Article Title – Travel route and scheduling effects on perceived jet lag, fatigue and sleep in footballers travelling to and from national teams.

Submission Type – Original Investigation

Authors: Ewan Clements[1,2], Fabian Ehrmann[2], Andrew Clark[2], Mark Jones[2], Alan McCall[1,2], Rob Duffield[1,2]

Affiliations:

1. School of Sport, Exercise and Rehabilitation, Faculty of Health, University of Technology Sydney, NSW, Australia
2. Football Australia, Sydney, NSW, Australia

Corresponding Author:

Ewan Clements

ewan.j.clements@student.uts.edu.au

0412 874 896

Abstract word count: 250

Text Only Word Count: 3499

Number of Figures: 4

Number of Tables: 1

Abstract:

Purpose: This study examined post-travel perceptual responses of national team footballers (soccer) following different travel routes, arrival/departure times and trip contexts.

Methods: Details of 396 flights from national team players (n=68) were obtained and verified via an online flight database. Each player provided ratings of perceptual fatigue, sleep, soreness, stress, and jet lag for two days before and after each trip. The travel route (continents of departure and arrival), travel context (into vs out of national team), and arrival and departure time were obtained for each trip. Linear mixed models compared the pre- to post-travel change in perceptual responses based on travel route, context and schedule.

Results: Perceived jet lag ratings were more responsive to travel variables (R^2=0.48) than other perceptual ratings (R^2<0.26). Travel from Asia to Europe ($p<0.05$) and Europe to Australia ($p<0.001$) had significantly higher jet lag ratings than all other routes. Fatigue scores were worst following Asia to Europe ($p<0.05$) and Europe to Australia ($p<0.05$) travel, while sleep scores were worst following Europe to Australia ($p<0.01$). Perceptual responses were poorer following travel from national team to club compared to all other travel contexts ($p<0.05$). Arrival around lunch (11:00-17:00) resulted in better perceptual responses than early morning or late-night arrivals ($p<0.05$).

Conclusions: Perceived jet lag ratings are more responsive to travel demands than perceptual wellness scales in national football athletes. Poorer perceptual responses may be expected when travel is longer in nature, arrives later in the day or involves travel out of the national team back to club.

Introduction:

National football (soccer) teams often require athletes to undertake extensive travel from different club locations into a single competition or camp location. The diversity of travel for athletes spread around the world result in a range of travel-induced states on arrival into each camp[1]. Factors that influence this post-travel state, such as jet lag, travel fatigue or sleep disruption, are dependent on the travel duration, time zone change and direction, which vary based on individual travel schedules[1]. Hence, practitioners need to consider the effects of these schedules on athlete arrival into the national team and return to club[2]. Further, the travel route, arrival and departure time, and whether the trip was into or from the national team, are all likely to influence the athlete's response to the journey[1]. Whilst travel research uses extensive jet lag questionnaires, physiological or performance measures[3], these are logistically impossible in national team contexts, where player monitoring is commonly limited to perceptual questionnaires relating to fatigue, sleep, soreness and stress[4]. Despite concerns about the validity of these "wellness" scales[5], they capture elements of symptoms reported in jet lag and travel fatigue[1], though few studies assess their responsiveness to different travel demands. Given the pervasive use of these scales in football teams, understanding their responses to travel across different routes, schedules and contexts can inform athlete monitoring of travel for national football teams.

For many non-European national teams, travel often follows particular patterns, whereby players located in a range of countries will travel routes based on club and competition locations[6]. The duration and direction of the travel will influence the extent of jet lag/travel fatigue symptoms on arrival in the club or national team[7-9]. While current travel studies have explored fatigue, jet lag and sleep responses in footballers following trips between Australia, Asia, Europe, South America and North America[10-17], such studies only explore singular trips and deeper understanding of responses to common travel routes is missing. Given the variation in populations and methodologies between studies, drawing comparisons on the effects of different travel routes on fatigue, sleep and jet lag responses is difficult[9,15,17,18]. As players involved in any single national football team camp are required to travel from various locations, understanding travel responses to common routes can aid travel management strategies. Furthermore, effects of the route may also be influenced by whether it involved travelling into or out of the national team[4]. While poorer countermovement jump, jet lag and fatigue were reported after both outbound and return travel responses from a 6hr flight, no comparisons were made between the two trip contexts and only a single short-duration trip was reported[18]. Larger data sets on longer travel are missing to inform national team footballers undertaking both outbound and return travel to clubs.

Further concerns for national team players include the departure/arrival time and how these factors may influence sleep and fatigue in the days following arrival. Arrival closer to sleep periods has previously been related to reduced jet lag and fatigue ratings in elite athletes[19]. However, these results consider only a single trip and do not cover the diversity of travel schedules experienced by national team footballers. Broader comparisons are needed across the range of arrival and departure times experienced by national team footballers. Accordingly, for a national football federation, understanding how travel route, context, and schedule influence player responses to travel will allow staff to better plan for athlete arrival/departure. This study aims to compare post-travel perceptual jet lag, fatigue, sleep, soreness, and stress ratings between different travel routes, schedules, and trip contexts.

Methods

Participants

Participants included 68 professional footballers (soccer) from a senior men's national team who were part of travelling squads between March 2018 to July 2022. Consent to use the data anonymously was obtained from the national football federation. All athletes provided consent for the collection and use of their data anonymously via national team contracts. Ethical approval was obtained from the institutional Human Ethics Committee (ETH20-5080).

Overview

The details of 796 flights were obtained and aligned with pre- and post-travel perceptual responses. Overall, 396 flights included pre- and post-travel perceptual scales, and 223 flights included perceived jet lag ratings. Perceptual ratings of fatigue, sleep, soreness, and stress (collectedly termed 'wellness') were obtained for two days prior to travel and up to three days after travel. Perceived jet lag ratings were obtained on the first three days after arrival from travel. All measures were obtained as part of national team monitoring procedures with players required to complete a daily perceptual questionnaire via the organisation's athlete monitoring software on the athlete's smartphone. All players had previously used the questionnaire extensively. Trips were excluded if they did not include at least one pre- and all post-travel perceptual monitoring responses.

Travel Details

Travel details for each trip were obtained from booked travel schedules, with the arrival and departure times for each trip then verified using an online flight database (Flightera.com). Trips were classified based on 1) route 2) context (into or out of national team) and 3) arrival and departure time. The travel route was classified based on the departure continent and arrival continent, based on the geographical location of the airport (not including land-based travel). Accordingly, the following categories were derived: I) Asia to Asia, II) Asia to Australia, III) Asia to Europe, IV) Australia to Asia, V) Europe to Asia, and VI) Europe to Australia. The arrival and departure time of each trip was grouped into categories of Morning (05:00-11:00), Lunch (11:00-17:00), Evening (17:00-23:00) and Night (23:00-05:00). Each trip was also categorised based on context with trips either being outbound (travelling into the national team), transition (travelling between national team matches/training camps), or return (travelling out of the national team). A players age and number of national team appearances at the time of travel was also obtained from the federation databases and included within analysis.

Perceptual Response Scales

Players completed a perceptual questionnaire every morning from two days before travel into national team through to three days after they left the national team. In this questionnaire players provided subjective ratings of fatigue, sleep, soreness, and stress via a seven-point Likert scale. Descriptive anchors were included at scores of one, four and seven, with scores of 1 labelled as having “No” fatigue, soreness or stress and “Outstanding” sleep. Scores of 4 labelled as “Moderate” fatigue, soreness or stress and “Average” sleep. Scores of 7 labelled with “Maximal” fatigue, “Extreme” soreness, “Worst Possible” stress or “Horrible” sleep. The sum of all 4 scales for each day was also included in analysis as a “Total Wellness” score. For each trip, raw scores were converted into a change score by subtracting the latest score obtained prior to departure from the score on each day (Day 1 and Day 2 post-arrival).

These perceptual monitoring scales are frequently used in football teams to monitor responses to training, especially given the lack of available objective data for many national teams[4]. Although these scales have been suggested to lack a conceptual framework[5], prior studies observed their responsiveness to training stress in both national[20] and club football teams[21]. However, the limitations of these scales should be considered when interpreting results as travel may account for only a small proportion of variation in scores – which further necessitates the current study. Despite this, these scales represent a practical and frequently used tool in national teams to monitor athletes and can potentially aid understanding of travel responses in national teams[4].

Perceived Jet Lag Rating

Athletes completed a perceived jet lag rating every day for three days after travel. A modified version of the single-item jet lag rating from the Liverpool John Moore's University Jet Lag questionnaire (LJMJLQ)[22] was used. Athletes were asked "Do you have any jet lag or fatigue from your travel?" and answered on a 10-point rating scale with scores of 0 labelled as "None at all" and scores of 10 labelled as "Extreme". While jet lag is a bio-psychological and chronobiological concept, the LJMJLQ attempts to measures this perceptually, and the decision to include "travel fatigue" in this study was due to the inability to distinguish between symptoms of the two conditions. As such, this scale aimed to be a more specific measure of travel response compared to the aforementioned perceptual scales. For each trip, perceived jet lag ratings were obtained as a raw value and labelled by the day they were collected relative to arrival (i.e. +1, +2, +3).

Statistical Analysis

Travel details and perceptual monitoring scales were collated into a single excel spreadsheet and imported into R studio[23]. Perceptual monitoring scores for each day were labelled as Day 1 (D1), Day 2 (D2) or Day 3 (D3 – Perceived jet lag only) based on when the score was provided relative to arrival. Each outcome was aligned with the details of the prior travel. For all statistical tests, statistical significance was set at 0.05.

To analyse the influence of travel factors on the perceptual response to travel, linear mixed models were built for each outcome using the lme4 package[24]. A numerical player identifier was included as a random effect within the model to account for non-independence of outcomes. Models were built using a stepwise approach with the inclusion of fixed effects determined by statistical significance as measured by an F-test with Satterthwaite degrees of freedom approximation[25]. The models Aikake Information Criterion and R^2 values were used to determine the overall fit of the model at each step. Once the final model had been built, assumptions of normality and homogeneity of variance were checked using QQ-plots and residual plots. Post-hoc pairwise comparisons between categorical variables were performed via estimated marginal means[26]. Given the absence of significant interactions between variables, the mean value for each category was averaged out over levels of other variables.

Results

Model Details

Details of the final models for each outcome variable are provided in Table 1. Based on R^2 values, perceived jet lag scores were most sensitive to the travel route, context, and arrival time (R^2 = 0.48). Conversely, perceptual "wellness" scales showed lower sensitivity (R^2 = 0.15 to 0.26) with fatigue showing the highest association with analysed travel variables.

Perceived Jet Lag

Travel routes from Asia to Europe (p=0.002 to 0.047) and Europe to Australia (p<0.001) produced significantly higher jet lag ratings than all other routes (Figure 1A). Travel from Australia to Asia resulted in lower perceived jet lag ratings than travel within Asia (p<0.001). Figure 1B shows perceived jet lag was significantly higher following travel between national team matches compared to travel into the national team (p<0.001); however, no other differences were observed between trip types. Player age had a positive relationship with jet lag scores, with an increase in one unit (year) resulting in a 0.185 increase in perceived jet lag score ($p<0.001$). In contrast, for each national team appearance a player's perceived jet lag score decreased by 0.023 ($p=0.008$).

Effects of Travel Route on Perceptual Wellness Scales

Travel route had a significant effect on all perceptual scales (Total wellness $p=0.005$; Fatigue $p<0.001$; Sleep $p<0.001$; Soreness $p=0.013$; Stress $p=0.036$). Pairwise comparisons between each route are shown in Figure 2. Europe to Australia travel resulted in poorer wellness compared to all other routes except Asia to Europe ($p<0.01$). Similarly, for fatigue ratings, Europe to Australia had significantly poorer scores than Asia to Asia, Australia to Asia and Europe to Asia ($p=0.004$ to 0.043). Asia to Europe travel resulted in poorer fatigue scores compared to Asia to Asia and Australia and Europe ($p=0.003$ to 0.047). Travel from Australia to Asia also caused poorer fatigue scores than travel from Asia to Asia ($p=0.013$). Poorer perceptual sleep ratings were observed after Europe to Australia compared to all other routes ($p<0.01$). Significantly worse changes in soreness scores were observed after both Europe to Australia and Asia to Europe travel compared to Asia to Asia ($p=0.068$; $p=0.045$) and Asia to Australia ($p=0.041$; $p=0.006$). Lastly, lower stress ratings occurred after travel from Europe to Asia compared to Asia to Australia ($p=0.014$), Asia to Europe ($p=0.004$) and Australia to Asia ($p=0.020$).

Effects of Trip Type on Perceptual Wellness Scales

Figure 3 shows poorer scores were observed following travel out of the national team compared to travel into the national team and transition travel for total wellness (Into $p<0.001$; Transition $p<0.001$), fatigue (Into $p=0.002$; Transition $p<0.001$), sleep (Into $p=0.024$; Transition $p<0.001$), and soreness (Into $p=0.003$; Transition $p=0.004$). For stress ratings, poorer scores were observed after transition travel compared to travel into national team ($p=0.008$).

Effects of Arrival Time on Perceptual Wellness Scales

Compared to morning arrivals, lunch arrivals were associated with significantly better total wellness ($p<0.001$), fatigue ($p=0.006$), sleep ($p=0.050$), and soreness scores ($p<0.001$). Lunch arrivals also resulted in better total wellness ($p=0.008$) and soreness ($p=0.020$) compared to night arrivals. Similarly, evening arrivals resulted in better total wellness ($p=0.029$), fatigue ($p=0.013$) and soreness ($p<0.001$) scores compared to morning arrivals. However, compared to lunch arrivals, evening arrivals had poorer total wellness ($p=0.005$) and sleep scores ($p=0.002$). Lastly, stress scores were the worst after night arrivals compared to all other arrival times (Morning $p=0.008$; Lunch $p=0.003$; Evening $p=0.005$).

Discussion

The current study identified travel-induced perceptual responses of jet lag, fatigue, sleep, soreness and stress, from elite national team footballers based on travel routes, arrival/departure times, and trips contexts. Travel from Europe to Australia or Asia to Europe had the greatest impact on athlete perceptual responses. Travel responses were worse when returning to clubs than into or between national team matches. Arrival during the day (between 11:00-17:00) resulted in better perceptual responses. Whilst athlete ratings of fatigue, sleep, soreness, and stress are responsive to certain travel demands, a subjective jet lag scale represents a more responsive tool to monitor travel responses.

Importantly this study showed that a perceptual jet lag rating has better association with variations in travel demands than perceptual wellness measures. Although the full LJMUJLQ scale[19] represents a more validated tool to monitor travel responses, this study highlighted a simplified version can be a practical and informative tool for national football teams. As expected, jet lag was worst following trips from Europe to Australia (Figure 1), representing eastward travel with the largest time zone change[1]. Prior studies show support, with detrimental jet lag symptoms following longer travel demands and eastward travel[8,9,27]. Interestingly, elevated jet lag was also observed following travel from Asia to Europe. As this route was common for athletes returning to their clubs, it is possible that accumulated travel fatigue from multiple long-haul flights in a short time may explain this[28], though further research is needed. A limitation of these comparisons, however, was that due to match scheduling and Covid-related venue changes, insufficient data existed from Australia to Europe trips and thus such trips were not included. Regardless, support in the form of jet lag mitigation strategies[29] is recommended for athletes travelling from Europe to Australia or returning to Europe from Asia. Of note, elevated jet lag ratings were evident in older athletes and lower jet lag ratings in more experienced athletes. Prior studies have observed detrimental effects of age on jet lag symptoms[11,30], however, such findings are not consistent, with studies reporting positive[19] or no effects of age[12,31,32]. The protective effect of experience has been previously observed amongst travelling footballers[11,12], and development of travel management strategies is recommended for inexperienced players.

Although jet lag ratings likely provide a better indication of travel stress, perceptual wellness scales commonly collected in football teams showed some, albeit low responsiveness to different travel bouts. Total wellness, fatigue, and sleep scores were worst following travel from Europe to Australia. As fatigue and impaired sleep are common symptoms of jet lag/travel fatigue[33], these elevated ratings are likely explained by the long-haul travel and eastward direction. Prior research assessing Europe to Oceania travel observed no changes in objective sleep measures in professional Rugby 7s athletes in the 6 days following arrival[34]. The contrasting findings may relate to differences in the sensitivity of objective versus subjective sleep measures; alongside the authors suggesting travel management strategies implemented by the Rugby 7s athletes prevented sleep deficits[34]. All other routes included in this study appeared to have limited impact on perceptual responses, thus priority should be with players undertaking travel from Europe to Australia and on return to Europe from Asia.

Regardless of travel route, athletes reported poorer perceptual fatigue, sleep, soreness, and total wellness scores after travel from the national team back to their club, which is a novel finding that has not been reported previously in national team athletes. Elevated jet lag and fatigue scores have been observed following the return journey of a round-trip domestic American travel schedule; however, comparisons were not reported between outbound and return travel[18]. As such, this study highlights that athletes may have additional difficulty in recovering from travel back to clubs following national team duties. The elevated ratings following return travel could be explained by effects of prior training/match load from the national team duties[20]. While data was not available for this study, it is likely that variations in physical load prior to travel will influence an athlete's wellbeing state[20] and therefore, may interact with post-travel perceptual responses. Further exploration is necessary to examine the interaction between prior match load and travel demands on athlete recovery. Also of concern are the short timeframes between national team and club matches and the frequent need to travel almost immediately following matches. Such requirements may restrict opportunities for rest and recovery interventions following matches and future research should, therefore, explore how the time between match completion and travel departure influences post-match travel responses. Accumulated travel fatigue from the short-term congested travel schedules (i.e. national team athletes are often required to undertake up to 3 long-haul flights in space of two weeks) may also partially explain the poorer responses to return travel[28]. However, given the lack of studies assessing responses of athletes to multiple long-haul trips in a short-time frame, this remains speculative. Regardless, this study highlights a need for travel and recovery interventions for athletes returning to their club following national duties.

An athlete's time of arrival should also be considered when travelling into and out of national teams. On the day after arrival, better fatigue and sleep ratings were evident when arriving around lunch (11:00-17:00) compared to the morning or evening. These findings are similar to those of Waterhouse, et al. [19] who reported better jet lag and fatigue scores in athletes and support staff arriving late afternoon compared to early morning following travel from Europe to Australia. Those authors suggested the longer period of wakefulness for the morning arrival group may have induced greater fatigue ratings[19]. The findings of the current study may also be explained by the additional time for athletes to arrive at their hotel prior to attempting sleep and thus less interruption to the sleep period on the night of arrival. Where logistically possible, travel schedules arriving during the middle of the day to later afternoon are recommended; however, this may not be feasible and ensuring athletes are provided with adequate sleep on the night of arrival is important.

While the findings of this study provide useful insight into monitoring travel in national football teams, several limitations need to be considered. Although data collection for this study occurred in an ecologically valid national team environment, limited control existed across what the athletes did before, during or after travel. Given the perceptual scales used are likely influenced by other external factors (evidenced by low R^2 values), caution should be taken on the application of the study findings. The pre-travel baseline used for comparisons represents the measure from a single day and, as such, may be more susceptible to external influences. Lastly, perceptual jet lag ratings were obtained at a single time point during the day and variations in scores may be expected if the ratings were performed at other points throughout the day[22].

Practical Applications

- In national team footballers subjective jet lag ratings are more responsive to variations in travel demands than perceptual wellness scales.
- Europe to Australia or Asia to Europe travel reduced perceptual ratings for this national team and thus additional travel management strategies may be required.
- Additional support for national team footballers may be required when travelling back to clubs following national team camps or when arriving later in the day.

Conclusions

This study has identified several trip related factors likely to cause poorer perceptual responses to travel in national team footballers. Europe to Australia or Asia to Europe travel appears to be the most challenging to athletes from this national federation, and thus additional support may be required for these trips. Return travel after a national team camp produced poorer ratings of fatigue, sleep, and soreness and thus further support may be required when returning athletes to clubs. Lunchtime arrivals (11:00-17:00) were the least detrimental to sleep and fatigue ratings and where possible trips should be scheduled to arrive during the day. Overall, the specific conditions of the trip should be considered, and travel management strategies individualised when planning for the transport of players in and out of national team camps.

Acknowledgements

The authors would like to thank the players, coaches, and staff of the Sports Science Department of Football Australia for their support and feedback in the development of this project. No financial assistance was provided for this project.

References

1. Janse Van Rensburg DC, Jansen Van Rensburg A, Fowler PM, et al. Managing Travel Fatigue and Jet Lag in Athletes: A Review and Consensus Statement. *Sports Med*. 2021;doi:10.1007/s40279-021-01502-0
2. Buchheit M, Dupont G. Elite clubs and national teams: sharing the same party? *Science and Medicine in Football*. 2018;2(2):83-85. doi:10.1080/24733938.2018.1470156
3. Rossiter A, Warrington GD, Comyns TM. Effects of Long-Haul Travel on Recovery and Performance in Elite Athletes: A Systematic Review. *J Strength Cond Res*. 2021;Publish Ahead of Printdoi:10.1519/JSC.0000000000004021
4. McCall A, Davison M, Andersen TE, et al. Injury prevention strategies at the FIFA 2014 World Cup: perceptions and practices of the physicians from the 32 participating national teams. *Br J Sports Med*. 2015;49(9):603-608. doi:10.1136/bjsports-2015-094747
5. Jeffries AC, Wallace L, Coutts AJ, McLaren SJ, McCall A, Impellizzeri FM. Athlete-reported outcome measures for monitoring training responses: A systematic review of risk of bias and measurement property quality according to the COSMIN guidelines. *Int J Sports Physiol Perform*. 2020;15(9):1203-1215.
6. Clements E, Ehrmann F, Clark A, Jones M, Lu D, Duffield R. The type and extent of travel for professional footballers undertaking national team duties for a National Football Federation. *Biol Sport*. 2022;
7. Mitchell JA, Pumpa KL, Pyne DB. Responses of lower-body power and match running demands following long-haul travel in international rugby sevens players. *J Strength Cond Res*. 2017;31(3):686-695.
8. Fowler P, Knez W, Crowcroft S, et al. Greater Effect of East versus West Travel on Jet Lag, Sleep, and Team Sport Performance. *Med Sci Sports Exerc*. 2017;49(12):2548-2561.
9. Fowler P, Duffield R, Vaile J. Effects of simulated domestic and international air travel on sleep, performance, and recovery for team sports. *Scand J Med Sci Sports*. 2015;25(3):441-451.
10. Fowler PM, Duffield R, Lu D, Hickmans JA, Scott TJ. Effects of long-haul transmeridian travel on subjective jet-lag and self-reported sleep and upper respiratory symptoms in professional rugby league players. *Int J Sports Physiol Perform*. 2016;11(7):876-884. doi:10.1123/ijspp.2015-0542
11. Fowler P, McCall A, Jones M, Duffield R. Effects of long-haul transmeridian travel on player preparedness: Case study of a national team at the 2014 FIFA World Cup. *J Sci Med Sport*. 2017;20(4):322-327. doi:10.1016/j.jsams.2016.08.021
12. Fowler P, Duffield R, Howle K, Waterson A, Vaile J. Effects of Northbound Long-Haul International Air Travel on Sleep Quantity and Subjective Jet Lag and Wellness in Professional Australian Soccer Players. *Int J Sports Physiol Perform*. 2015;10(5):648-654.
13. Bullock N, Martin DT, Ross A, Rosemond D, Marino FE. Effect of long haul travel on maximal sprint performance and diurnal variations in elite skeleton athletes. *Br J Sports Med*. 2007;41(9):569-573. doi:10.1136/bjsm.2006.033233
14. Fullagar HHK, Duffield R, Skorski S, et al. Sleep, Travel, and Recovery Responses of National Footballers During and After Long-Haul International Air Travel. *Int J Sports Physiol Perform*. 2016;11(1):86-95.
15. Kölling S, Treff G, Winkert K, et al. The effect of westward travel across five time zones on sleep and subjective jet-lag ratings in athletes before and during the 2015's World Rowing Junior Championships. *J Sports Sci*. 2017;35(22):2240-2248. doi:10.1080/02640414.2016.1265141

16. Lastella M, Roach GD, Sargent C. Travel fatigue and sleep/wake behaviors of professional soccer players during international competition. *Sleep Health*. 2019;5(2):141-147. doi:10.1016/j.sleh.2018.10.013

17. Stevens CJ, Thornton HR, Fowler PM, Esh C, Taylor L. Long-Haul Northeast Travel Disrupts Sleep and Induces Perceived Fatigue in Endurance Athletes. *Front Physiol*. 2018;9doi:10.3389/fphys.2018.01826

18. Kraemer WJ, Hooper DR, Kupchak BR, et al. The effects of a roundtrip trans-American jet travel on physiological stress, neuromuscular performance, and recovery. *J Appl Physiol*. 2016;121(2):438-448.

19. Waterhouse J, Edwards B, Nevill A, et al. Identifying some determinants of "jet lag" and its symptoms: A study of athletes and other travellers. *Br J Sports Med*. 2002;36(1):54-60. doi:10.1136/bjsm.36.1.54

20. Noor D, McCall A, Jones M, et al. Perceived load, fatigue and recovery responses during congested and non-congested micro-cycles in international football tournaments. *J Sci Med Sport*. 2021;doi:10.1016/j.jsams.2021.07.001

21. Thorpe RT, Strudwick AJ, Buchheit M, Atkinson G, Drust B, Gregson W. Monitoring Fatigue During the In-Season Competitive Phase in Elite Soccer Players. *Int J Sports Physiol Perform*. 2015;10(8):958-964. doi:10.1123/ijspp.2015-0004

22. Waterhouse J, Edwards B, Nevill A, et al. Do subjective symptoms predict our perception of jet-lag? *Ergonomics*. 2000;43(10):1514-1527. doi:10.1080/001401300750003943

23. *R: A language and environment for statistical computing*. Version 4.1.1. R Foundation for Statistical Computing; 2021. https://www.R-project.org/

24. Bates D, Mächler M, Bolker B, Walker S. Fitting Linear Mixed-Effects Models Using lme4. *Journal of Statistical Software*. 2015;doi:10.3929/ethz-b-000105397

25. Kuznetsova A, Brockhoff PB, Christensen RH. lmerTest package: tests in linear mixed effects models. *Journal of statistical software*. 2017;82(1):1-26.

26. *emmeans: Estimated Marginal Means, aka Least-Squares Means*. 2021. https://CRAN.R-project.org/package=emmeans

27. Thornton HR, Miller J, Taylor L, Sargent C, Lastella M, Fowler PM. Impact of short- compared to long-haul international travel on the sleep and wellbeing of national wheelchair basketball athletes. *J Sports Sci*. 2018;36(13):1476-1484. doi:10.1080/02640414.2017.1398883

28. Samuels CH. Jet lag and travel fatigue: A comprehensive management plan for sport medicine physicians and high-performance support teams. Article. *Clin J Sport Med*. 2012;22(3):268-273. doi:10.1097/JSM.0b013e31824d2eeb

29. Janse Van Rensburg DC, Jansen Van Rensburg A, Fowler P, et al. How to manage travel fatigue and jet lag in athletes? A systematic review of interventions. *Br J Sports Med*. 2020;54(16):960-968. doi:10.1136/bjsports-2019-101635

30. Moline ML, Pollak CP, Monk TH, et al. Age-Related Differences in Recovery from Simulated Jet Lag. *Sleep*. 1992;15(1):28-40. doi:10.1093/sleep/15.1.28

31. LaGarde D, Beaumont M, Batejat D, Catrycke M, Van Beers P. *Influence of age and gender on jet-lag syndrome: recommendations*. 2000.

32. Becker T, Penzel T, Fietze I. A new German Charité Jet Lag Scale for jet lag symptoms and application. *Ergonomics*. 2015;58(5):811-821. doi:10.1080/00140139.2014.982209

33. Waterhouse J, Nevill A, Edwards B, Godfrey R, Reilly T. The relationship between assessments of jet lag and some of its symptoms. *Chronobiol Int*. Nov 2003;20(6):1061-73. doi:10.1081/cbi-120025249

34. Leduc C, Robineau J, Tee JC, et al. The travel demands of an elite rugby sevens team: effects on objective and subjective sleep parameters. *Int J Sports Physiol Perform*. 2021;16(5):688-694.

Table 1. Final models detailing the relationship between travel scheduling factors and perceptual measures

Model	AIC	R^2	R^2 Fixed
Total Wellness ~ Travel Route + Day + Trip Type + Arrival Time + (1|Player Code)	3445.41	0.23	0.17
Fatigue ~ Travel Route + Day + Trip Type + Arrival Time + (1|Player Code)	2038.65	0.26	0.21
Sleep ~ Travel Route + Day + Arrival Time + Trip Type + (1|Player Code)	2426.79	0.22	0.13
Soreness ~ Travel Route + Arrival Time + Trip Type + Day + (1|Player Code)	1963.19	0.16	0.13
Stress ~ Travel Route + Departure Time + Arrival Time + Trip Type + (1|Player Code)	1193.08	0.15	0.07
Perceived Jet Lag ~ Day + Travel Route + Trip Type + Player Age + National Team Caps + (1|Player Code)	2380.37	0.48	0.31

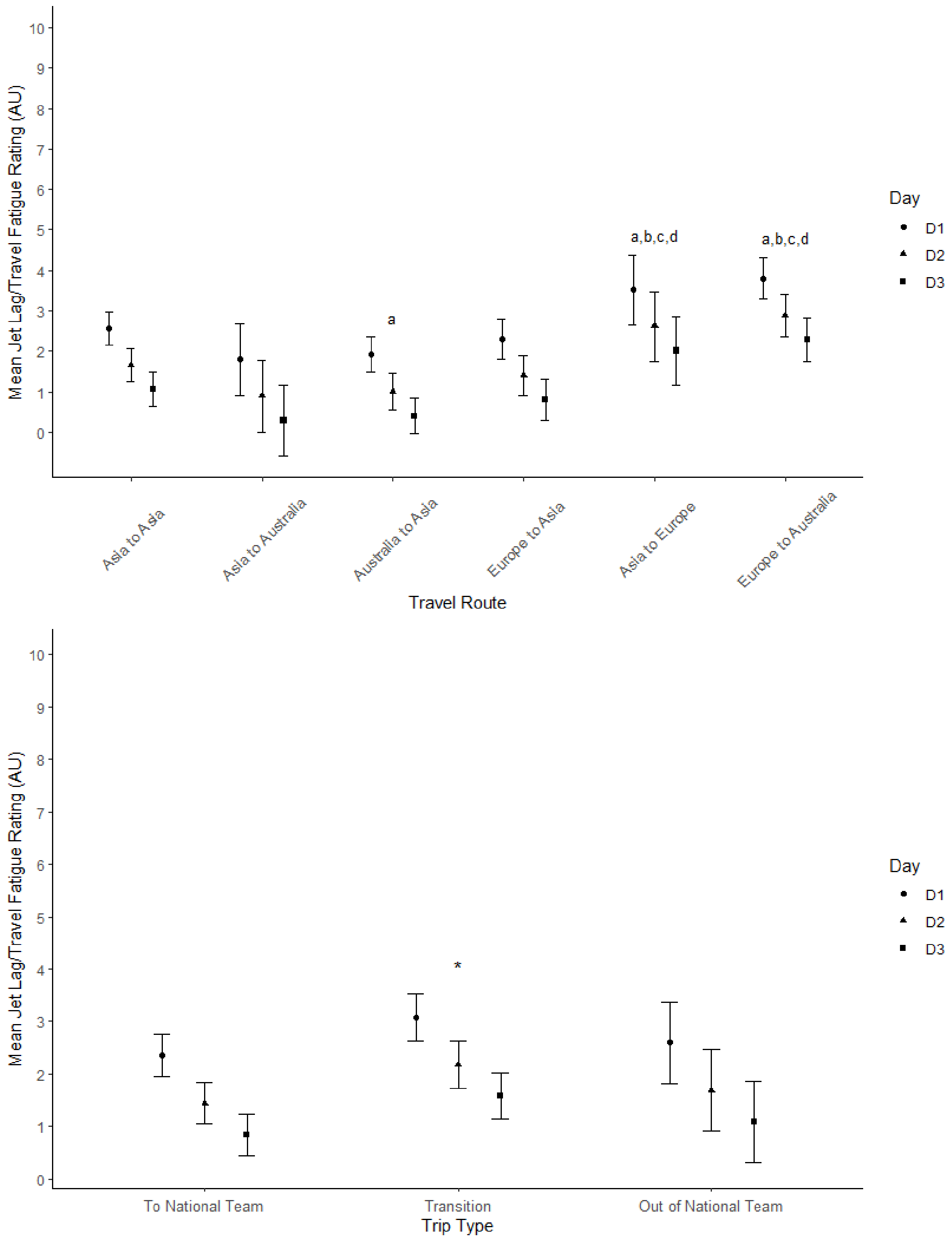

Figure 1. Mean change in perceptual perceived jet lag score by travel route and trip type (averaged out over day, player age and national team caps).

a – significantly different to Asia to Asia
b - significantly different to Asia to Australia
c - significantly different to Australia to Asia
d - significantly different to Europe to Asia
** - significantly different to travel To National Team*

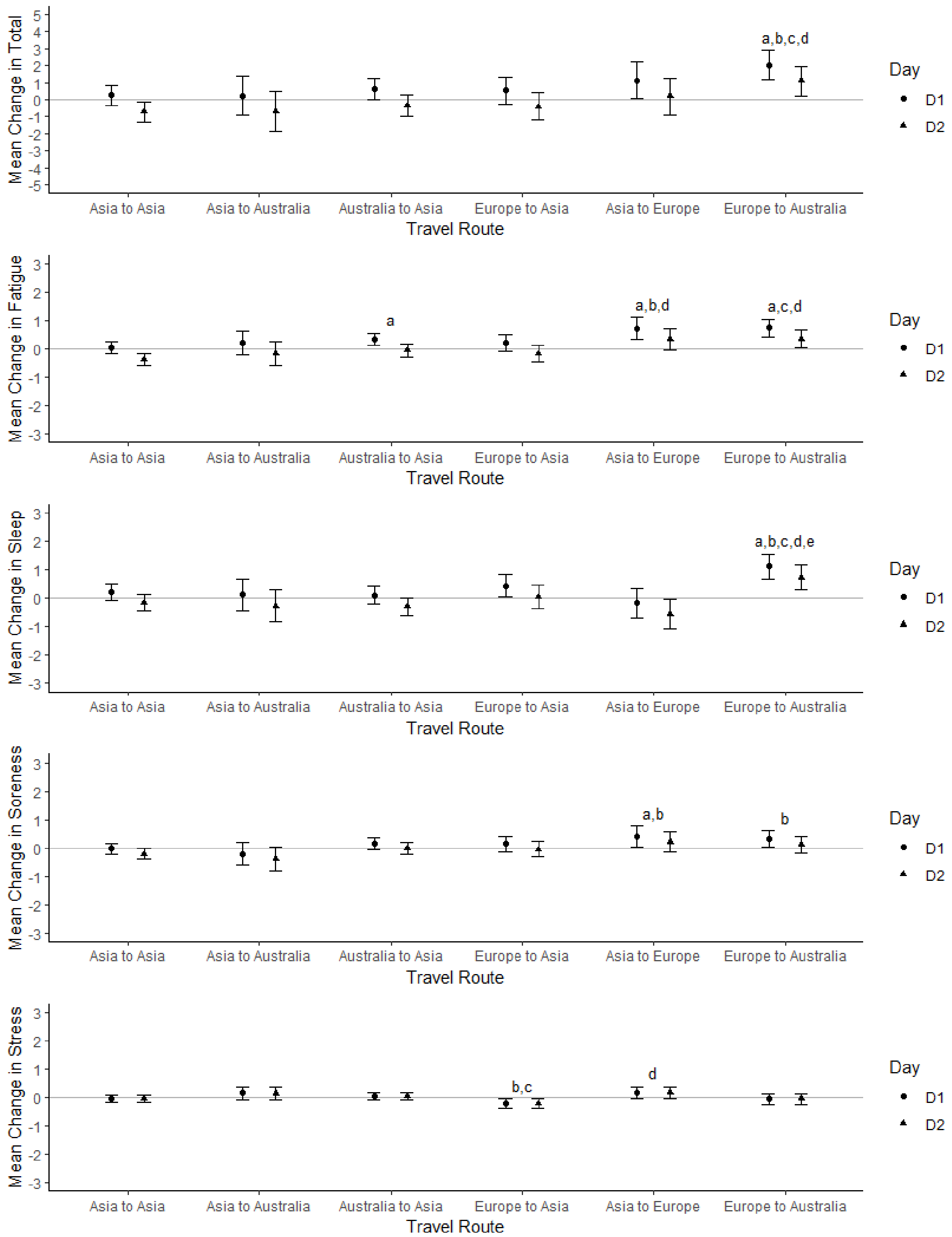

Figure 2. Mean change in perceptual wellness scores by travel route (values are averaged out over levels of other variables).

a – significantly different to Asia to Asia
b - significantly different to Asia to Australia
c - significantly different to Australia to Asia
d - significantly different to Europe to Asia
e - significantly different to Asia to Europe

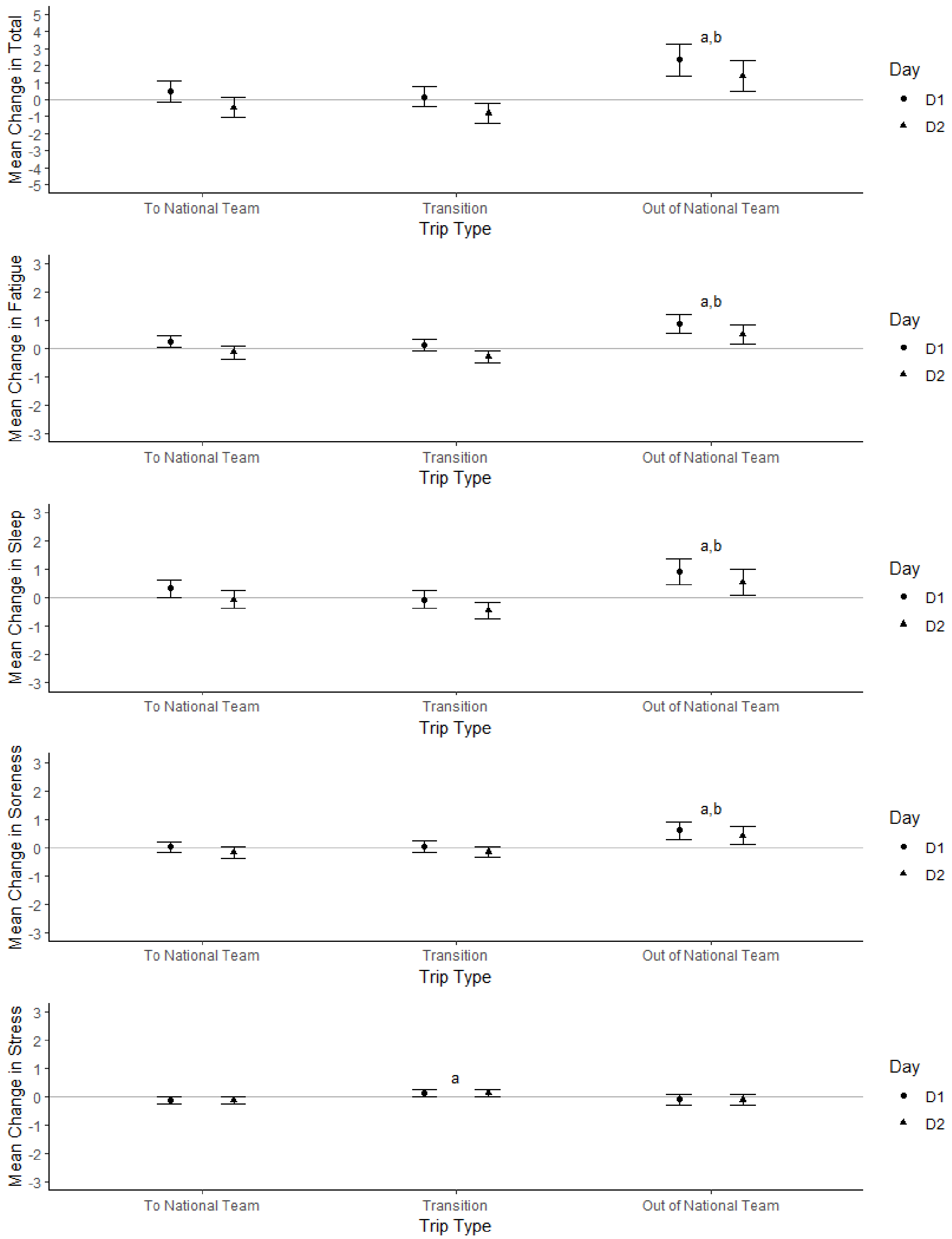

Figure 3. Mean change in perceptual wellness scores by trip type (values are averaged out over levels of other variables).

a – significantly different to travel To National team
b - significantly different to Transition

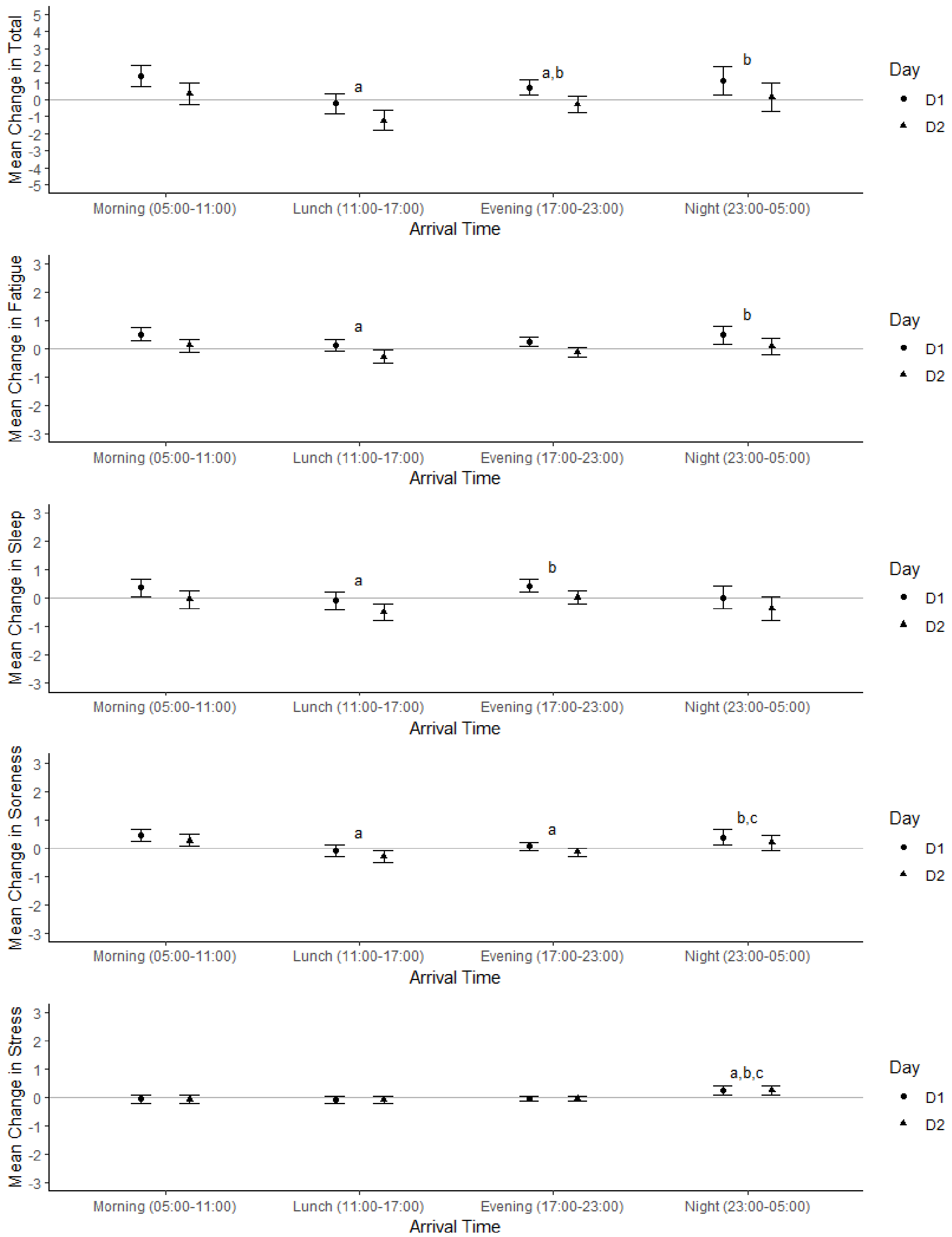

Figure 4. Mean change in perceptual wellness scores by Arrival Time (values are averaged out over levels of other variables).

a – significantly different to travel Morning
b - significantly different to travel Lunch
c - significantly different to travel Evening