The examination of mental toughness, sleep, mood and injury rates in an Arctic ultra-marathon

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There is scarcity of research examining the physiological and psychological effects of ultra-endurance racing on athletes in extreme conditions. The purpose of the current study was to identify common injury patterns and illness, profile mood states and sleep patterns and finally examine the relationships between mental toughness, sleep, mood and injury rates during a 120 mile, three day Arctic ultra-marathon. Twelve participants (3 females, 9 males) with a mean age of 42± 5.35 participated in the study. Mental toughness was measured using the MT18 questionnaire. Injuries were clinically assessed and recorded each day. Temperatures ranged from -20 to -6 degrees Celsius throughout the race. Sleep quantity and mood state were recorded using the BRUMS questionnaire. The results showed that 10 out of the 12 participants experienced injuries during the race; almost half of the participants had injuries that carried over a number of days. Mean sleep duration over the three days was 4.07 hours, with an average of 0.78 injuries per day. Significant changes in mood were recorded across the three days, specifically a reduction in vigour (p=.029) and increase in fatigue (p=.014). Neither sleep quantity nor mental toughness was correlated with injury rate. Interestingly, sleep quantity was not related to changes in mood, as previously shown in ultra-marathons. Mental toughness had a moderate negative correlation (p<0.01) with depression (-.623), reduced anger (-.616), confusion (-.558), increased vigour (.497) and tension (-.420) during the race.

Keywords: endurance; environmental physiology; fatigue; injury & prevention; psychology

Introduction

Studies examining ultra-endurance racing (multi-day races in excess of 100 miles), in particular events held in 'extreme environments' such as desert, Arctic or jungle, are sparse (Anglem, Lucas, Rose, & Cotter, 2008; Anoton – Solanas et. al. 2016). Due to small numbers of athletes, relatively long distances, environmental safety concerns and complicated and expensive logistics, data collection is difficult. Research has previously reported on injury patterns and mood states in desert ultra-marathons (Graham, McKinley et al., 2012), but there have been few studies which have examined ultra-endurance races in the Arctic or Antarctic. The unique effects of polar conditions on mood, sleep, and performance have been well documented (Leon, Sandal, and Larsen 2011). Ultra-races often share a lot of the same challenges and risks of acute and chronic injuries, particularly those in the lower extremities regardless of competition location and environment. (Krabak, Waite, & Schiff, 2011; McGowan & Hoffman, 2015). However, there are additional race and environment specific challenges that must be taken in to account as well, e.g. extreme heat/cold, as it has been previously shown that the number of athletes requiring intravenous (IV) fluids at the completion of races can be directly related to maximum ambient temperature (McGowan & Hoffman, 2015). In marathon distance races, greater than 20% of reported injuries are skin problems (Roberts, 2000) with blisters making up more than 39% of reported dermatology complaints (Mailer-Savage & Adams, 2006). Ultramarathon runners have shown an increased reporting of skin related problems with 33-74% of overall injuries being related to blisters (Krabak et al., 2011). In ultramarathon races musculoskeletal injuries have been reported to account for 50-60% of injuries with the majority occurring at the knee and ankle (Knechtle and Nikolaidis 2018).

Injuries related to skin problems may be particularly pertinent in Arctic conditions, with athletes who have extremities overwhelmed by the cold conditions may develop pernio (chilblains), cold panniculitis or frostbite (Graham, McKinley et al., 2012; Helm & Bergfeld, 1998). Previous work in an Arctic environment (Graham, Connaboy, Brow, & McKinley, 2012) has reported serious exposure and frostbite injuries. Arctic conditions may cause athletes to be more prone to injuries as a consequence of incorrect training. In addition, inappropriate, inadequate or incorrect usage of clothing allied to wet clothing through excessive perspiration will increase injury rates.

Furthermore, sleep deprivation during long periods of exercise has been shown to elicit mood changes such as increased fatigue, reduced vigor (Graham, McKinley et al., 2012; Scott, McNaughton, & Polman, 2006), and impaired thermoregulation (Dewasmes, Bothorel, Hoeft, & Candas, 1993). Mood has been shown to be significantly affected over increasing time periods during exercise, for example during 100-hour adventure racing (Speedy et al., 1999). Mood changes may be a contributing factor in susceptibility to overreaching in athletes with minimal recovery opportunity during long duration events. This in turn may have serious performance and/or health consequences, as exemplified in pacing strategy selection which has been shown to be related to the balance of positive and negative affect that is experienced during competition (Helm & Bergfeld, 1998). Furthermore, when mental resources are depleted, endurance athletes are particularly prone to experiencing heightened perceived exertion (Martin, 1981), which is associated with impaired choice of pacing strategy. Such mentally demanding conditions seem likely in extreme ultra race conditions; as such, mood management appears to be of particular concern.

Given the significant challenge involved in ultra-racing, particularly those in extreme conditions, it is surprising that there is not more research examining the psychology of ultra-marathon running. Research at time of this publication has focused on investigating mood profiles (Graham, McKinley et al., 2012; Tharion et al., 1989) the types of coping strategies employed (Crust, Nesti, & Bond, 2010), personality (Hughes, Case, Stuempfle, & Evans, 2010), and pacing strategy (Henrich, 2001). Some work has also examined the relationship between psychological characteristics (such as emotional intelligence) and mood (Lane & Wilson, 2011). This is important because an athlete's affective experience and interpretation of perceived exertion is linked to performance and motivational outcomes (Salmon, Hanneman, & Harwood, 2010).

Furthermore, according to Jones, Hanton and Connaughton (2002) mentally tough athletes can be more consistent and better than their opponents in remaining determined, focused, confident, and in control under pressure. Elite athletes have described resilience, perseverance and the ability to deal with adversity as elements of mental toughness (Bull, Shambrook, James, & Brooks, 2005). Characteristics such as mental toughness have been shown to have performance and self-regulation benefits particularly in challenging circumstances (Jones, Hanton & Connaughton, 2002), which seems particularly pertinent to ultra-marathon racing. In addition, Crust and Clough (2011) suggested that individuals need to be must be exposed to challenging situations which will allow them to develop personal resources through problem solving. As such, it may be an important consideration for preparation and performance.

The purpose of this investigation was to 1. identify common injury patterns and illness; 2. profile mood states and sleep patterns and finally; 3. examine the relationships between mental toughness, sleep, mood and injury rates during an Arctic ultra-marathon.

The authors' hypothesis for this study was that despite the unique conditions of an Arctic ultra-marathon that injury patterns would be similar to races in other climates, decreased sleep would correlate with depressed mood, and that athletes with better mental toughness, sleep and mood would have lower injury rate.

Methods

Subjects

Twelve competitors, nine male and three female (Age: 42±5.35 yrs.) completed the 120 mile distance. All participants were experienced ultra-marathon runners. Five of the participants had previous experience in Arctic ultra-marathon racing. Runners participating in the 6633 Arctic Ultra-Marathon were recruited as volunteers for the study. All subjects gave written informed consent. Ethical approval was given by Edinburgh Napier University ethics committee prior to the event in accordance with the Declaration of Helsinki.

Design

This was a prospective cohort study. As this was a field-based study, a convenience sample was obtained. Because of the observational nature of the study, there was no requirement for a control group as no intervention took place.

Methodology

Race description

The 6633 Ultra, examined in this study, is an ultra-marathon event of two distances, 120 miles and 350 miles, held in the Yukon and North West Territories areas of Canada during the end of the winter season (March). It follows the course of the Dempster Highway from Eagle Planes to Ft McPherson (120-mile stage) moving onto the frozen river (ice road) in the McKenzie Delta at Inuvik to its 350-mile stage completion at Tuktoyaktuk. Weather is determined as 'ending of winter' Arctic type cold conditions with risk of environmental related injuries and little potential of adverse animal interactions. Ambient air temperatures and wind speeds are shown in Table 1.

[Insert Table 1 near here]

Athletes ran 120 miles (completed within 3 days) with self-selecting pace, rest and sleeping periods. Athletes were required to possess sufficient food, spare clothing, sleeping bag, mat and survival equipment to sustain their needs throughout the duration of the event. This food and equipment was pulled behind them in a wheeled sled (pulk) (Figure 1). The only additional provision from the race organizers was that of hot water for cooking/drinking during the race. Athlete's negotiated undulating terrain including snow covered graveled road, tundra and a frozen river (ice road). Objective dangers included environmental factors and the possibility of road traffic collision with heavy-duty haulage trucks. As such this particular ultra-marathon has significant event specific challenges and danger associated with it.

[Insert Figure 1 near here]

Pre-event

Prior to the event, volunteers filled out a questionnaire to provide background demographics and fill in the 18 item Mental Toughness Questionnaire (MT18). The MT18 is a reliable and valid tool developed to make it an accessible and user friendly in applied settings (Clough, Earle, & Sewell, 2002). It measures a single scale of mental toughness and uses a five-point Likert scale (1 - strongly disagree to 5 - strongly agree). Participants are asked to answer the items carefully, thinking about how they feel in relation to the 18 items (e.g., even when under considerable pressure I usually remain calm).

During and post-event

During the event, the Emergency Medical Technician-Wilderness (EMT-W) provided assessment and emergency trauma care, soft tissue rehabilitation and recorded each medical event. This process was delivered at vehicle checkpoints along the event route and in the rest stops. A basic physical assessment was performed by an EMT-W on each presenting athlete. Injuries and illnesses were documented on standardized injury reporting forms. If a competitor was treated multiple times for the same injury or condition (for blister treatment as an example), then each treatment was recorded as one injury. Any gastrointestinal (GI) conditions, including vomiting and diarrhea, that were related to hydration status were documented as dehydration.

Mood state was assessed using the Brunel Mood State (BRUMS) (Terry, Lane, & Fogarty, 2002). The BRUMS is reliable and has been validated for use by athletes (Galambos, Terry, Moyle, & Locke, 2005) and is suitable for application in ultra-endurance events in wilderness areas due to brevity, relative ease of administration and carriage. BRUMS measures six subcategories of mood including anger, confusion, depression, fatigue, tension, and vigor. The 24 items in the scale are rated on a 5-point scale from 0 (not at all) to 4 (extremely). Examples of items include: panicky; sleepy; depressed; lively; uncertain; energetic; angry; tired; alert; active and muddled. Finally, after the event, a full self-assessment sleep log was submitted by all athletes documenting the quantity of sleep achieved on a daily basis.

Statistical analysis

Data analysis was performed using SPSS (PASW Statistics 18.0, SPSS Inc., Chicago, IL, USA). Descriptive statistics were used to describe the patterns of injury and illness and mood states of the participants on a daily basis. Repeated measures ANOVAs were used to test differences between the variables (e.g., injury, illness and mood) across the three days. The relationships between mood, mental toughness, sleep, and injury rates were investigated using the non-parametric Kendal’s Tau-b correlation. Differences were considered statistically significant at the $p<0.05$ level.

Results

Pathology

Of the twelve participants, eight reported multiple injuries, two reported a single injury and two reported no injuries across the three-day race. Over half of the participants (58%) reported abrasions, two reported hip musculoskeletal pain, two reported diarrhea and vomiting, two reported blisters and two cases of frost injury were reported (Figure 2). Fatigue/exhaustion, back, knee, ankle, knee and shin problems were injuries reported by individuals. Almost half (42%) of the participants reported injuries that carried over multiple days. These included abrasions, blisters, diarrhea and vomiting, fatigue and hip and back muscular pain. Across time, different patterns of injuries were apparent. Through the first day, eight participants reported no injuries, one had a single injury and three reported multiple injuries. During the second day, six participants reported multiple injuries, one reported a single injury while three reported no injuries. On the final day, two participants reported multiple injuries, three a single injury and four reported no injuries. Mean number of injuries reported was significantly different across the three days ($F(7, 2) = 5.224$; $p = 0.041$) with most injuries occurring on day two (1.2 ±.8) and least on day one (.3 ±.7), with third day mean injury rates at .8 (±.8).

[Insert Figure 2 near here]

Sleep, mood, injuries and mental toughness

Mean sleep duration over the three days was 4.1 (± 2.8) hours. Sleep duration was at its lowest on day two (3.7 ± 2.7 hours) but did not vary much across the three days. Perceived vigor showed statistically significant differences across time ($F(7, 2) = 6.112$; $p = 0.029$), where mean values decreased from day one to day two and maintained day two levels into day three. Perceived fatigue significantly changed over time ($F(7, 2) = 8.303$; $p = 0.014$), increasing from day one to day two and decreased on day three but not back to day one levels. While the trend of mood increasing from day one to day two and reducing through day three was apparent for anger, confusion, and depression, no results reached statistically significant differences. The mean mental toughness score across the twelve participants was 3.6 (±.5).

With regards to sleep and mood, no significant relationships were observed. However, significant relationships were found between mental toughness and mood states. Specifically, there were moderate negative correlations between mental toughness and anger (r = -.61); confusion (r = -.55); depression (r = -.62), and for tension (r = -.42), and moderate positive correlation for vigour (r = .49), $p<0.01$. No relationships were found between sleep, mental toughness and injury rates (Figure 3).

[Insert Figure 3 near here]

Discussion

The purpose of this investigation was to 1. identify common injury patterns and illness; 2. profile mood states and sleep patterns and finally; 3.examine the relationships between mental toughness, sleep, mood and injury rates during an Arctic ultra-marathon.

In support of the authors' hypothesis, despite the unique conditions of an Arctic ultra-marathon injury patterns were be similar to races in other climates. In contrast to the authors' hypothesis in regards to the effect of sleep on mood, no significant relationships were observed, however, significant relationships were found between increased mental toughness resulting in improved mood states. Finally, no relationships were found between sleep or mental toughness in relation to injury rates.

This study supported the assertion that both acute and chronic (spanning multiple days) injuries are common in ultra-racing (Anglem et al., 2008). Specifically, 85% of racers sustained an injury, with almost half managing injuries that spanned multiple days. Approximately two-thirds of the participants were treated for abrasions and/or blisters. This is consistent with previous research that highlighted that 70% of injuries reported in ultras were skin and soft tissue (Krabak et al., 2011; McLaughlin et al., 2006) usually located in lower extremities (Fallon, 1996).

It is clear that any preparation and medical support that can minimize the rates of soft tissue injuries would be advantageous. Participants, medical and support staff must plan for the diverse range of climatic conditions associated with specific ultra-marathon races, in order to provide effective support in extreme environments. Knowledgeable delivery of pre-race preparation and planning, particularly in equipment, clothing, nutrition and training strategies will maximize athletes' potential and minimize injury. While this study did not investigate pre-race physical training and did not directly measure footwear suitability, gait or biomechanics of movement, or musculature imbalance it is suggested that lower leg injury rates could be reduced by improving training by making it more event specific. For instance, the common method of movement with a pulk is more akin to a fast 'polar plod' (a slow regular jog with low foot lift similar to military movement with heavy load carriage as espoused by Sir Ranulph Fiennes) than to normal marathon running while training generally consisted of road and trail running (Fiennes, R 1983). By not considering specific training strategies concerned with footwear type and sizing, terrain familiarity and distance athletes are increasing their potential for injury and race failure (McLaughlin et al., 2006).

Past research has highlighted that mood disruption is typical during ultra-marathon racing (Anglem et al., 2008; Graham, Connaboy et al., 2012; Graham, McKinley et al., 2012), and particularly over longer expeditions (Pedlar et al., 2007). This was supported within this study, where the vigor and fatigue components of mood were affected over the three-day race. Furthermore, evidence from ultra-marathon research supports the contention that positive feelings are linked with sleep (Scott et al., 2006). For example, reduced sleep time has been shown to be related to reduced vigor, reduced exercise tolerance (Martin, 1981), and increased depression and fatigue (Graham, Connaboy et al., 2012; Graham, McKinley et al., 2012; Pedlar et al., 2007), which has subsequently been linked to motivation and pacing strategy choice (Speedy et al, 1999). Indeed, a combination of sleep deprivation and exercise has been shown to exacerbate the mood disturbances, as well as cognitive function (Scott et al., 2006; Nybo & Secher, 2004). However, in contrast to previous work, this study did not show any correlations between sleep and mood.

While there was some contrast with this study and previous research in the relationships between sleep and mood, interestingly there were significant relationships found between mental toughness and increased vigor, as well as mental toughness and decreased anger, confusion, depression and tension. Work by Lane and Wilson (2011), reported that emotional intelligence was related to mood regulation during ultra-marathon racing, supporting the assertion that certain psychological characteristics improve our ability to regulate emotions effectively (Lucas, Anson, Palmer, Hellemans, & Cotter, 2009). There are many examples, of multi-modal skills training packages that can help to develop emotional self-regulation (Robazza, Pellizzari, & Hanin, 2004; Collins, Martindale, Button, & Sowerby, 2010). This potentially holds much promise for improved preparation and performance of ultra-runners. It is clear from research examining expedition in extreme conditions that additional challenges exist (Dinges, 1992; Leon, Sandal, and Larsen 2011), and a wide range of coping skills and strategies are required to self-regulate successfully (Devonport, Lane & Lloyd, 2011). Finally, while previous research has suggested that individual athletes should more adequately prepare sleep strategies in order to enhance their performance, this study provides evidence that strategies improving mental toughness may be more pertinent, particularly as there are performance advantages with spending less time sleeping if it can be handled effectively.

There are a number of limitations with this study design. This study used a convenience sample in which the authors did not have control over which athletes participated in the race and as a result it is unknown whether this population accurately reflects the population of athletes that participates in ultramarathon racing which may limit the overall generalization of these findings. Injury rate was reliant on athlete self-reporting and as a result it is possible that athletes may have underreported injuries and/or illnesses during the race which would affect accurate correlation with sleep and mental toughness. The authors also did not collect data from athletes on prior or current injuries at the start of the race which could also have played a role in the injury rate encountered during the race. Finally, while ultramarathons share a lot of common attributes regardless of competition and environment it should be noted that this ultramarathon had unique attributes that may limit the applicability to all races.

In consideration of future research there should be a focus on how mental toughness training as part of a multi-disciplinary training regimen can affect mood and performance during ultramarathons. In addition, further studies to evaluate the best way for medical providers to incorporate psychological support during races to improve and augment mental toughness of the athletes during ultramarathons are needed.

Practical Applications

Pre-event emotional states and resiliency have been linked to enhanced performance during strenuous competitions (Maguen et al. 2008). The demonstration of the correlation between stronger pre-race mental toughness and improved physical (vigor) and mood during ultramarathon distance races highlights the importance of an underappreciated aspect of training for coaches, sports psychologists, and trainers to focus on incorporation into a well-rounded training regimen.

Sport physiologists and coaching staffs may want to consider utilizing the MT18 questionnaire during pre-race training evolutions to monitor the progression of mental toughness leading up to race day. Training sessions and intensity, as well as, additional psychological support can then be provided and incorporated into training evolutions based on these findings. This ultimately may lead to enhancement of physical and cardiovascular training regimens and improved performance during the race.

Once the race begins a final pre-race assessment can allow a new and unique way for coaches and medical personnel to identify those athletes who may need additional psychological support during the race.

Conclusion

Despite the unique conditions of an Arctic ultra-marathon injury patterns were be similar to races in other climates. Sleep did not have a significant effect on mood, however, a significant relationship weas found between increased mental toughness resulting in improved mood states. There was no relationship found between sleep or mental toughness in relation to injury rates.

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Table 1. Ambient air temperatures and wind speeds.

Figure 1. Wheeled sled (pulk).

Figure 2. Example of frost injury caused by inadequate windproof coverage in high wind chill conditions.

Figure 3. Mood and sleep scores.

Table 2 Inter correlations of the Main Variables