SAARLAND UNIVERSITY (GERMANY)

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Faculty of Health

SLEEP-RELATED ISSUES FACING PROFESSIONAL FOOTBALL PLAYERS

By

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This thesis is presented for the award of a Doctor of Philosophy (Sports Medicine) from the Philosophical and Medical Faculty, Saarland University, Saarbrücken, Germany in conjunction with the Faculty of Health, University of Technology Sydney, Australia

CERTIFICATE OF AUTHORSHIP/ORIGINALITY

I, Hugh Head Kelsham Fullagar, declare that this thesis, is submitted in partial fulfilment of the requirements for the award of Doctor of Philosophy in the Institute of Sport and Preventive Medicine, Saarland University (Germany) and at the University of Technology Sydney (Australia) conducted jointly under the Memorandum of understanding between both institutions as part of an international joint PhD program. This thesis is wholly my own work as the sole author unless otherwise referenced or acknowledged. I have observed proper academic practice in the production of this thesis, and recognise and am thankful for the assistance in the production of this research and the preparation of this thesis from Saarland University supervisor Professor Tim Meyer and the Doctoral Graduate Research Program within Saarland University, in conjunction with University of Technology Sydney supervisor Associate Professor Rob Duffield and the respective Graduate Research School and Faculty of Health at the University of Technology Sydney. As such, I also certify to the best of my knowledge and belief that this thesis does not:

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I also acknowledge that this research was supported by an Australian Government Research Training Program Scholarship.

I also grant permission for the library at Saarland University and University of Technology Sydney to produce duplicate copies of my thesis as required.

Hugh Head Kelsham Fullagar

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STANDARD ABBREVIATIONS

^{o}	Degrees
^{o}C	Degrees Celsius
ANOVA	Analysis of variance
CV	Coefficient of variation
d	Day
g	Gram
HR	Heart rate
ICC	Inter-class coefficient
Kg	Kilogram
km	Kilometre
m	Metre
mM	Milli-molar
min	Minute
n	Number of (participant sample size)
r	Correlation statistic
RPE	Rating of perceived exertion
s	Second
SEM	Standard error of measurement
SD	Standard deviation
VO_{2max}	Maximal oxygen consumption
W	Watt
y	Year

TABLES

FIGURES

LIST OF PUBLICATIONS RELEVANT TO THE THESIS

Literature Review

1. **Fullagar, H.H.K.,** Skorski, S, Duffield, R, Hammes, D, Coutts, A, Meyer, T. (2015). Sleep and athletic performance: The effects of sleep loss on exercise performance, and physiological and cognitive responses to exercise. *Sports Medicine.* 45(2):161-186. DOI: 10.1007/s40279-014-0260-0

2. **Fullagar, H.H.K.,** Duffield, R, Skorski, S, Coutts, A, Julian, R, Meyer, T. (2015). Sleep and recovery in team sport: current sleep-related issues facing professional team-sport athletes. *International Journal of Sports Physiology and Performance.* 10(8):950-7. DOI: 10.1123/ijspp.2014-0565

Studies - Original Investigations

3. **Fullagar, H.H.K**., Skorski, S, Duffield, R, Julian, R, Bartlett, J, Meyer, T. (2016). Impaired sleep and recovery following night matches in elite football players. *Journal of Sports Sciences: Science and Medicine in Football*. 34(14):1333-9. DOI: 10.1080/02640414.2015.1135249

4. **Fullagar, H.H.K,** Duffield, R, Skorski, S, White, D, Bloomfield, J, Kolling, S, Meyer, T. (2016). Sleep, travel and recovery responses of national footballers during and following long-haul international air travel. *International Journal of Sports Physiology and Performance.* 11(1):86-95. DOI: 10.1123/ijspp.2015-0012

5. **Fullagar, H.H.K,** Skorski, S, Duffield, R, Meyer, T. (2016). The effect of an acute sleep hygiene strategy following a late-night soccer match on player recovery. *Chronobiology International.* 33(5):490-505. DOI: 10.3109/07420528.2016.1149190

ABSTRACT

Introduction: The ability of football players to tolerate and recover from the physiological and psychological stressors of training and match play is critical to ongoing performance success. The ability to recover from these stressors is affected by numerous factors; including, experience, fitness, motivation and the natural fluctuation of physiological and behavioural processes – particularly the sleep-wake cycle. Indeed, sleep loss incurred prior to competition may reduce subsequent performance; whilst a reduction in sleep quantity or quality following competition may impede the recovery timeline. As such, sleep for athletes' has been recognised anecdotally amongst coaches and players as critical to performance and recovery. However, normative sleep behaviour in football players remains unknown. Moreover, there is limited evidence to show that when sleep is disturbed, performance and recovery suffer within the elite football environment. Consequently, the potential positive impact of improving sleep parameters on the recovery and performance timeline therefore remains to be substantiated. Thus, the aim of this thesis was three-fold: i) to determine the sleeping patterns of football players and to assess whether and when disrupted sleep indices occurred and ensuing effect on perceptual recovery status; ii) to assess the sleep, travel and recovery responses of footballers during and following long-haul international air travel and ensuing matchplay; and iii) to investigate the effect of an acute sleep hygiene strategy on physical, physiological and psychological recovery of players following a late-night match.

Methods: i) To determine the sleeping patterns in elite football, a group of sixteen elite football players completed a subjective online questionnaire twice a day (morning and night) for 21 days during the regular season. Subjective recall of sleep variables (duration, time of wake and sleep, wake episode duration), a range of perceptual variables related to recovery, mood and performance, internal training loads and non-exercise stressors were collected. ii) To assess the sleep, travel and recovery responses of footballers during and following long-haul international air travel and match-play, fifteen national football players undertook 18 h of predominately westward international air travel from the United Kingdom to South America (-4 h time-zone shift) for a 10-day tour (including two night matches). Objective sleep parameters, external and internal training loads, subjective player match performance, technical match data and perceptual jet-lag and recovery measures were collected. iii) The final investigation determined the effect of an acute sleep hygiene strategy (SHS) on physical, physiological and psychological recovery of players following a late-night match. Two

highly-trained amateur teams (20 players) played two late-night friendly matches (20:45 start) against each other seven days apart. Players completed a sleep hygiene strategy after the match or undertook normal post-game routines in a randomised cross-over design. Objective sleep parameters, countermovement jump (CMJ), YoYo Intermittent Recovery test (YYIRT), venous blood and perceived recovery and stress markers were collected prior to and during the ensuing 48 h post-match.

Results: In summary of the above studies; i) Elite club players appear to sleep within healthy adequate ranges following training days and match days. However, players report significantly reduced sleep duration and perceptual recovery following night matches compared to day matches and training. The reasons for this poor sleep were varied and very individualistic in nature. ii) Similarly, objective measurements of sleep show sleep duration is truncated during long-haul international travel with a 4 h time-zone delay in national level players. Furthermore, sleep duration is reduced following night matches, though limited effects on perceptual recovery were evident in this professional cohort. iii) To combat such a reduction in sleep duration in night matches, a SHS was shown to be able to improve sleep quantity following a late-night football match in highly trained amateur players. Despite such increased sleep duration, no improvement in physical performance, perceived stress and recovery or blood-borne markers of muscle damage and inflammation were evident.

Discussion/conclusion: The first study in this dissertation provided evidence that sleep duration and quality is hindered following night matches in elite footballers, though sleep responses were deemed within normal population-based ranges following training and day-based match days. In addition, perceptual recovery is significantly worse following these night matches compared to day matches and training. The second study showed that long-haul international travel results in lower sleep quantities than healthy averages for adults. Further, there were limited changes in perceptual recovery markers due to reduced sleep; possibly due to increases in sleep duration on the days upon arrival. However, the effect of the reduction in sleep quantity on physiological and perceptual recovery (especially during/over the course of a season) remains unclear. In the final study of this thesis, results suggested football players might consider sleep hygiene strategies where possible following a late-night match to promote restorative sleep. There appeared to be no additional benefit for the acute recovery of exercise performance markers, perceptual stress, or blood-borne markers of muscle damage and inflammation. Accordingly, more research is required to

assess whether a larger sleep differential (e.g. longer duration/higher quality sleep) is required to affect the physical and physiological markers measured here. In addition, the effect of (chronic) SHS on recovery in real-world elite environments requires further research.