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Letter to editor

The Effects of Transmeridian Travel and Altitude on Sleep: Preparation for Football Competition

Dear Editor-in-Chief

International competitions require football teams to travel across multiple time zones. In some circumstances these competitions are held at altitudes of up to 3600 m. This presents football players with challenges associated with transmeridian travel and altitude exposure, which have been shown to impair sleep quantity and quality (Reilly, 2009; Roach et al., 2013). Specifically, youth football players' at altitude obtain less deep sleep and less rapid eye movement sleep (Sargent et al., 2013). Given that muscle recovery takes place during deep sleep, the reduction in deep sleep at altitude may limit athletes' post-exercise processes (Dattilo et al., 2011, Samuels, 2008). Sleep disturbances in athletes has been shown to decline with the amount of time spent at altitude, at least in the absence of jet-lag (Roach et al., 2013, Sargent et al., 2013). Yet, international competition at altitude is often accompanied by transmeridian travel, which causes a temporary misalignment between the internal body clock and the local destination time. Although transmeridian travel and altitude exposure are known to disrupt sleep, their combined effects have not been examined. To address this oversight, this study examined the longitudinal changes in the extent of sleep disruption, in response to, the combination of transmeridian travel and ascending to altitude.

Sixteen members of the Australian U/20 men's football team (Mean ± SD: age 18.8 ± 0.9 years, height 182.5 ± 5.2 cm, weight 77.8 ± 4.3 kg) participated in the study and gave written informed consent. This study was approved by the human research ethics committees of both the University of South Australia and the Australian Institute of Sport and complied with the Declaration of Helsinki. Data collection commenced four weeks prior to the 2011 U/20 FIFA World Cup held in Manizales, Colombia. Participants' sleep/wake behaviour were collected for three nights at sea level (43 m, Sydney, Australia), 10 nights at low altitude (1600 m, Denver, USA) and six nights at moderate altitude (2150 m, Manizales, Colombia) using sleep diaries and wrist activity monitors (Philips Respironics, Bend, Oregon, USA). The following dependent sleep variables were derived from the activity monitor and sleep diary data:

- *Total Sleep Time (h):* the total amount of sleep obtained during a sleep period.
- *Sleep Efficiency (%):* the percentage of time in bed that was spent asleep.
- *Mean Activity Score:* the sum of the activity counts between sleep onset and sleep offset divided by the number of epochs between sleep onset and sleep offset.
- *Subjective Sleep Quality*: the participant's self-rating of sleep quality on a 5-point Likert scale of 1 (very good) to 5 (very poor).

The trip from Australia to North America required an 8-h eastward time zone change between Sydney (GMT +10 h) and Denver (GMT -6 h). In Denver, the participants followed a schedule of sunlight exposure/avoidance to facilitate adjustment to the new time zone. The trip from North America to South America required a 1-h eastward time zone change between Denver (GMT -6 h) and Manizales (GMT -5 h). Mixed-effects ANOVAs were conducted to examine the changes in the amount and quality of sleep obtained by football players traversing multiple time zones and ascending to altitude. At low altitude, the participants obtained less sleep 6.6 h (± 1.3) per night compared to sea level 7.5 h (± 1.3) and moderate altitude 6.9 h (± 0.9). Participants rated their subjective sleep quality as 'better than average' (2.5 ± 0.8) at sea level, and 'average' at low altitude (3.0 ± 1.0) and moderate altitude (2.9 ± 1.0). Figure 1 presents the daily comparisons between sleep variables (i.e. total sleep time, sleep efficiency, mean activity score, and subjective sleep quality) at sea level, low altitude, and moderate altitude.

In this study, football players' sleep was compromised following transmeridian travel and altitude ascent. This was evident as the amount of sleep football players obtained was longest at sea level and shortest following transmeridian travel and at low altitude. The exposure to low altitude facilitated the adjustment to the new time zone and moderate altitude. The amount of sleep obtained by football players stabilised following five–six days of exposure to low altitude (Figure 1a). Despite ascending a further 550 m to Manizales, Colombia (2150 m) football players obtained 0.6 h more sleep compared to low altitude. It is possible that football players had ample time (i.e. 10 days) to adapt to the new time zone and low altitude such that a further ascent of 550 m was not enough to disrupt their sleep. The amount of sleep obtained on Day 25 was shortest compared to any day as this was the night preceding an early morning flight to Manizales, Colombia. The quality of sleep was poorest immediately following transmeridian travel and altitude ascent. There was some, but no major disruption to the quality of sleep on the first night following the 550 m ascent to moderate altitude (2150 m). This observation was consistent for all sleep variables where football players showed signs of sleep disturbances on the first night at moderate altitude. Given that the football players had already been exposed to low altitude (1600 m), this disruption may be attributed to a first night effect as football players relocated to the location of competition and slept in a new bedroom environment.

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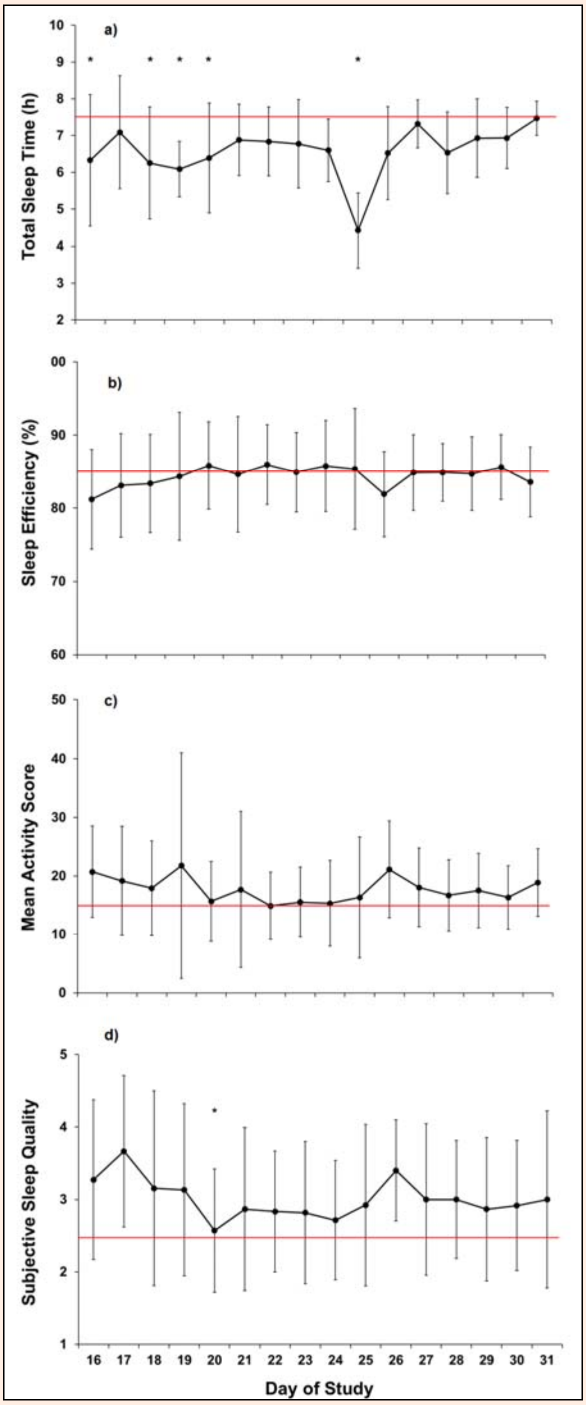

Figure 1. Total sleep time (a), sleep efficiency (b), mean activity score (c), and subjective sleep quality (d) at low and moderate altitude compared to sea level. The horizontal red line represents the mean of each sleep variable at sea level. Data are presented as M ± SD. Significant difference from sea level * $p < 0.05$. Note: Day 16 – 25 represents data collected at low altitude in Denver (1600 m), where Day 16 represents the first day at low altitude. Day 26 – 31 represents data collected at moderate altitude in Manizales (2150 m).

The findings of this study are consistent with research indicating that athletes experience sleep disturbances at moderate-high altitude (Roach et al., 2013; Sargent et al., 2013). The data presented by Roach et al. (2013) and Sargent et al. (2013) were limited as they did not examine sleep immediately after transmeridian travel and/or compared sleep between sea level and altitude natives. The results from this study show that football players' sleep behaviour stabilised following five–six days of exposure to low altitude (Figure 1). Typically, an 8 h phase advance following an eastward flight would take approximately 7.6 days (57 min/day) to adjust the body clock to the new time zone (Aschoff et al., 1974). However, the exposure and avoidance of sunlight increased football players' rate of adaptation to the new time zone one-two days (37-42 min/day) faster than normal. This is the first study to investigate the combined effects of transmeridian travel and altitude ascent on the amount and quality of sleep obtained by football players in preparation for a major football competition at altitude. It is possible that altitude natives experience less, if any, sleep disturbances at altitude when compared to sea level natives (Roach et al., 2013). Interestingly, the first game of the tournament was against Ecuador (e.g. an altitude native team, ~2800 m) in Manizales, Colombia (i.e. 2150 m) which finished in a 1-all draw. Data from this study indicate that 14 days at a new time zone and respective altitude provided a suitable adaptation period for football players to successfully compete against an altitude native team. These data, in conjunction with those presented in Roach et al. (2013) and Sargent et al. (2013) indicate that football teams scheduled to compete at altitude are encouraged to expose themselves to the respective altitude for a minimum of 14 days prior to competition to ameliorate the challenges associated with adjusting to a new time zone and sleeping at altitude.

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References

Aschoff, J., Hoffmann, K., Pohl, H. and Wever, R. (1974) Re-entrainment of circadian rhythms after phase-shifts of the zeitgeber. *Chronobiologia* **2(1),** 23-78.

Dattilo, M., Antunes, H., Medeiros, A., Mônico Neto, M., Souza, H., Tufik, S. and De Mello, M. (2011) Sleep and muscle recovery: Endocrinological and molecular basis for a new and promising hypothesis. *Medical Hypotheses* **77(2),** 220-222.

Reilly, T. (2009) How can travelling athletes deal with jet-lag? *Kinesiology* **41(2),** 128-135.

Roach, G.D., Schmidt, W.F., Aughey, R.J., Bourdon, P.C., Soria, R., Claros, J.C.J., Garvican-Lewis, L.A., Buchheit, M., Simpson, B.M. and Hammond, K. (2013) The sleep of elite athletes at sea level and high altitude: A comparison of sea-level natives and high-altitude natives (isa3600). *British Journal of Sports Medicine* **47(Suppl. 1),** i114-i120.

Samuels, C. (2008) Sleep, recovery, and performance: The new frontier in high-performance athletics. *Neurologic Clinics* **26(1),** 169-

180.
Sargent, C., Schmidt, W.F., Aughey, R.J., Bourdon, P.C., Soria, R., Claros, J.C.J., Garvican-Lewis, L.A., Buchheit, M., Simpson, B.M. and Hammond, K. (2013) The impact of altitude on the sleep of young elite soccer players (isa3600). *British Journal of Sports Medicine* **47(Suppl. 1),** i86-i92.

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