Effects of long-haul transmeridian travel on player preparedness: Case study of a national team at the 2014 FIFA World Cup.

Abstract

Objectives: Describe the effects of eastward long-haul transmeridian air travel on subjective jet-lag, sleep and wellness in professional football (soccer) players prior to the 2014 FIFA World Cup in Brazil.

Design: Single cohort involving twenty-three male professional football players representing a national football team.

Methods: Data was collected from players prior to and following international travel from Sydney, Australia to Vitoria, Brazil. In total there were three flights, 19-h and 14,695 km of travel east across 11 time-zones. Training load and wellness measures were obtained in the week prior to and following travel, whilst sleep and jet-lag measures were collected on the day prior to travel (Pre), the day of arrival and for five days following travel (Post 1 to 5).

Results: Compared to Pre, perceived jet-lag was significantly increased on Post 1 to 4, with significantly greater levels on Post 1 compared to Post 5 ($p<0.05$). Self-reported sleep duration during travel was 5.9 (4.8-7.0) h, which was significantly lower than all other nights ($p<0.01$), except for the night of arrival, where time in bed and sleep duration were significantly reduced compared to Post 1, 2, 3 and 4 ($p<0.01$). Lastly, compared to the week prior to travel, mean wellness was significantly reduced during the week following travel ($p<0.01$).

Conclusions: Self-reported sleep disruption during and following eastward long-haul transmeridian air travel, together with exacerbated jet-lag symptoms may result in reduced player wellness. Consequently, player preparedness for subsequent training and competition may be impeded, though physical performance data is lacking.

Keywords: Soccer, jet-lag syndrome, sleep, recovery of function, wellness questionnaire

1. Introduction

Optimal preparation for major international football (soccer) competition is essential, since they occur infrequently and often following a prolonged and strenuous domestic season. Further, given these competitions occur at various destinations around the world, long-haul international travel is often inevitable. As reduced physical performance, sleep disruption and negative mood states have all been reported in response to long-haul transmeridian travel[1-3], players' preparation may be compromised by travel. However, limited information currently exists on the effects of long-haul travel prior to international football competitions on player preparedness[4].

Jet-lag symptoms, particularly sleep disruption and increased daytime fatigue, occur following the loss of synchrony between endogenous circadian rhythms (e.g. body temperature) and external cues (e.g. light-dark cycle), due to rapidly crossing multiple time-zones during air travel[5-7]. Conversely, travel fatigue is induced by the demands of air travel, including the schedule (departure/arrival times and stop-over's), mild hypoxia, cramped conditions, and associated sleep disruption[8,9]. Consequently, it is plausible that long-haul travel may impact players' sleep and wellness, which could compromise preparation for ensuing training and competition. Whilst a plethora of studies report detrimental effects of long-haul air travel[2,3,6], few are with professional football players; thus the inter-individual variation in travel responses[6] suggests further research is warranted.

Due to the fatigue and disruption of routine induced by long-haul travel, perceived player wellness (fatigue, sleep quality, stress and muscle soreness), may be worse. In turn, suppressed wellness may have ramifications for training sessions performed in the first few days following arrival. For example, compared to the week preceding travel, mean wellness was reduced in professional football players the week following 10-h northbound air travel across one time-zone[10]. Though it is likely this resulted from the training schedule rather than explicitly travel, it is the only study to investigate long-haul travel prior to competition for player preparedness.

Therefore, the aim of the present study was to describe the effects of long-haul air travel from Australia to Brazil on subjective jet-lag, sleep and wellness responses in professional football players prior to the

2014 FIFA World Cup. In addition, the study aimed to identify whether player age and/or experience were determining factors for inter-individual variation in travel responses.

2. Methods

Twenty three male professional football players from the Australian national football team participated in the present study (Mean±SD; 26±4 y, height 180±6 cm, body mass 75.8±6.5 kg). Data were collected based on procedures cleared by the Institutional Human Research Ethics Committee and as part of routine sports science servicing that players consent to as part of their national-team duties.

Following familiarisation with all experimental measures and procedures, data was collected from players prior to and following international travel from Sydney, Australia to Vitoria, Brazil for the 2014 FIFA World Cup. Specifically, training load and wellness measures were obtained in the week prior to (Pre 6 to 1) and following travel (Post 1 to 6), whilst subjective sleep and jet-lag measures were collected on the day prior to travel (Pre 1), the day of arrival and for five days following travel (Post 1 to 5). The departure and arrival times were 12:25 Australian Eastern Standard Time (AEST) and 20:30 on the same day Brazilian Time (BRT [AEST -13h]). In total there were three flights, 19 h and 14,695 km of travel east across 11 time-zones; Flight 1 - Sydney, Australia to Santiago, Chile (12.7h and 11,365 km); Flight 2 - Santiago, Chile to Curitiba, Brazil (4.0h and 2,255 km); Flight 3 - Curitiba, Brazil to Vitoria, Brazil (2.5h and 1,075 km). Players travelled in business class for flight 1 and economy class for flights 2 and 3.

The Liverpool John Moore's University (LJMU) jet-lag questionnaire[5] was completed immediately prior to travel (12:00 AEST) and at a standardised time (19:00 BRT; 08:00 +1day AEST) for five days following travel. Following previous methods[11], negative outcomes were allocated positive scores and positive outcomes were provided negative scores before being pooled for summation into five categories; jet-lag, sleep, function, diet and bowel movement. A greater overall value indicated worse symptoms.

Players' sleep patterns were monitored through self-report diaries, from which the following dependent variables were derived [12];

- Bed time (hh:mm): in bed and start attempting to sleep.
- Sleep-onset time (hh:mm): estimated time fell asleep.
- Wake time (hh:mm): initial wake-up time.
- Get-up time (hh:mm): stopped attempting to sleep and got out of bed.
- Time in bed (h): time in bed attempting to sleep between bed and get-up time.
- Sleep onset latency (min): time between bed and sleep-onset time.
- Sleep duration (h): time spent in bed asleep (wake time - sleep-onset time).
- Sleep efficiency (%): sleep duration expressed as a percentage of time in bed.

Naps were not recorded, which is recognised as a limitation of the present study. In addition, players self-reported their sleep duration (h) during each flight, which was summed and reported as total sleep duration (h) during travel. Though no specific sleep schedule was provided to players, general sleep hygiene guidelines were distributed prior to travel. Furthermore all players were administered 2 mg of prolonged release melatonin (Ciracdin®, Aspen Pharmacare, NSW, Australia) by the team doctor at ~14:00 local time on Flight 1, ~1 h prior to attempting to sleep.

Training loads (arbitrary units, [AU]) were calculated by multiplying each players training session or match duration (min) by their session rating of perceived exertion (sRPE) provided approximately 30 min after[13]. Furthermore, a wellness questionnaire[14] was completed at a standardised time each day (~09:00 local time) to assess players' fatigue, sleep quality, muscle soreness and stress on a Likert scale from 1 (worst) to 5 (best). Overall wellness was determined by summing the four scores[14]. To identify whether playing experience was a determining factor for inter-individual variation in travel responses, player age and number of international appearances was obtained from Football Federation Australia's official records.

Data are presented as mean (95% confidence intervals [CI]). Differences in total training load and mean wellness between the week prior to and week following travel were assessed using a two-tailed, paired samples t-test. Repeated measures multivariate analyses of variance (MANOVA) determined effects of time (day) on grouped dependent variables related to sleep, jet-lag and wellness (SPSS, version 20, Chicago, IL). Where a significant multivariate main effect was observed ($p<0.05$), univariate main effects were examined and if significant, Bonferroni adjusted post-hoc pairwise comparisons were calculated. Furthermore, standardized effect size (Cohen's d) analyses were used to interpret the magnitude of differences, though only large effect sizes (ES; d>0.90) are reported. Lastly, Pearson's product-moment correlation analysis assessed the association between players' experience and their sleep, jet-lag and wellness responses on the first day only (6 variables) and average for the week following travel (6 variables), based on standard criteria[15]. In total 24 correlations were performed and thus adjustments were made to account for multiple related analyses with significance set at $p<(0.05/\text{number of tests})$.

3. Results

Significant multivariate main effects of time were observed for the grouped variables assessing constructs related to sleep ($p=0.02$) and jet-lag ($p=0.007$), but not wellness ($p=0.06$). Significant univariate main effects of time were detected for jet-lag ($p<0.001$) and sleep ($p=0.007$). Compared to Pre 1 subjective jet-lag was significantly greater on Post 1 to 4 ($p<0.001$, d>0.90; Figure 1). No significant pairwise comparisons were observed for sleep ($p>0.001$). Large ES suggested worse sleep and function on Post 1 and 2 compared to Pre (d>0.90; Figure 1).

Insert Figure 1 here

Significant univariate main effects of time were detected for all sleep variables ($p<0.006$). Total sleep duration during travel was 5.9 (4.8-7.0) h (Flight 1=4.5 (3.7-5.3) h; Flight 2=0.9 (0.5-1.4) h; Flight 3=0.4 (0.2-0.6) h), which was significantly lower than all other nights, except for Post 1 ($p<0.001$, d>0.90). Bed and sleep onset times were significantly later on the day of arrival compared to Post 1, 2, 3 and 4 (*p*<0.001, d>0.90; Table 1). In addition, wake times were significantly later on Pre compared to all other time points (*p*<0.001, d>0.90; Table 1), with large ES suggesting that get-up times were also later on Pre compared to all other time points (d>0.90; Table 1). Time in bed and sleep duration were significantly reduced on the day of arrival compared to Post 1, 3 and 4, and all other time points, respectively (*p*<0.001, d>0.90; Table 1), and sleep efficiency was significantly reduced on the day of arrival compared to Pre (*p*<0.001, d>0.90; Table 1). Moreover, large ES indicated that compared to Pre, sleep efficiency was reduced at all other time points (d>0.90).

Insert Table 1 here

Though no significant differences were evident between the week prior to and week following travel for total training duration (311 (280-342) vs. 313 (278-348); *p*=0.69; d=0.02) and load (1955 (1713-2197) vs. 1904 (1643-2165); *p*=0.32; d=0.12), a significant reduction in mean wellness was observed during the week following travel compared to the week prior to travel (15.8 (15.2-16.4) vs. 16.3 (15.6-17.0); *p*<0.01, d=0.40). Large ES indicated fatigue, sleep and wellness were all worse on Post 1 compared to Pre (d>0.90; Figure 2).

Insert Figure 2 here

No significant correlations were observed between players experience and their sleep, jet-lag and wellness responses on the first day only and average for the week following travel (*p*>0.002). However, a large negative correlation was evident between function ratings on Post 1 and number of international appearances (*r*=0.54, *p*=0.007) - i.e. better function ratings on Post 1 were associated with a greater number of international appearances. A moderate negative correlation was detected between international appearances and both jet-lag (*r*=0.35, *p*=0.10) and sleep duration (*r*=0.36, *p*=0.08) on Post 1. Lastly, a moderate negative correlation was observed between mean sleep duration for the week following travel and age (*r*=0.44, *p*=0.03) and international appearances (*r*=0.43, *p*=0.04).

4. Discussion

The present study examined the effects of 19-h eastward air travel across 11 time-zones on subjective jet-lag, sleep and wellness in professional football players prior to the 2014 FIFA World Cup in Brazil. Self-reported sleep duration was reduced during travel and the night following arrival and consequently, worse function, fatigue and wellness ratings were reported on the first day post-travel. Whilst the self-reported sleep-wake cycle appeared to normalise after the first day following travel, jet-lag was increased for five days post-travel. As a result, despite no differences in training duration and load, a reduction in mean wellness was observed during the week following compared to the week prior to travel. Though these results indicate that long-haul eastward transmeridian travel may reduce player preparedness, given sport-specific performance was not measured, it is unclear whether this had an impact on subsequent training and/or competition performance.

Subjective jet-lag was increased for five days post-travel in the present study, with greater levels on the first day and ameliorating thereafter. Additionally, worse function and sleep ratings persisted up to two days post-travel. Following transmeridian air travel, the sleep-wake cycle may normalise prior to the adjustment of body temperature, which appears to coincide with the disappearance of jet-lag symptoms[16]. Though it is a limitation that no physiological markers of circadian rhythms were measured, a similar pattern of subjective adjustment was observed. Since the destination time-zone was 13 h behind the departure location it is assumed that a phase-delay adjustment occurred. However, this is unsubstantiated and melatonin administration during travel may have assisted induced phase-advances[17]. Previously, increased subjective jet-lag symptoms were only reported up to two days following 18-h of westward air travel across four time-zones in professional football players[4], and symptoms were elevated for seven days following 24-h of eastward air travel across 14 time-zones in elite skeleton athletes[18]. Though it is purported that the magnitude and duration of jet-lag symptoms are affected by the direction and distance of travel[7,9], it is tenuous to make comparisons between studies, given the differences in the frequency and timing of measures, along with participant populations and the impact of zeitgebers, particularly the timing of light exposure and melatonin administration[17].

Theoretically, full adjustment to the new time-zone should have taken 13 days in the present study, as the rate of resynchronisation following eastward travel is estimated as one day per hour of the time difference[7,9]. However, perceived jet-lag symptoms had almost returned to baseline by day five, and thus, results from the current and previous research[18] indicate that this estimation may not be accurate. However, the lack of multiple daily jet-lag measures is acknowledged as a limitation, since differences in responses would be likely if they were assessed at a different local and thus body clock time post-travel. Regardless, since physical performance may be suboptimal prior to the adjustment of body temperature and disappearance of jet-lag symptoms[16], it is acknowledged as a limitation that sport-specific performance wasn't measured in the present study. Consequently, it is unknown if the elevated perceived jet-lag had an ensuing effect on training quality.

Reduced sleep duration has previously been reported during long-haul air travel (≤ 24-h) from the United Kingdom to Australia (4.0 [2.0-5.0] h)[6], and South America (5.5 [3.75-7.25] h)[4]. Similarly, reduced sleep duration was evident during travel in the present study (5.9 [4.8-7.0] h). Due to the extensive distance and time-zone change of these travel routes, overnight travel is often required. As a result sleep disruption is likely as the timing of stopovers, meals and cabin lighting changes can enforce waking during the sleep phase of the sleep-wake cycle[9]. Further, the cramped conditions, non-supine position and cabin noise are not conducive for sleep. Of note, the greater sleep duration reported in the present study may be a consequence of the players travelling in business class, where it is possible to lay in a supine position. Moreover, general sleep hygiene guidelines were distributed prior to travel and players were administered melatonin, which is recognised as an ecological valid occurrence in travelling professional athletes.

Reduced sleep duration was also reported on the first night following arrival, which is likely due to the late arrival time (20:30 local time) and subsequent later bed and sleep onset times, together with earlier wake times and reduced time in bed. Conversely, Fullagar et al.[4] observed a 'rebound' effect following reduced sleep duration during long-haul travel, with an increased sleep duration detected on the first night following arrival (10:00 local time). This was speculated as an increased homeostatic drive for sleep overriding any sleep disruption due to circadian influences[19]. Indeed, a similar result may have been observed in the present study if the arrival time was earlier and time in bed wasn't compromised. Compared to the day prior to travel early awakening and therefore reduced sleep efficiency were reported for the five days following travel in the present study, with players waking earliest on day one and progressively later each day. Though speculative given the lack of physiological markers of circadian rhythm, players' peak body temperature and alertness would have occurred at ~04:00 local time given the 13 h time difference[17]. Further, only a single night of sleep was assessed prior to travel and that sleep was monitored subjectively, rather than with objective measures such as actigraphy. Regardless, given that sleep disruption is associated with worse cognitive performance[20] and mood states[21], reduced sleep duration is likely why worse function ratings were reported on the first day following arrival.

Despite no differences in training duration and load, a reduction in wellness was observed the week following compared to the week prior to travel, suggesting the players' ability to cope with training demands was reduced. In addition, fatigue and sleep components of wellness and overall wellness were worse on the first day following arrival, which is again likely due to travel-induced sleep disruption. Similar responses were observed in professional football players following 10-h northbound air travel across one time-zone[10]. Specifically, sleep duration was reduced the night before travel and total training duration and load, together with mean wellness were reduced during the week following compared to the week prior to travel[10]. However, these results were attributed to training schedule differences rather than an effect of travel[10]. Regardless, findings from the current and previous research[10] indicate player preparedness for training and competition may be diminished following long-haul travel. However since sport-specific performance wasn't measured, it is unclear whether this had an impact on subsequent training and/or competition performance.

Inter-individual variation in jet-lag symptoms may occur due to differences in age, sleeping habits, time of arrival and previous travel experience[6]. Indeed, the number of first team appearances was greater in football players who had a low mean jet-lag for five days following 10-h of northbound air travel across one time-zone[10]. Similarly, a greater number of international appearances were associated with reduced jet-lag and improved function ratings on the first day following arrival in the present study. However, reduced sleep duration on the first day post-travel was also associated with a greater number of international appearances. These results imply that more experienced players could be less affected by the sleep disruption associated with long-haul travel, and that playing experience may mediate travel-induced responses, potentially due to greater travel experience. However, it should be considered that results from the current and previous research[10] are only case studies of singular teams and scenarios. There may also be other explanations for these findings, including more experienced players could be better at moderating the extent of any stress being experienced. Therefore, further research involving multiple trips and/or teams is required to determine predictors of travel-induced responses, in turn allowing targeted support of particular players around travel.

5. Conclusions

The present study indicates jet-lag, sleep and wellness responses could be adversely affected following eastward long-haul travel in professional football players. Though it is acknowledged as a limitation of the present study that there was no control group and consequently it is unclear whether this disruption was due to the long-haul travel (travel fatigue), time-zone change (jet-lag), timing of the measures and/or other factors. Whilst the sleep-wake cycle normalised after the first day following arrival, perceived jet-lag was increased for five days post-travel. Since physical performance may be suboptimal prior to the disappearance of jet-lag symptoms, teams should arrive with sufficient time prior to competition to recover and ensure optimal performance. However due to their busy schedules this is not always feasible and therefore practical, evidence-based interventions that enhance recovery from long-haul travel are required. Results from the present study indicate that interventions to reduce sleep disruption during and following travel may have some merit given the travel-induced effects on sleep duration.

Practical Implications

- Practitioners should be aware that jet-lag symptoms are likely to be present for ≥ 5 days following long-haul eastward air travel, which may have implications for training and competition scheduled within this time frame.
- Due to a late arrival time, subsequent time in bed and therefore, sleep duration was reduced. Whilst a travel schedule that minimises the time between the last sleep period at the place of departure and the first sleep period at the destination is preferable, if feasible, late arrival times should be avoided, as sleep is also likely to be disrupted during travel.
- Players with greater experience could be less affected by travel and therefore, practitioners may consider providing more sports medicine/science support to less experienced players around travel.

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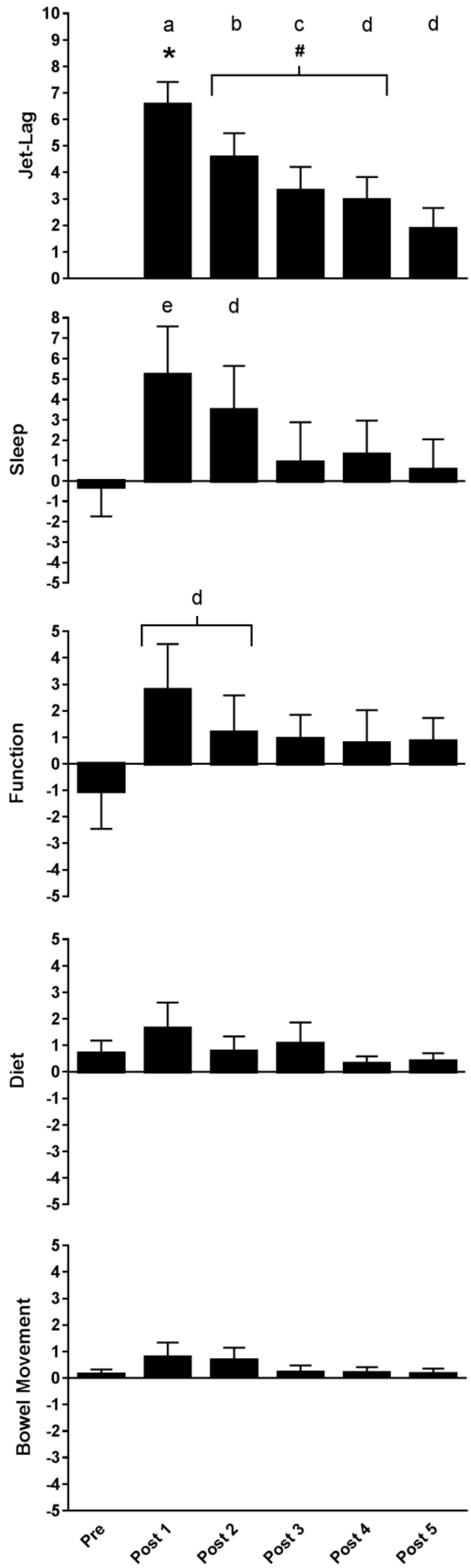
Table 1 Mean (95% CI) for sleep/wake variables one day prior to and following international travel.

Measure	Pre	Day of Arrival	Post 1	Post 2	Post 3	Post 4
Bed time (hh:mm)	23:03 (22:34 - 23:32)[c]	23:33 (23:13 - 23:52)[¤c]	21:27 (20:47 - 22:07)	22:06 (21:46 - 22:25)	21:36 (21:16 - 21:57)[#]	21:45 (21:26 - 22:03)[#]
Sleep onset (hh:mm)	23:35 (23:12 - 23:59)[c]	0:21 (0:03 - 0:39)[¤bc]	22:03 (21:12 - 22:55)	22:35 (22:11 - 22:58)	22:12 (21:50 - 22:35)[#]	22:24 (22:02 - 22:45)[#]
Wake time (hh:mm)	7:54 (7:43 - 8:04)*[a]	6:07 (05:35 - 06:40)	6:19 (5:49 - 06:49)	6:12 (05:40 - 06:43)	6:32 (06:07 - 06:57)	06:35 (06:11 - 06:58)
Get-up time (hh:mm)	8:06 (07:55 - 08:18)[a]	07:03 (06:31 - 07:35)	07:15 (06:53 - 07:38)	07:18 (06:55 - 07:40)	07:19 (06:58 - 07:40)	07:26 (07:08 - 07:44)
Time in bed (h)	9.1 (8.6 - 9.6)	7.5 (6.9 - 8.1)[†a]	9.8 (9.3 - 10.3)	9.2 (8.8 - 9.6)	9.7 (9.3 - 10.1)	9.7 (9.3 - 10.1)
Sleep onset latency (min)	32.4 (18.7 - 46.1)	48.7 (31.9 - 65.5)	35.9 (16.7 - 55.1)	29.3 (15.5 - 43.2)	35.9 (20.2 - 51.5)	39.1 (21.9 - 56.3)
Sleep duration (h)	8.3 (7.9 - 8.7)	5.8 (5.2 - 6.3)*[a]	8.3 (7.5 - 9.0)	7.6 (7.1 - 8.1)	8.3 (7.9 - 8.7)	8.2 (7.8 - 8.6)
Sleep efficiency (%)	92.2 (89.7 - 94.7)[a]	77.6 (72.2 - 83.1)[#]	83.8 (79.3 - 88.2)	83.0 (78.5 - 87.5)	85.9 (82.6 - 89.1)	84.9 (81.2 - 88.6)

*Significantly different to all other time points (P<0.001).
[#]Significantly different to Pre (P<0.001).
[†]Significantly different to Post 1, 3 and 4 (P<0.001).
[¤]Significantly different to Post 1, 2, 3 and 4 (P<0.001).
[a]Large ES for difference to all other time points (*d*>0.90).
[b]Large ES for difference to Pre (*d*>0.90).
[c]Large ES for difference to Post 1, 2, 3 and 4 (*d*>0.90).

Fig.1.



Jet-Lag
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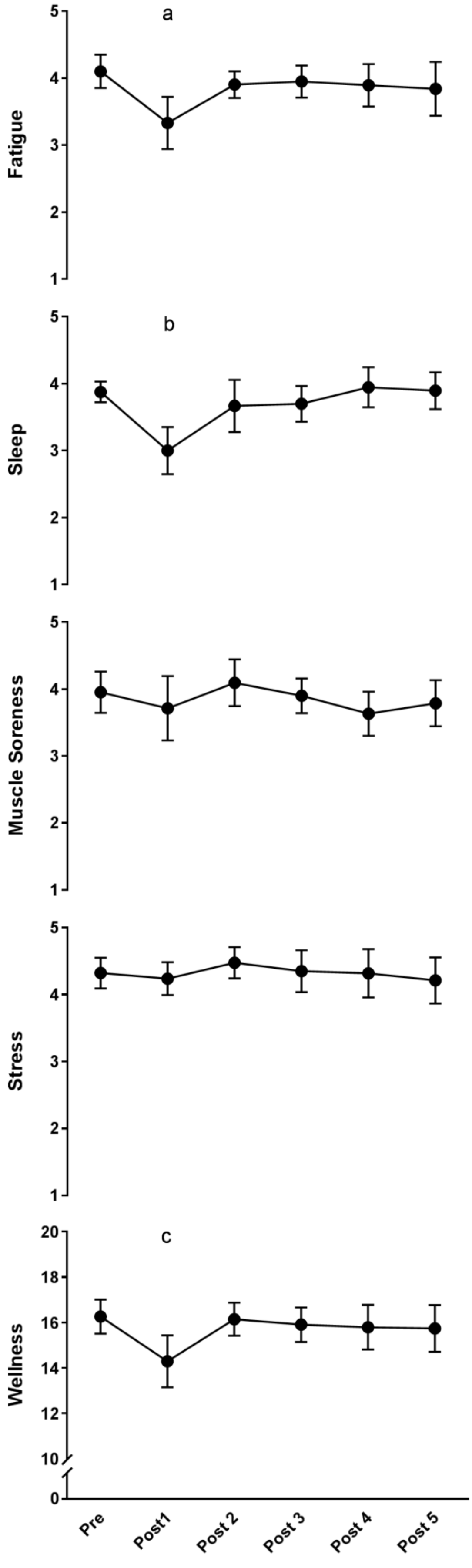
Fig.2.



a
Fatigue
b
Sleep
Muscle Soreness
Stress
c
Wellness
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Post1
Post 2
Post 3
Post 4
Post 5

Figure Legends

Fig. 1. Mean (95% CI) jet-lag and sleep, function, diet and bowel movement ratings prior to (**Pre**) and following (**Post 1 - 5**) international travel. *Significantly different to all other time points ($p<0.001$). [#]Significantly different to Pre ($p<0.001$). [a]Large ES for difference to all other time points ($d>0.90$). [b]Large ES for difference to Pre, Post 4 and 5 ($d>0.90$). [c]Large ES for difference to Pre and Post 5 ($d>0.90$). [d]Large ES for difference to Pre ($d>0.90$). [e]Large ES for difference to Pre, Post 3, 4 and 5 ($d>0.90$).

Fig. 2. Mean (95% CI) wellness ratings prior to (**Pre**) and following (**Post 1 - 5**) international travel. [a]Large ES for difference to Pre, Post 2, 3 and 4 ($d>0.90$). [b]Large ES for difference to all other time points ($d>0.90$). [c]Large ES for difference to Pre, Post 2 and 3 ($p<0.05$).