Brief Report: Sleep profiles and mood states during an expedition to the South Pole.

Corresponding Author: Charles R Pedlar

Prof. Andrew M Lane

Juliette C Lloyd

Jean Dawson

Stephen Emegbo

Dr Neil Stanley, PhD

and

Prof. Gregory P Whyte

Running Header: Antarctic expedition

ABSTRACT Objectives: To investigate sleep parameters and mood profiles of a female explorer traveling solo and unaided to the South Pole during the winter. Methods: During the 44-day expedition, global activity and sleep were assessed using a wrist actigraph (AW) worn on the non-dominant wrist. Mood was assessed using an adapted Profile of Mood States questionnaire. Pre- and post- expedition physiological profiles were conducted to assess body composition, strength and power and aerobic capacity. Results: The AW data revealed decreasing sleep duration throughout the expedition, with an average sleep time of 5 hours (range: 8hr 14mins – 1hr 42mins), with sleep times consistently below 3 hours during the final third of the expedition. Mood responses indicated a progressive reduction in vigour and increase in fatigue. Sleep time was positively related to vigour and inversely related to depression and fatigue, a finding that is consistent with the notion that positive feelings (high vigour and low fatigue) are linked with sleep. Conclusions: This account provides insight to help understand the limits of human tolerance and may be directly applicable when planning future expeditions of this nature.

INTRODUCTION

The explorer skiing solo and unaided to the South Pole is faced with many challenges including extreme cold, 24 hour light, difficult and varied terrain, and large distances. Furthermore, the majority of the trek is uphill, with an increasing altitude from sea-level to 2,900m. Prolonged exercise is associated with sleep disturbances and mood changes (Taylor, Rogers, & Driver, 1997) loss of body fat (Raschka and Plath, 1992), and this physiological and psychological stress may be exacerbated in the polar environment (Parker, 1985).

Previous research has tended to use a global measure of mood disturbance by summing anger, confusion, depression, fatigue, and tension and subtracting vigour scores. Studies that have investigated each mood state independently, however, have demonstrated that fatigue and vigour exhibit the greatest variation in scores (see Lane, Whyte, Shave, Barney, Wilson and Terry, 2003).

Performing repeated prolonged bouts of intense exercise in Antarctic conditions are likely to be associated with both mood disturbance and sleep deprivation, which could have an impact upon performance in terms of achieving the aim of arriving at the South Pole. Accordingly, the primary aim is to assess mood states and sleep patterns of a female explorer during an expedition to the South Pole. A secondary aim was to assess the physiological impact of the expedition. Research of this nature could be used to develop a more comprehensive understanding of the psychological and physiological experiences of the polar explorer in order to better inform and prepare future explorers and to better understand the limits of human endurance performance.

METHODS

The participant was female (n=1, see table 1), hauling a harnessed sled using skis and ski poles, aiming to reach the South Pole, a distance of 600 km, within 45 days, starting in December. This was her third expedition to the South Pole, however, it was the first occasion where she traveled solo and unaided. The explorer monitored her own progress via GPS, thus she was aware of time, distance covered and altitude. Additionally, the explorer was in daily contact via radio with a support team agent.

- Insert table 1 about here -

Physiological characteristics: The following tests, in order, were conducted 17 days pre- and 30 days post-expedition (the closest dates to the expedition that the explorer could attend due to travel constraints). 1. Estimated percent body fat, assessed using a 4-site skinfold test (Durnin & Womersley, 1973). 2. Leg power, using a counter movement jump performed on a contact mat device and software (KMS version 2005.0.2, Fitness Technology, Australia). 3. Maximal strength for one repetition, using a barbell back squat technique to the parallel position. 4. Maximum aerobic capacity ($\dot{V}O_2max$), during a treadmill test according to standard guidelines (BASES, 1997), via measurement of gas exchange at the mouth (Oxycon Pro, Germany).

Sleep: Sleep and activity were monitored continuously by the use of an Actiwatch® (AW) and Sleepwatch software (Version 5.28; Cambridge Neurotechnology Ltd. UK) worn on the non-dominant wrist. The recording epoch was set to 2 minutes to allow sufficient memory storage for the entire expedition. The Actiwatch has been shown to be a relatively accurate instrument against polysomnography (Kushida, Chang, Gadkary, Guilleminault, Carrillo and Dement, 2001) for measuring sleep/wake parameters in a number of situations (Stanley, 2003). The following parameters were investigated (automatically calculated by the software):

1. Actual Sleep Time - the actual time spent asleep determined from Sleep Start to Sleep End minus any wake time.

2. Percentage Actual Sleep Time – the Actual Sleep Time expressed as a percentage of time asleep from Sleep Start to Sleep End;

3. Percentage Moving Time - the percentage of time spent moving during the Actual Sleep Time which is derived from the number of epochs where scores greater than zero were recorded and is an indicator of restlessness;

4. Wake Movement Average - the average activity per epoch for the whole of the daytime prior to the sleep period from Sleep End to Sleep Start;

5. Sleep Start and Sleep End – the time of onset and offset of sleep.

Mood: Mood was assessed daily using the comprehensively validated Brunel Mood Scale (BRUMS; Terry, Lane, Lane, and Keohane, 1999; Lane, Whyte, Shave, Barney, Wilson and Terry, 2003), completed before bedtime. The BRUMS assesses anger, confusion, depression, fatigue, tension, and vigour. Examples of Anger items include “Bad-tempered” and “Angry”, Confusion items include “Muddled” and “Uncertain”, Depression items include “Depressed” and “Miserable”, Fatigue items include “Sleepy” and “Tired”, Tension items include “Anxious” and “Panicky”, and Vigour items include “Lively” and “Energetic”. Items are rated on a 5-point scale anchored by “not at all” (0) and “extremely” (4).

RESULTS

Physiological differences were apparent pre- and post- expedition (see table 1), including an improved aerobic capacity (8.8% change, relative to bodyweight), a dramatic loss of bodyweight in the form of muscle and fat (8.1%) and a loss of leg power (18.5% reduction in counter movement jump height).

The Actiwatch data reveal that each day after wake up, approximately 2 hours was spent decamping before trekking began. The daily exercise routine then involved extended periods of intense physical effort, interspersed with 10 to 15 minutes rest periods, followed by 2 hours making camp, eating and preparing for bed. The longest sleep time achieved was 8hrs 14mins on Day 2, and the minimum was only 1hr 42mins on the Day 35, with 2hrs 06mins for the night prior to reaching the South Pole on Day 44 (see figure 1). The average sleep time was 5hrs 01mins. There was a gradual reduction in the hours spent asleep throughout the expedition, and during the final third, the average sleep time was only 3hrs 21mins.

- Insert figures 1 – 4 about here -

Pre-expedition mood data indicated considerable variation in vigour scores, some variation in confusion, depression and fatigue. Tension scores tended to increase as the expedition drew nearer.

Statistical relationships between mood, performance and sleep quality during the expedition indicate 26 significant intercorrelations (see table 2). Vigour was inversely related with fatigue, depression, and positively related to sleep time. Depression was positively related to anger and inversely related to sleep time. Relationships between mood, sleep and performance are highly influenced the final days of the expedition. There was a sharp increase in depression and fatigue and a reduction in vigour during the final 10 days of the expedition (see figure 4).

DISCUSSION

Consistent with previous research on physiological and psychological responses to extreme conditions, the present data show extreme fatigue and reduced vigour whilst coping with high scores of depression, tension and confusion, simultaneous with long bouts of hard exercise and little sleep. Due to the length of the expedition there may be a multitude of factors affecting mood states on a daily basis, however, only trends can be discussed in the present brief report. The pre- and post- expedition physiological and anthropometric data, coupled with the AW data showing distance and work time, clearly demonstrate extreme physiological stress which may be due to high workloads, inadequate calorific intake or both.

The reduction in the length of sleep can be explained by examining sleep start and end times. The sleep end times were consistent at approximately 11:00h until Day 39, when an earlier wake up pattern emerged starting at approximately 08:00h, however, the sleep start times became progressively later. Mood data indicated the explorer reported intense fatigue and low vigour, suggesting a strong urge to sleep. The nature of the task and necessary focus on achieving the expedition goal, coupled with the lack of environmental time cues (24 hour light) could account for a psychological overcoming of the desire to sleep longer.

The percentage of time spent asleep was moderately stable with a mean of 88.7%, (range: 73.3% on the night of Day 4 - 100% on Day 44). The Percentage Moving Time (an indication of restlessness in sleep), is considered to be normal about 20%, the range of Percentage Moving Time varied from 32.4% on Day 3 to 7.4% on Day 40, with an average of 18.9%. A downward trend was observed as the expedition progressed, reflecting better, if shorter, sleep (see figure 2). This could be due to sheer exhaustion (high fatigue and low vigour) and causing a greater drive for restorative slow wave sleep.

Figure 3 shows Moving time (hours), Wake Movement Average (activity counts) and Distance covered (miles/day) during the expedition: A comparison was made between the hours of trekking and the mileage achieved each day. The longest day was on Day 35, sleep ended at 11:28h, trekking commenced at 15:25h and ended at 07:18h (16 hours trekking) and sleep started at 09:34h (total 22 hour day). The next day started just 1hour 42 minutes later at 11:32h. Of note, the trekking hours continue to rise from day 30 to day 44, and yet distance covered fails to increase during this period, part of which may be attributed to a reduction in efficiency that could be explained by sleep deprivation.

Relationships between sleep time, mood and performance indicate that increased mileage was associated with low vigour, high fatigue, and reduced sleep. Relationships between mood and indices of sleep indicated that sleep time was positively related to vigour and inversely related to fatigue. This is consistent with the notion that positive feelings (high vigour and low fatigue) are linked with sleep. It should be noted that high mileage was associated with more moving hours, and in the context of the present study indicate that the individual had little time for sleep.

The use of intervention strategies to improve mood regulation is suggested. These are most effective when focusing on future events rather than the past, and setting achievable goals (Totterdell, Parkinson, Briner, & Reynolds, 1997). It is suggested that as well as discovering a baseline mood profile for each individual, practitioners should attempt to establish which mood management strategies are favored, and which are the most effective for the explorer’s different moods.

CONCLUSIONS

This assessment of sleep and mood revealed that it is possible to continuously decrease sleep time to an extremely low level for a prolonged period (44 days), and simultaneously maintain a very high work load, however, this pattern may have adverse affects on mood characteristics and efficiency of travel. Teaching the individual mood regulation strategies to cope with extreme negative mood could not only enhance the quality of the experience from the perspective of the explorer, but also improve performance.

REFERENCES

British Association of Sport and Exercise Sciences *Physiological testing guidelines*, 1997; 3rd edition, eds. Bird S and Davison R. BASES, UK.

Durnin JV and Womersley J. Body fat assessed from total body density and its estimation from skinfold thicknesses: measurements on 481 men and women aged from 16 – 72 yrs. *British Journal of Nutrition* 1973; 32: 77–97.

Kushida C, Chang A, Gadkary C, Guilleminault C, Carrillo O and Dement W. Comparison of actigraphic, polysomnographic, and subjective assessment of sleep parameters in sleep-disordered patients. *Sleep Medicine* 2001; 389-396.

Lane AM, Whyte GP, Shave R, Barney S, Wilson M and Terry PC. Mood disturbance during cycling performance at altitude. *Medicine & Science in Sports & Exercise* 2003; 35: S162.

Parker RH. Physiological adaptations and activity recorded at a polar base. *European Journal of Applied Physiology and Occupational Physiology* 1985; 54: 363-370.

Raschka C and Plath M. Body fat compartment and its relationship to food intake and clinical chemical parameters during extreme endurance performance. *Schweiz Z Sportsmed* 1992; 40(1): 13-25.

Stanley N. Actigraphy in human psychopharmacology: A review. Human psychopharmacology. *Clinical Experimental* 2003; 18: 39-49.

Taylor SR, Rogers GG and Driver HS. Effects of training volume on sleep, psychological, and selected physiological profiles of elite female swimmers. *Medicine and Science in Sports and Exercise* 1997; 29: 688-693.

Terry PC, Lane AM, Lane HJ and Keohane L. Development and validation of a mood measure for adolescents: POMS-A. *Journal of Sports Sciences* 1999; 17: 861-872.

Totterdell P, Parkinson B, Briner R and Reynolds S. Forecasting feelings: The accuracy and effects of self-predictions of mood. *Journal of Social Behavior & Personality* 1997; 12: 631-650.

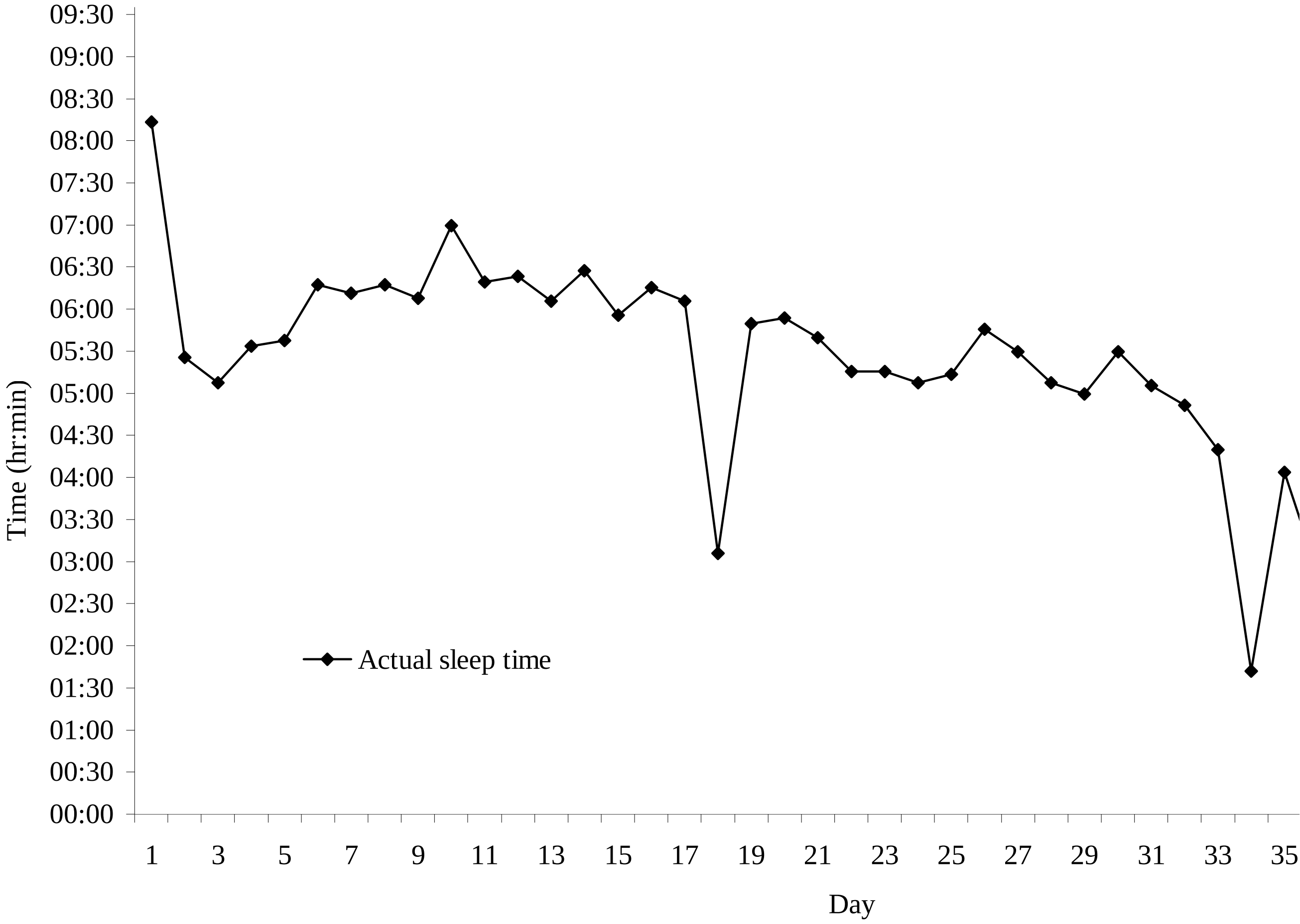

Figure 1. Actual Sleep Time during the expedition

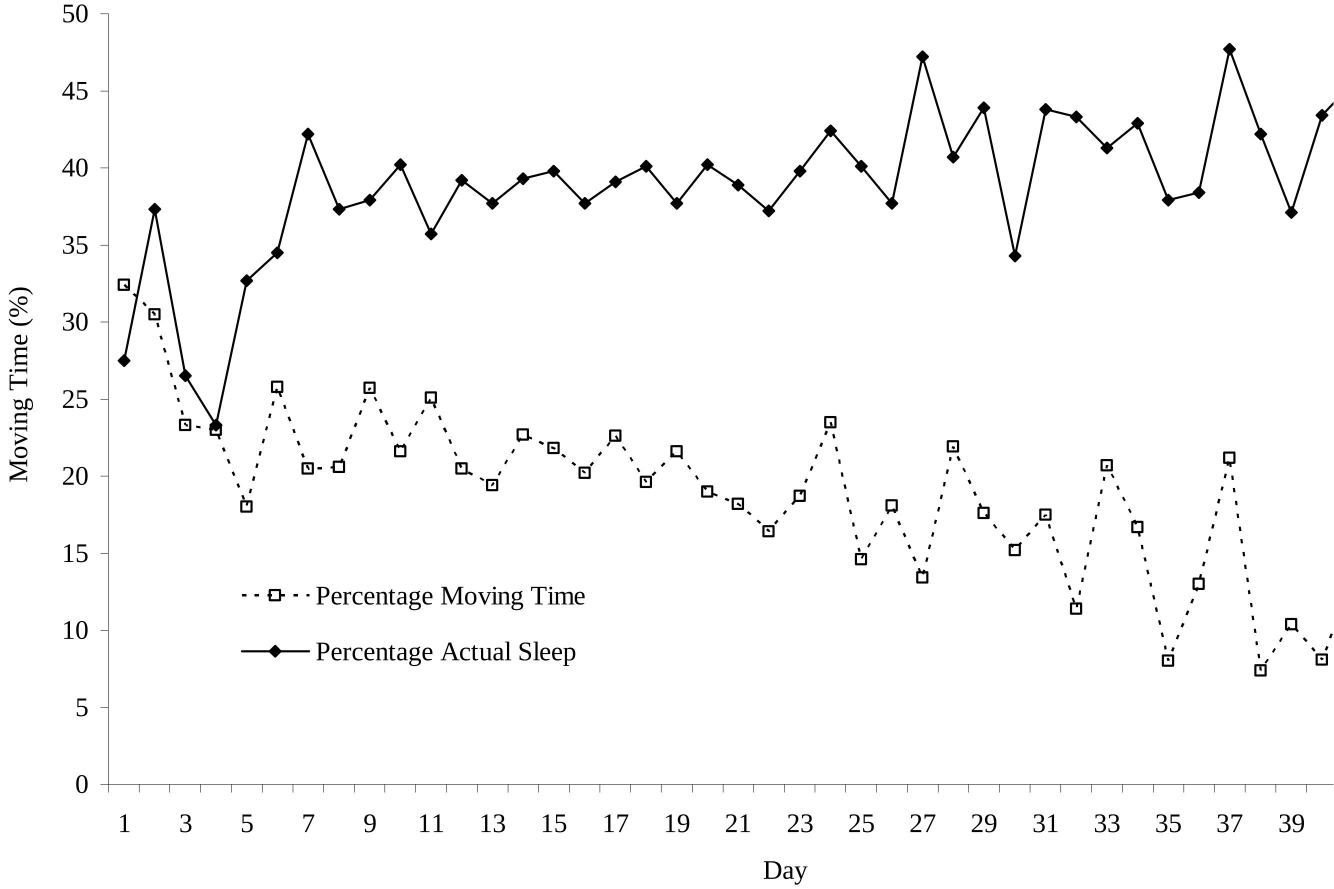

Figure 2. Percentage Actual Sleep and Percentage Moving Time during sleep

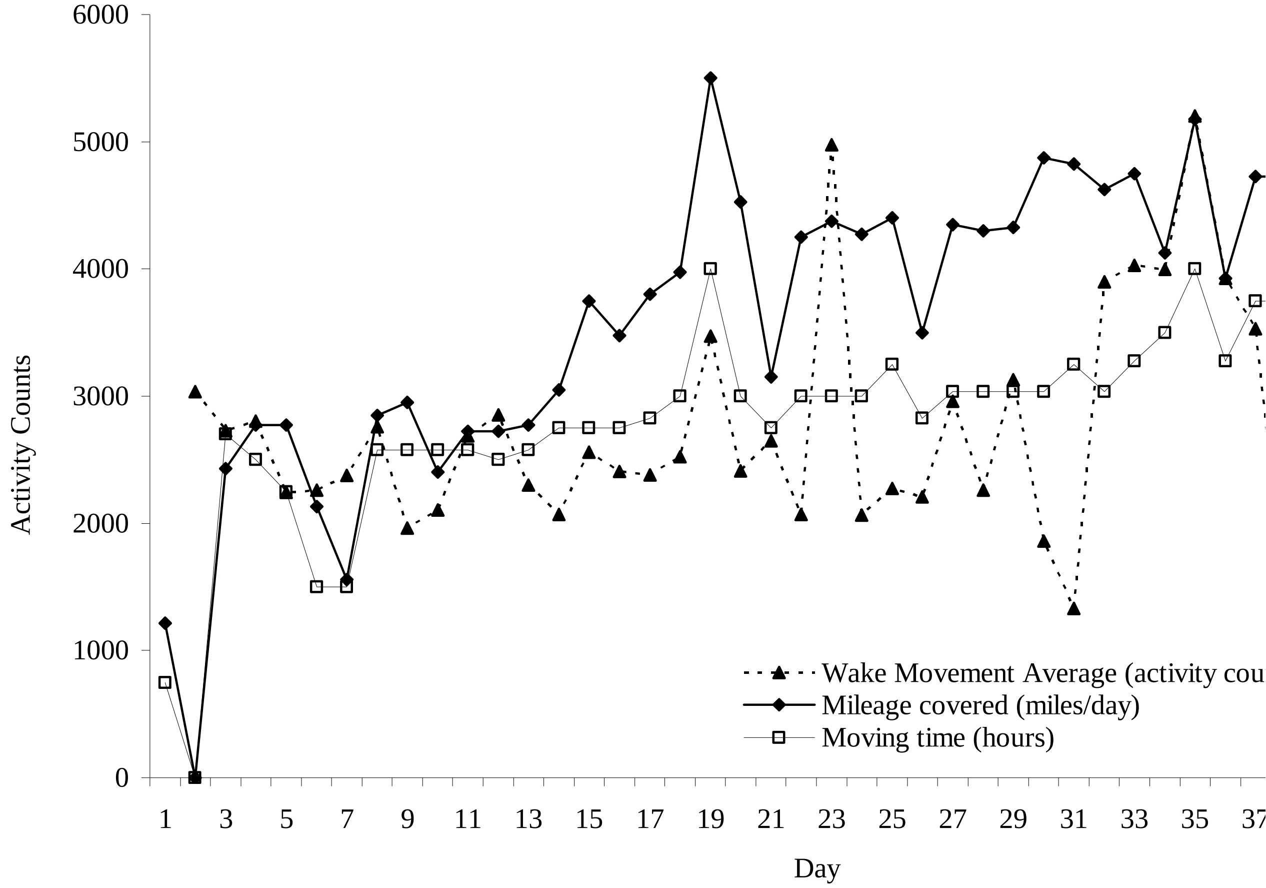

Figure 3. Wake Movement Average, hours spent trekking or hours awake, and distance during the expedition.

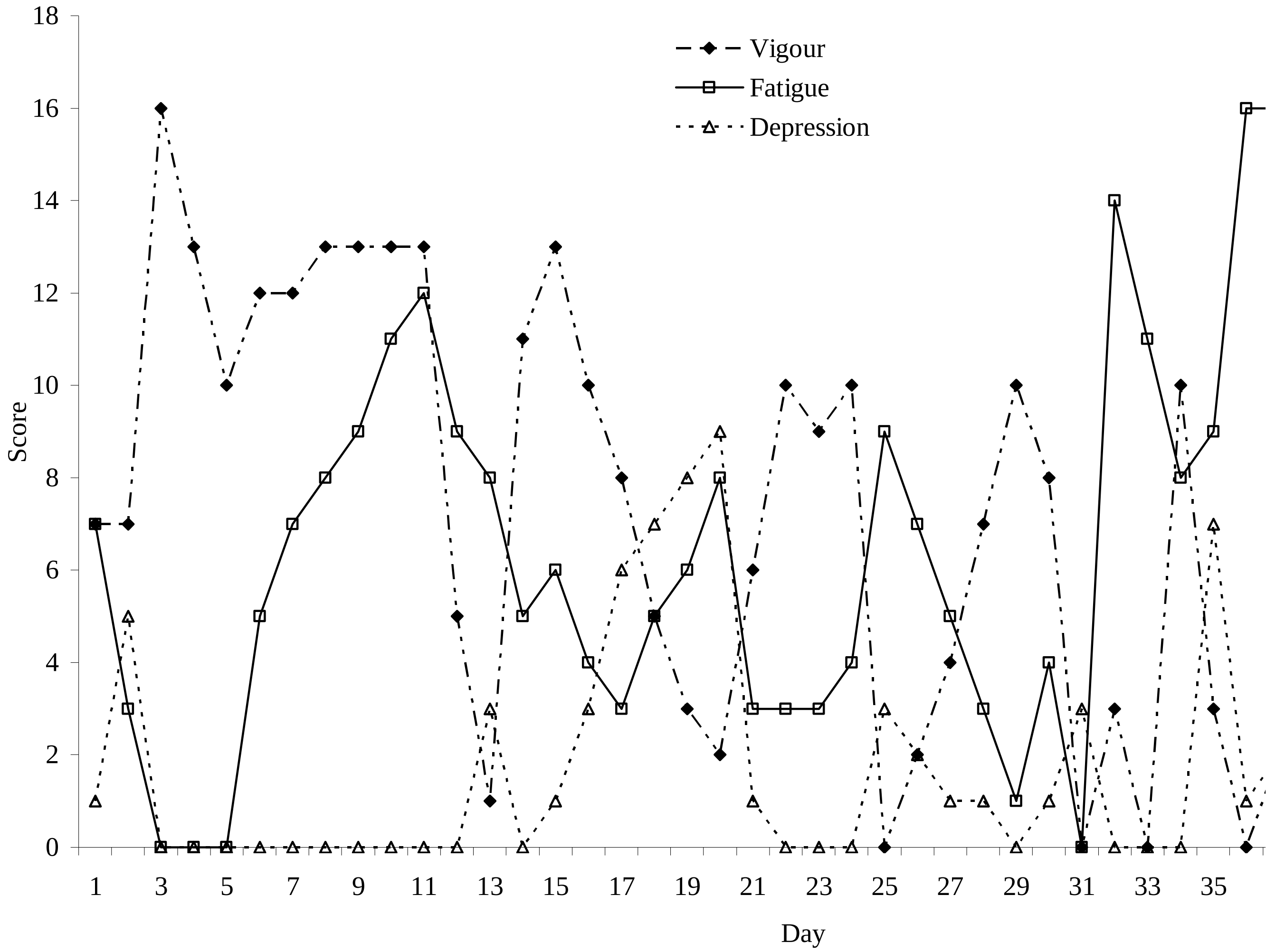

Figure 4: Mood states (Vigour and Fatigue) during the expedition

Table 1. Subject characteristics

	17 days pre-expedition	30 days post-expedition
Age (years)	43	44
Height (cms)	161.3	161.3
Weight (kg)	53.5	46.0
Estimated body fat (%)	22.6	14.5
Absolute $\dot{V}$ O_2max ($L.min^{-1}$)	2.675	2.503
Relative $\dot{V}$ O_2max ($ml.kg^{-1}.min^{-1}$)	50.0	54.4
Squat (kg)	75	75
Counter Movement Jump (cms)	32	27

Table 2. Relationships between mood, performance and sleep quality during the expedition

	Ten	Vig	Con	Fat	Dep	Ang	Hrs	Mile	
Vigor	.16								
Confusion	.32	-.10							
Fatigue	-.16	-.59*	.20						
Depression	-.02	-.35*	.49*	.27					
Anger	.02	-.17	-.03	.13	.37*				
Hours	-.74*	-.40*	-.12	.48*	-.23	.21			
Mileage	-.61	-.40*	-.19	.30	.18	.23	.88*		
Sleep time	.27	.51*	-.22	-.62*	-.35*	-.15	-.75*	-.58*	
Sleep %	-.43*	-.48*	-.09	.49*	.32	.45*	.66*	.61*	-.
Sleep fragmentation index	.16	.45*	-.07	-.52*	-.27	-.39*	-.44*	-.42*	

* $p < .05$