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The impact of a simulated grand tour on sleep, mood, and well-being of competitive cyclists

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Aim. **Professional cycling is considered one of the most demanding of all endurance sports. The three major professional cycling stages races (*i.e.* Tour de France, Giro d'Italia and Vuelta a España) require cyclists to compete daily covering between ~150-200 km for three consecutive weeks. Anecdotal evidence indicates that such an event has a significant effect on the sleep, mood, and general well-being of cyclists, particularly during the latter stages of the event. The primary aim of this study was to simulate a grand tour and determine the impact a grand tour has on the sleep, mood, and general well-being of competitive cyclists.**

Methods. **Twenty-one male cyclists (M±SD, age 22.2±2.7 years) were examined for 39 days across three phases (*i.e.* baseline, simulated grand tour, and recovery). Sleep was assessed using sleep diaries and wrist activity monitors. Mood and general well-being were assessed using the Brunel Mood Scale (BRUMS) and Visual Analogue Scales (VAS).**

Results. **The amount and quality of sleep as assessed by the wrist activity monitors declined during the simulated grand tour. In contrast, self-reported sleep quality improved throughout the study. Cyclists' mood and general well-being as indicated by vigour, motivation, physical and mental state declined during the simulated tour.**

Conclusion. **Future investigations should examine sleep, mood and well-being during an actual grand tour. Such data could prove instrumental toward understanding the sleep and psychological changes that occur during a grand tour.**

Key words: Monitoring, Physiologic - Sleep - Bicycling - Athletes

Professional cycling is considered one of the most demanding of all endurance sports.[1] Professional cyclists may perform on a variety of surfaces (*e.g.* track, road, cross-country, and mountain) and terrains (*e.g.* flat, uphill, and downhill). The events can range in duration from ten-seconds to three-week stage races covering distances between 200 m to 4000 km.[2] The grand tours, the Tour de France, Giro d'Italia, and Vuelta a España, are the three major professional cycling stage races, which represent a unique racing format requiring cyclists to race almost daily (~150-200 km or 4 to 5 h per day) for three consecutive weeks.[3]

Anecdotal evidence indicates that cyclists become increasingly more fatigued, obtain very little sleep, and often require sleeping tablets to initiate sleep toward the end of a grand tour.[4] However, the extent to which a grand tour affects cyclists' physiological and psychological well-being is not well known.[2] This is predominantly due to professional management staff and coaches' reluctance to volunteer their cyclists for invasive research methodologies during important events.

Sleep is essential for recovery, mood, and daytime functioning,[5, 6] so any event (*i.e.* a grand tour) that has the potential to disrupt cyclists' sleep may need to be examined closely. Sleep is characterised by two main phases, rapid eye movement (REM) and non-rapid eye movement (NREM) sleep, which consists of progressively deeper sleep stages 1, 2, and 3. While REM sleep is important for learning and memory consolidation,[7] it is during slow-wave

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sleep (SWS; NREM 3), the deepest sleep stage, where growth hormones are secreted stimulating the protein synthesis necessary for body restoration. This process is essential for muscle repair, bone building, and burning fat.[8, 9] Given that sleep, specifically SWS is associated with the repair and growth of muscle, it is essential that athletes maximise their sleep opportunities following intense exercise and peak competition phases. It is plausible that a lack of sleep may inhibit the restorative processes that occur during sleep and as a consequence disrupt the important adaptations that occur during intensified training and competition.[10]

The interrelationship between sleep and mood is complex such that a lack of sleep negatively affects mood.[11, 12] In a similar fashion, negative mood states cause sleep disturbances.[13, 14] Sleep is widely recognised as an essential part of the physiological and psychological well-being of an athlete;[15, 16] however no study has examined sleep, mood, and the general well-being of competitive cyclists during longer endurance events such as a grand tour. To this end, the aim of this study was to simulate a grand tour to examine its impact on the sleep, mood, and the general well-being of competitive cyclists.

Materials and methods

Participants

Twenty-one male cyclists participated in this study (M±SD, age 22.2±2.7 years; height 179.6±6.0 cm; weight 70.2±7.2 kg; HR_{max} 190.9±7.1; maximal aerobic power W/kg 5.1±0.3).[17] On the first day of the study, physiology staff at the Australian Institute of Sport provided comprehensive verbal and written information regarding the purpose of the study and participants gave written informed consent. The inclusion criterion required participants to have competed at national and/or international level within the past year. This study was approved by the human research ethics committees of the University of South Australia and the Australian Institute of Sport.

Design

Data were collected over three distinct phases (*i.e.* normal, simulated grand tour [intensified], and recovery) (Figure 1). The training of each participant was controlled and monitored for the duration of the study. The first phase (*i.e.* seven days) consisted of low-moderate training which was used to establish a baseline and familiarise participants with the study procedures. The second phase (*i.e.* 21 days) was a simulated grand tour divided into three weeks (*i.e.* SGTW1, SGTW2, and SGTW3) whereby the duration and distances participants covered progressively increased week-to-week (Table I). Each day during the simulated grand tour, participants completed a road ride, a laboratory ride and/or a combination of both rides. The third and final phase (*i.e.* 11 days) was a recovery phase (*e.g.* taper) which involved a reduction in training load (Figure 1).

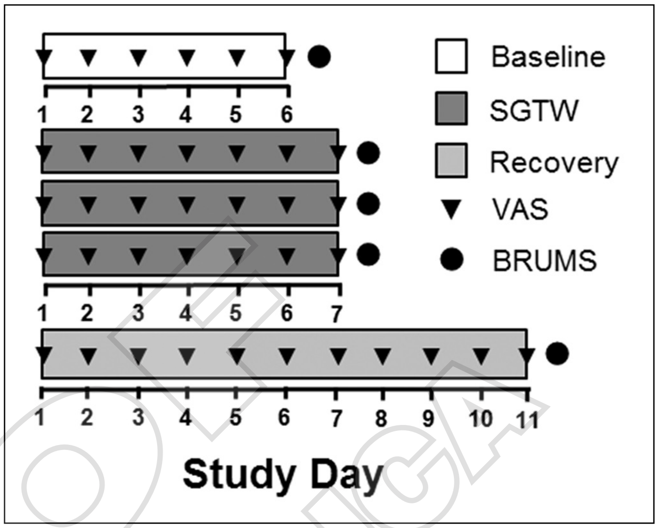

Figure 1.—A visual representation of the study protocol.

Setting

Participants resided on site at the Australian Institute of Sport for the duration of the study. Participants shared an apartment with three or four other participants. Each participant was allocated an individual bedroom which enabled them to control their sleep environment (*e.g.* lighting and air conditioning). All meals were served and consumed in the dining hall at specific hours each day (breakfast: 06:30-10:00 h; lunch: 12:00-13:45 h; dinner: 17:45-20:45 h). All participants had equal access to the dining hall in between meal times to prepare snacks as required. Dietary intake was not controlled throughout the study.

TABLE I.—*Training data over the course of each study phase.*

	Phase of study				
	Baseline Day 1-7 M±SD	SGTW1 Day 8-14 M±SD	SGTW2 Day 15-21 M±SD	SGTW3 Day 22-28 M±SD	Recovery Day 29-39 M±SD
Per day					
Average cycling duration (h)	1.6±0.7	3.0±1.4	3.4±1.8	3.4±2.3	1.0±0.8
Average cycling distance (km)	53.2±22.4	102.2±51.8	116.5±50.4	118.9±66.8	37.1±27.8
Average elevation gain (m)	553.3±285.7	1190.4±719.2	1311.0±827.8	1214.3±838.3	330.7±245.7
Average cycling speed (km·h)	28.4±2.7	29.8±3.3	28.6±2.6	27.6±2.4	26.0±3.1
Per week					
Total duration (h)	9.6±0.7	21.3±1.4	23.6±1.8	24.0±2.3	10.0±0.5
Total distance (km)	319.5±20.4	715.7±51.8	815.8±50.4	832.3±66.8	370.9±19.5

SGTW1: simulated grand tour week 1; SGTW2: simulated grand tour week 2; SGTW3: simulated grand tour week 3.

Sleep/wake assessments

Sleep/wake behaviour was monitored using self-report sleep diaries and wrist activity monitors (Philips Respironics, Bend, OR, USA). Data derived from the sleep diaries and wrist activity monitors were used to determine the amount and quality of sleep participants' obtained daily. This was achieved using the Phillips Respironics' Actiwatch Algorithm where time was scored as wake unless: 1) the sleep diary indicated the participant was lying down attempting to sleep; and 2) the activity counts derived from the activity monitor were sufficiently low to indicate that the participant was immobile. Once these conditions were met simultaneously, time was scored as sleep. This scoring process was conducted with a sensitivity set at "medium".[18, 19] This algorithm has recently been used to quantify the sleep/wake behaviour in elite athletes.[20, 21] The algorithm was also used to generate an activity plot which provides a visual representation of participants' sleep/wake behaviour. Visual inspection of the activity plot allowed users to assess the consistency of records and adjust or exclude data where appropriate. Based on the visual inspection of the activity plot the following rules were applied: 1) if the activity monitor was not worn as indicated by no activity on the activity plot, data were excluded from all analyses; and 2) if the discrepancy between the sleep diary and activity monitor data exceeded 30 min, the sleep dairy data were adjusted to match the activity monitor data. The following outcome measures were derived from the activity monitors' and sleep diary data:

— total sleep time (h): duration of sleep during a sleep period.

— sleep efficiency (%): percentage of time in bed that was spent asleep.

— Mean Activity Score: 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: participants were asked "*Please rate how you feel this morning*" according to the subscale (*e.g.* sleep quality) by placing a mark on a standard linear non-numeric bipolar Visual Analogue Scale (VAS) that consisted of a 100 mm line with anchors "very poor" and 'very good' at either end.

Training phases

Training schedules for the duration of the study were set by coaching and management staff (Table I). All rides were completed together as a single cohort and involved variable terrain (*e.g.* climbing and flats). All long rides were supervised by a support vehicle and a coach (on a motor cycle) to ensure safety and compliance. A detailed description of the training programme is reported in a companion paper.[17]

Psychological assessments

BRUNEL MOOD SCALE

Mood was assessed using the Brunel Mood Scale (BRUMS).[22] The BRUMS consists of 24 adjectives that describe mood which comprise of six separate mood subscales: anger, confusion, depression, fatigue, tension, and vigour. For each adjective, participants indicate whether they have experienced such feelings on a 5-point Likert Scale (*i.e.* 0= not at all, 1= a little, 2= moderately, 3= quite a bit, and 4= extremely) using a standard response timeframe of "*How have you felt during the past week including today"*.[22] Total mood disturbance score was calculated by summing the five negative mood states (tension, anger, depression, fatigue, confusion), subtracting the vigour score, and adding a constant of 100 to prevent negative numbers.

VAS

Every day for the duration of the study, general well-being was assessed using seven visual analogue scales (*i.e.* motivation, alertness, happiness, health, physical state, mental state, stress, and global well-being). Global well-being was calculated by summing the average of all VAS scores. Participants were asked "*Please rate how you feel this morning"* according to the subscale by placing a mark on a standard 100mm linear non-numeric bipolar VAS.

Procedure

For the duration of the study, participants were asked to maintain a bed and get-up time of 22:00 h and 07:30 h. Participants wore a wrist activity monitor and were instructed not to remove it except when showering or swimming. Self-report sleep diaries were used in conjunction with the wrist activity monitors where participants were asked to record their bedtime prior to a night-time sleep period and their get-up time as soon as practicable after waking. Participants were instructed to complete their daily VAS after recording their get-up times. The BRUMS was completed in the late afternoon (*i.e.* 16:00-18:00 h) on five occasions during the data collection period, once at the end of the baseline training phase, once on the last day of each week during the simulated grand tour, and once at the end of the recovery phase (Figure 1).

Statistical analysis

Data were analysed using SPSS (v17.0) statistical software. The statistical significance of all fixed effects was determined using F tests. The denominator degrees of freedom for F statistics were computed using the Satterthwaite approximation method.[23] Bonferroni corrections were made to reduce the chances of obtaining a Type 1 error. Effect sizes were calculated using Cohen's *d* and the criteria to interpret the magnitude of the effect size were: trivial (0-0.19), small (≤0.20-0.49), medium (≤0.50-0.79) and large (≥0.80).[24] An alpha of $P<0.05$ was the criterion for statistical significance. Data are presented as M±SD.

Sleep, mood and general well-being

Linear mixed models were conducted to determine if there was a main effect of phase on the sleep, mood, and general well-being cyclists' obtain during a simulated grand tour. Each mixed model included 'phase' (5 levels; baseline training, SGTW 1, 2, and 3, and recovery phase) as a fixed term and 'participant' (N.=21) as a random term. *Post-hoc* comparisons were conducted to determine which study phase differed from baseline.

The dependent variables for sleep, mood, and general well-being were as follows:

sleep: total sleep time, sleep efficiency, mean activity score and sleep quality.

mood: anger, depression, tension, confusion, fatigue, vigour, and total mood disturbance.

general well-being: motivation, alertness, happiness, health, physical state, mental state, stress, and global well-being.

TABLE II.—*Sleep variables during baseline, the simulated grand tour, and the recovery phase.*

Sleep variable	Baseline	Simulated tour			Recovery
	BL (N.=124) M±SD *(d)*	SGTW1 (N.=142) M±SD *(d)*	SGTW2 (N.=141) M±SD *(d)*	SGTW3 (N.=144) M±SD *(d)*	Recovery (N.=209) M±SD *(d)*
Total sleep time (h)#	7.4±0.8	7.2±0.9 (0.2)	7.0±0.9 (0.4)*	7.1±1.0 (0.3)*	7.1±0.9 (0.4)*
Sleep efficiency (%)#	86.6±4.8	84.4±5.3 (0.4)*	84.9±5.4 (0.3)*	85.1±5.9 (0.2)*	85.7±5.4 (0.2)
Mean activity score#	14.6±6.4	17.5±7.2 (0.4)*	17.1±7.4 (0.4)*	17.4±8.3 (0.4)*	15.6±7.7 (0.2)
Subjective sleep quality#	69.4±22.8	71.3±19.9 (0.1)	72.8±20.7 (0.1)	74.9±21.5 (0.2)	79.1±17.0 (0.5)*

#Significant main effects of phase. Mean values with * are significantly different from baseline. Cohen's *d* is represented as *(d).*

Results

Sleep

On average, participants obtained 7.2±0.9 h of sleep, had a sleep efficiency of 85±5.4%, mean activity score of 16.3±7.5, and rated their subjective sleep quality at 74.4±20.3 on the VAS (Table II). There were significant main effects of study phase on total sleep time ($F_{4,735}$=5.2, $P<0.001$), sleep efficiency ($F_{4,735}$=9.9, $P<0.001$), mean activity score ($F_{4,735}$=8.5, $P<0.001$) and subjective sleep quality ($F_{4,690}$=8.1, $P<0.001$).

Total sleep time was significantly shorter during the last two weeks of the simulated grand tour and the recovery phase than the baseline training phase (Figure 2A). Sleep efficiency was lowest during the simulated grand tour (Figure 2B). Mean activity scores were highest during the simulated grand tour. This was significantly higher than the baseline training phase (Figure 2C). Subjective sleep quality was also highest during the recovery phase. This was significantly higher than the baseline training phase (Figure 2D).

Mood: BRUMS

Linear mixed models revealed a main effect of study phase on vigour ($F_{4,28}$=4.4, $P<0.01$). Vigour scores were lowest during the simulated grand tour weeks 1 and 3 than the baseline training phase (Figure 3B). There were no main effects of study phase on anger, depression, tension, confusion, fatigue, and total mood disturbance (Table III).

General well-being: VAS

The changes in general well-being as assessed by the VAS ratings across the training phases are presented in Figure 4. Linear mixed models revealed main effects of study phase on alertness ($F_{4,674}$=2.9, $P<0.05$), happiness ($F_{4,677}$=3.0, $P<0.05$), health ($F_{4,676}$=4.5, $P<0.01$), mental state ($F_{4,676}$=7.2, $P<0.001$), motivation ($F_{4,632}$=3.8, $P<0.01$), and physical state ($F_{4,676}$=6.8, $P<0.001$).

The dependent variables of motivation, mental state and physical state VAS ratings were highest at baseline, lowest during the simulated grand tour and returned close to baseline levels during the recovery phase (Figure 4). There was no main effect of study phase on stress and global well-being (Table IV).

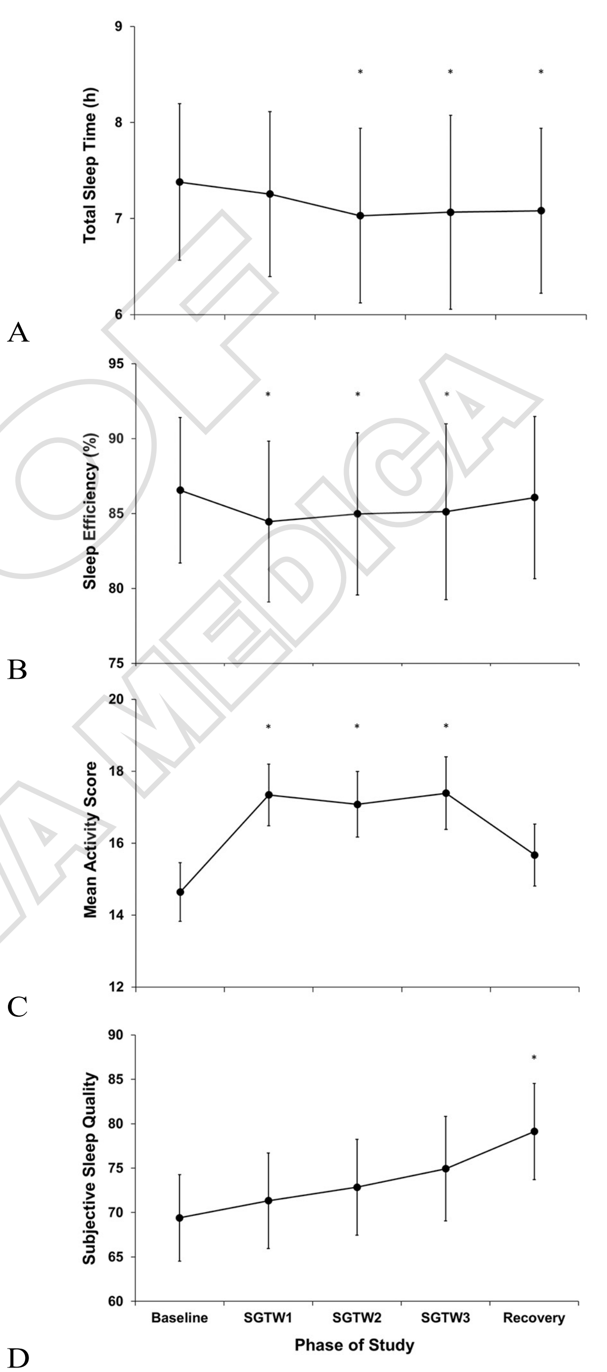

Figure 2.—A) Total sleep time (h); B) sleep efficiency; B) Mean Activity Score; D) subjective sleep quality over the course of the study phases. Data are M±SD. Statistical significance symbolized by *P<0.05 represents significance compared to baseline. SGTW1= simulated grand tour week 1; SGTW2= simulated grand tour week 2, SGTW3= simulated grand tour week 3.

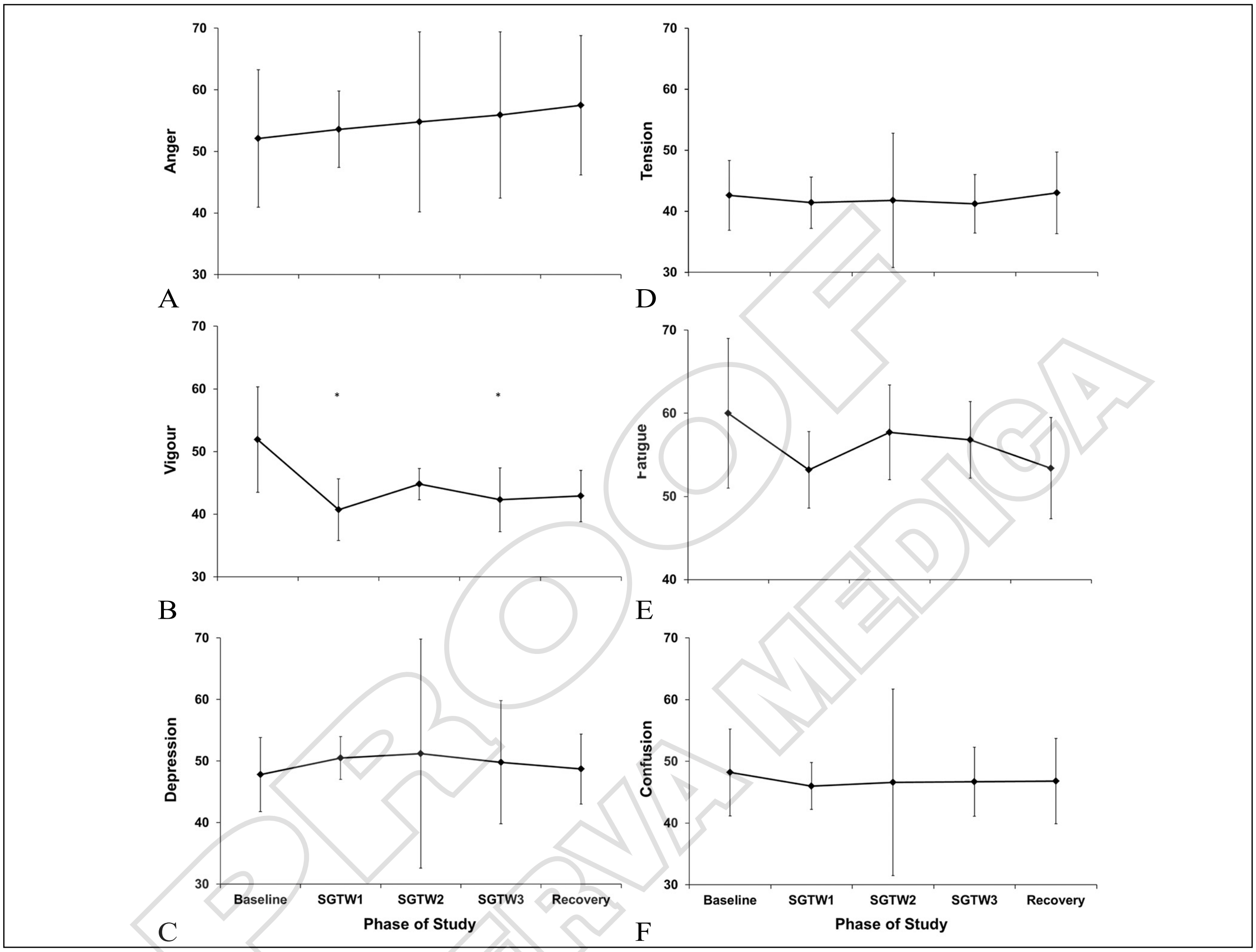

Figure 3.—A) Anger; B) vigour; C) depression; D) tension; E) fatigue; F) confusion T-scores as assessed by the BRUMS over the course of the study phases. Data are M±SD. Statistical significance symbolized by *P<0.05 represents significance compared to baseline. SGTW1= simulated grand tour week 1, SGTW2= simulated grand tour week 2; SGTW3= simulated grand tour week 3.

TABLE III.—*Mood variables during baseline, the simulated grand tour, and the recovery phase.*

BRUMS	Baseline	Simulated grand tour			Recovery
	BL (N.=124*)* M±SD *(d)*	SGTW1 (N.=142*)* M±SD *(d)*	SGTW2 (N.=141*)* M±SD *(d)*	SGTW3 (N.=144*)* M±SD *(d)*	Recovery (N.=209*)* M±SD *(d)*
Anger	52.1±11.2	53.6±6.2 (0.2)	54.8±14.8 (0.2)	55.9±13.5 (0.3)	57.5±11.3 (0.2)
Vigour#	51.9±8.4	40.7±13.6 (0.9)*	44.8±2.5 (1.0)	42.3±5.1 (1.1)*	42.9±4.1 (1.3)
Depression	47.8±6.0	50.5±3.5 (0.5)	51.2±18.9 (0.2)	49.8±10.0 (0.2)	48.7±5.7 (0.2)
Tension	42.6±5.7	41.4±4.2 (0.3)	41.8±11.1 (0.1)	41.2±4.8 (0.3)	43.0±6.7 (0.1)
Fatigue	60.0±9.4	53.2±4.6 (0.9)	57.7±5.7 (0.3)	56.8±4.6 (0.4)	53.4±6.1 (0.8)
Confusion	48.0±7.4	46.0±3.8 (0.3)	46.6±15.1 (0.1)	46.7±5.6 (0.2)	46.8±6.9 (0.2)
Total Mood Disturbance	101.8±6.2	104.2±9.9 (0.3)	102.9±8.6 (0.1)	102.4±8.0 (0.1)	100.5±8.3 (0.2)

#Significant main effects of phase. Mean values with * are significantly different from baseline. Cohen's *d* is represented as *(d)*.

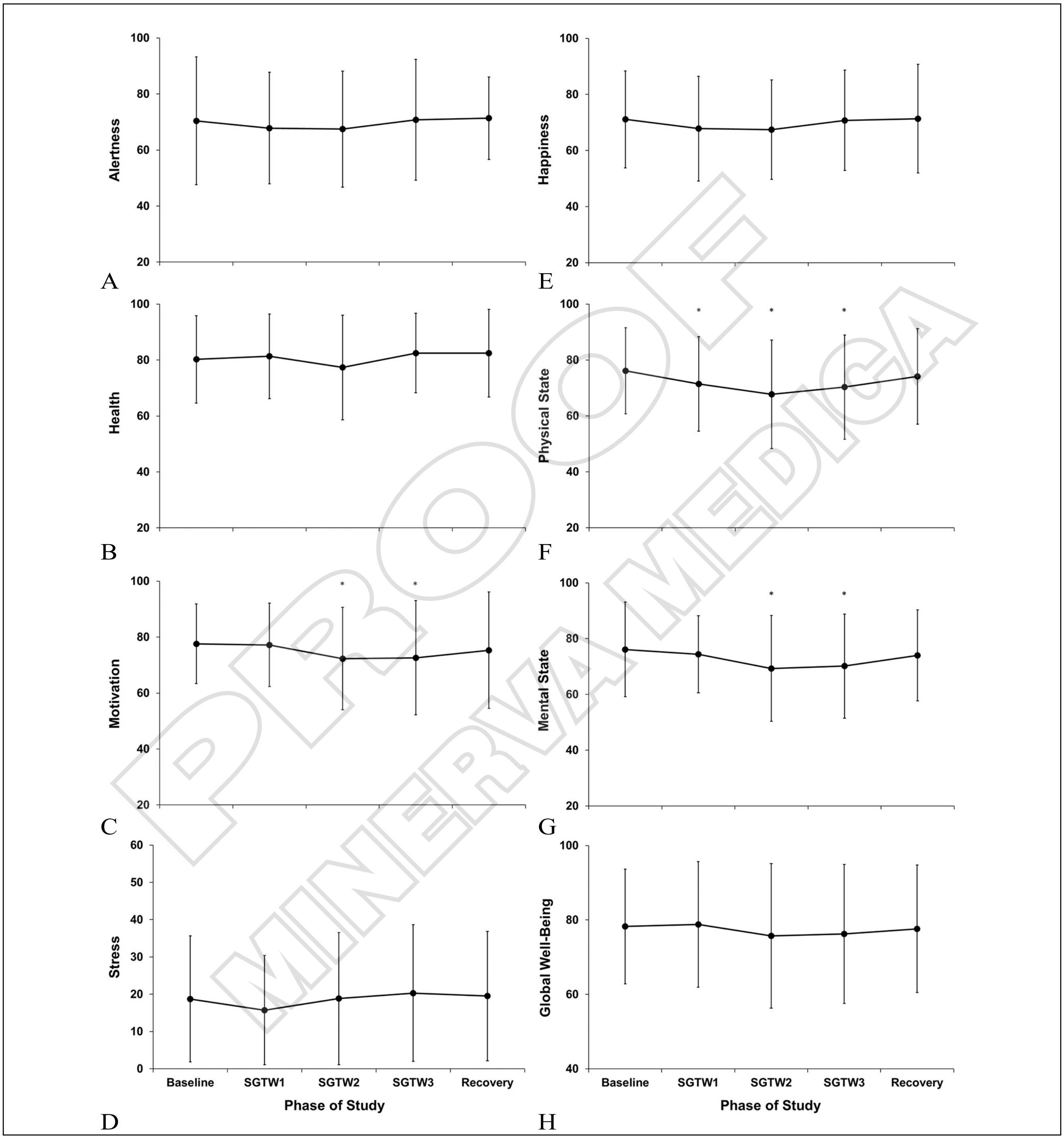

Figure 4.—A) Alertness; B) health; C) motivation; D) stress; E) happiness; F) physical state; g) mental state; H) global well-being scores as assessed by VAS ratings across each study phase. Data are M±SD. Statistical significance symbolized by $^{*}P<0.05$ represents significance compared to baseline. SGTW1= simulated grand tour week 1; SGTW2= simulated grand tour week 2; SGTW3= simulated grand tour week 3.

TABLE IV.—*Visual Analogue Scale scores during baseline, the simulated grand tour, and the recovery phase.*

Visual Analogue Scales	Baseline	Simulated tour			Recovery
	BL (N.=124) M±SD *(d)*	SGTW1 (N.=142) M±SD *(d)*	SGTW2 (N.=141) M±SD *(d)*	SGTW3 (N.=144) M±SD *(d)*	Recovery (N.=209) M±SD *(d)*
Alertness#	70.6±17.3	67.9±18.5 (0.2)	67.3±17.8 (0.2)	70.9±18.0 (0.2)	71.3±19.4 (0.1)
Health#	80.5±15.6	81.2±15.1 (0.0)	77.5±18.7 (0.2)	83.0±14.2 (0.2)	82.1±17.7 (0.2)
Motivation#	77.6±14.4	77.2±14.9 (0.0)	72.3±18.5 (0.3)*	72.6±20.4 (0.3)*	75.3±20.8 (0.1)
Stress	18.7±16.9	15.7±16.8 (0.2)	18.8±19.9 (0.0)	20.3±22.8 (0.1)	19.5±23.2 (0.0)
Happiness#	71.1±17.4	67.9±18.5 (0.2)	67.4±17.8 (0.2)	70.3±18.0 (0.0)	71.3±19.4 (0.0)
Physical State#	76.1±15.5	71.4±16.9 (0.3)*	67.8±19.9 (0.5)*	70.3±18.7 (0.3)*	74.1±17.1 (0.1)
Mental State#	76.3±16.9	75.3±13.7 (0.1)	69.4±18.8 (0.4)*	70.6±18.7 (0.3)*	74.0±16.3 (0.1)
Global Well-Being	78.2±16.5	78.7±15.5 (0.3)	75.6±18.1 (0.1)	76.2±18.1 (0.1)	77.6±17.7 (0.2)

#Significant main effects of phase. Mean values with * are significantly different from baseline. Cohen's *d* is represented as *(d)*.

Discussion

The aim of this study was to examine the effect a simulated grand tour has on the sleep, mood, and general well-being of competitive cyclists. The findings reveal that there was a reduction in the amount and quality of sleep during the simulated grand tour as assessed by wrist activity monitors. However, self-reported sleep quality improved throughout the duration of the study. There were also some disturbances to the mood and general well-being of competitive cyclists as indicated by the reductions in vigour, motivation, mental, and physical state during the simulated grand tour.

Cyclists obtained 20 minutes less sleep per week during the final two weeks of the simulated grand tour than the baseline training phase. Although this amount of sleep loss was statistically significant, cyclists obtained more than 7 h of sleep per night throughout the simulated grand tour. In healthy adult populations, performance is maintained following 7 h of sleep per night. However, when sleep was reduced to 5 h or less, significant degradations of mood and performance were observed.[6, 25]

For sleep quality, there were conflicting results between objective and subjective sleep assessments. The quality of sleep as assessed via wrist activity monitors (*i.e.* sleep efficiency and mean activity score) declined during the simulated grand tour. In contrast, cyclists reported the poorest sleep quality during the baseline training phase, which progressively improved throughout the simulated grand tour reaching the highest quality of sleep during the recovery phase. Although sleep quality typically improves during recovery phases due to the overall reduction in training load,[26] it was unexpected to observe gradual improvements over the course of the simulated grand tour.

These data show a difference between objective and subjective assessments of sleep. Several validation studies conducted within non-athletic populations reveal disagreement between individual perceptions of sleep than their objective sleep.[14, 27, 28] There are a few potential explanations for the discrepancy between the objective and subjective assessments of sleep. One plausible explanation is that cyclists experienced some level of anxiety upon entering the study environment.[29] This was apparent by the elevated scores for confusion and tension during the baseline training phase than the simulated grand tour (Figure 3). This can be described as an adjustment period whereby participants familiarised themselves with the study equipment, study procedures, other participants, research staff, and their new sleep environments. It is possible that this adjustment period affected the self-reported sleep quality of participants during the initial baseline training phase. However, it was unexpected that the self-reported sleep quality of cyclists continued to improve during the simulated grand tour.

The gradual improvement in sleep quality may be a result of the adaptation gains obtained with the increased training load (*e.g.* distance, elevation, and duration of road rides) throughout the simulated grand tour. Given this grand tour was simulated, it was difficult to replicate the intensity and stress of real life competition. In comparison to a real grand tour where cyclists are constantly changing their sleep environments, the cyclists within this sample consistently slept in the same environment. Therefore, it is possible that they became increasingly familiar with their surroundings resulting in improved self-reported sleep quality.

Mood and general well-being

Overall, cyclists experienced some mood disturbances during the simulated grand tour. There was evidence of confusion and tension during the initial baseline training phase. With the exception of confusion and tension, mood disturbances were minimal during the initial baseline training phase with few indices of mood disturbance during the simulated grand tour. These observations are contradictory to those observed in similar studies, where short-term increases in training load (comparable to those implemented in the simulated grand tour) affected mood in a dose-dependent manner *e.g.*[10, 30-32] For example, while examining mood in cyclists during three training phases (*e.g.* baseline, intensified, recovery), Halson *et al.* [10] found mood disturbance increased by 29% during the intensified training phase than the baseline training phase. In the present sample, vigour was the only mood subscale that showed indices of mood disturbance, recording a 14% decrease in vigour scores from baseline to the third week of the simulated grand tour.

Cyclists reported significant reductions in motivation, mental, and physical state during the simulated grand tour. As expected, these measures returned close to baseline levels during the recovery phase. The reduction and subsequent recovery of motivation, mental, and physical state indicate that the VAS were more sensitive to changes in mood and well-being than the BRUMS. The recovery of motivation, mental, and physical state during the recovery phase may reflect the simplicity of assessment which requires minimal demand on behalf of the participant.[33] The VAS were able to capture the preparatory nature of the recovery phase, which provided cyclists with the opportunity to rest and recover from a heavy three-week simulated grand tour and as a result restore their overall psychological state.[34]

Limitations

One of the main limitations of this study was that dietary intake was not controlled. This is an important issue as hydration, caffeine, type and timing of snacks have the potential to negatively influence sleep.[35, 36] It is possible that the introduction of a self-reported food diary may provide further information concerning any mediating effects dietary intake has on athletes' sleep.[37] An additional limitation to be considered was that sleep was examined during a simulated grand tour. These data may be limited as behaviour within a simulated environment may not resemble the behaviour of cyclists during a real grand tour. For example, professional cycling teams consist of various types of riders (*e.g.* sprinters, climbers, domestiques, time trial specialists and team leaders) where each rider has a role to serve for the team and ultimately works for the team leader. Further to this, during competition there are psychological stressors placed upon athletes (*e.g.* performance, media, and sponsorship requirements). In this study, there was an emphasis on performing at an individual best. However, no emphasis was made toward achieving specific results. This may have reduced the level of competitiveness between cyclists, and as a result may not have replicated the psychological disturbances experienced during a real tour.

Conclusions

Data from the present study indicate that an increase in training load in the form of simulated grand tour has the potential to negatively impact sleep and mood. In circumstances where athletes begin to show signs of mood disturbance, it is important to address both the physiological and psychological well-being of the athlete. For example, recovery in the form of cold water immersion, massage, consuming high nutrient meals, compression garments, and general comfort may aid both physiological and psychological well-being.[38]

Given that wrist activity monitors are non-invasive and can monitor sleep over consecutive days and/or weeks, it is recommended that they are employed in conjunction with daily visual analogue scales to closely monitor the physiological and psychological well-being of athletes during longer endurance events such as a grand tour. In doing so, coaches and support staff will be able to address any disturbances to mood and/or sleep. It is recommended that future investigations examine dietary intake, sleep, mood, and general well-being during an actual grand tour such as the Tour de France, Giro d'Italia or the Vuelta a España. It is acknowledged that this recommendation may be met with some reluctance on behalf of professional cycling teams as grand tours are viewed as the most prestigious among all cycling events. An alternative approach may be to increase competitiveness between participants within the study by introducing a financial reward and place a greater emphasis on performance.

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