the weather is very windy _____
After a long day's walking _______
When carrying a heavy rucksack
When the weather is very hot
When food supply is limited
When other people around me are completing the task quicker and easier than me
When I am not yet acclimatised to the altitude
When I am having to breathe very hard
When I have to complete physical activity day after day without a rest
After suffering from an illness
When I have not had enough sleep
When the terrain is very steep
When the ground underfoot is very difficult (e.gf. soft, deep snow)
When I have gone the wrong way and have to walk extra distance