IMPAIRED SLEEP AND RECOVERY AFTER NIGHT MATCHES IN ELITE FOOTBALL PLAYERS

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Abstract

Despite the perceived importance of sleep for elite footballers, descriptions of the duration and quality of sleep, especially following match play, are limited. Moreover, recovery responses following sleep loss remain unclear. Accordingly, the present study examined the subjective sleep and recovery responses of elite footballers across training days (TD) and both Day and Night matches (DM and NM). Sixteen top division European players from three clubs completed a subjective online questionnaire twice a day for 21 days during the 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 and internal training loads and non-exercise stressors were collected. Players reported significantly reduced sleep durations for NM compared to DM (- 157 min; $P <0.001$, $d = 3.71$) and TD (- 181 min; $P <0.001$, $d = 4.31$). In addition, sleep restfulness (SR) and perceived recovery (PR) were significantly poorer following NM than both TD (SR: $P<0.001$, $d=3.56$; PR: $P<0.001$, $d=3.09$) and DM (SR: $P=0.002$, $d=3.16$ PR: $P =0.002$, $d=1.78$), whilst PR was significantly poorer following a DM than TD ($P=0.04$, $d=1.31$). These results suggest that reduced sleep quantity and quality and reduced perceived recovery are mainly evident following night matches in elite players.

1. INTRODUCTION

Self-reported sleep loss is suggested as a common occurrence prior to competition in elite athlete populations (Erlacher, Ehrlenspiel, Adegbesan, & Galal El-Din, 2011; Juliff, Halson, & Peiffer, 2014), which can result in a reduction in ensuing athletic performance outcomes (Edwards & Waterhouse, 2009; Jarraya, Jarraya, Chtourou, & Souissi, 2013; Reyner & Horne, 2013;). However, despite these suggestions, there is limited evidence to highlight that team-sport athletes, particularly elite footballers, experience sleep issues as part of their normative behaviour (Erlacher et al., 2011; Juliff et al., 2014). In addition, sleep behaviour following competitive match play remains unclear (Fowler, Duffield, & Vaile, 2014). This is concerning, given the proposed relationship between sleep loss and reduced recovery in team-sport athletes (Fullagar, Duffield, Skorski, Coutts, et al., 2015; Skein, Duffield, Minett, Snape, & Murphy, 2013). Furthermore, it is not known whether footballers' sleep quality and quantity differs following training days and match play. Therefore, further research investigating the behavioural sleeping patterns of elite footballers is warranted.

Sleep issues experienced by team-sport athletes are postulated to be predominately situational and sport-dependant, though explicit evidence is minimal (Juliff et al., 2014). For instance, on the night of an Australian football match sleep duration was significantly decreased to a similar degree whether home or away (by 68 and 64 mins respectively). Of the various team sports, association football is one which comprises numerous situations which may disrupt players' sleeping patterns; including periods of travel, congested fixture scheduling and training or playing at night (Fullagar, Duffield, Skorski, Coutts, et al., 2015). However, data to support these perceptions, especially with regards to training and playing at night, is unclear. For instance, whilst football players' sleep volume is reportedly reduced following a

night match (Meyer, Wegmann, Poppendieck, & Fullagar, 2014; Nédélec et al., 2012), some have reported no effect of night matches (Roach et al., 2013) or early evening high-intensity training (Robey et al., 2013) on sleep duration and quality in elite junior players. Therefore, more research is required to confirm whether football players' sleep is hindered following night matches. Perhaps more importantly, whilst studies have investigated player sleeping patterns in comprising situations i.e. travel and night matches (Fullagar, Duffield, Skorski, White, et al., 2015), there is no study at present which has monitored *elite* footballers for more than an acute period (i.e. one week) during the regular season to give an accurate indication of a professional player's normal sleeping behaviour.

The lack of data surrounding sleep following match play is concerning, since these periods of sleep loss could potentially compromise the recovery process (Skein et al., 2013). Fowler et al. (2014) reported significant reductions in sleep duration and quality, along with an impaired stress-recovery balance, on the night of a match compared to the night prior for away matches in elite Australian footballers. Nonetheless, the evidence as to what are normal sleep and recovery responses within elite football is currently lacking. Accordingly, the purpose of the present study was to monitor the sleeping patterns of elite football players and to assess whether differences in sleep indices occurred in association with an altered perceptual recovery status. If sleep issues were present, we aimed to identify any potential factors within the professional sporting environment (e.g. stress, physical or psychological load) which contributed to these poor sleeping patterns, with a specific focus on the presentation of individual results.

2. METHODS

Participants

Sixteen elite male football players participated in the present investigation (mean SD age 25.9 ± 7.5 y, body mass 74.8 ± 8.9 kg, height 179.5 ± 12.1 cm). The players were representatives of three UEFA$^©$ clubs within the top division in either Germany (Bundesliga) or the Netherlands (Eredivisie). Players were given information regarding the synopsis of the study and the associated risks, and if they wished to participate they provided written informed consent. The study was conducted in accordance with the Declaration of Helsinki and was approved by the institutional Human Research Ethics Committee (Saarland University).

Study design

The present study was a descriptive, observational design. All players were familiarised with the study procedures prior to the collection of data, which was obtained over a 21 d period during either the second half of the 2013/2014 or the first half of the 2014/2015 season. Measures were obtained twice per day, whereby participants were asked to complete a sleep and sporting activity questionnaire (SosciSurvey^{TM}) in the morning after awakening, and at night prior to sleeping. This questionnaire was completed online, on the player's personal laptop or smart phone, and accessed through individual case-protected web URL links, ensuring complete confidentiality. Training schedules were set at the discretion of the team coaches and conditioning staff. Matches were scheduled by the respective external football organisations. Within this 21-d period, players did not complete the questionnaire on 'rest' days (e.g. days which they were away from the football club). Each player had approximately one designated rest day per week. Thus, players completed the

125   questionnaire for 18 days/nights. At the end of the collection period, data sets which

126   had an overall completion rate of 90% or greater were retained for analyses. These

127   data sets were also required to include at least three matches for each player during

128   this period (two day matches, one night match) where the player played at least 60

129   min of match play. Within these included data sets, days were categorised into

130   'training days' (day in which the player attended and participated in structured

131   training), 'day matches' (matches which concluded before 6 pm) and 'night matches'

132   (matches which kicked off after 6 pm; see Methods and Statistical Analysis) for final

133   analyses. If a participant experienced a prolonged injury or illness during the data

134   collection period (>1 weeks) they were also excluded from analyses. Furthermore,

135   players whom were recovering from an injury incurred immediately prior to data

136   collection were also excluded. From the 25 players originally recruited for the study,

137   16 were retained for final analyses. In total, 235 training days, 32 day matches and

138   16 night matches were analysed.

139

140   **Study procedures**

141   A subjective sleep questionnaire was used to assess players' sleep habits, perceptual

142   fatigue and stress prior to and following training and matches. This questionnaire

143   was previously created as part of the Regman^{TM} recovery project, in which the

144   authors' Institute is a co-partner. Although measures of sleep were subjective in

145   nature, the sleep indices within the questionnaire have previously been validated

146   against objective measures of actigraphy, with time in bed (ICC = 0.93 to 0.95) and

147   total sleep time (ICC = 0.90 to 0.92) revealing strong agreement (Kölling, Endler,

148   Ferrauti, Meyer, & Kellmann, 2015). This questionnaire (provided as Supplementary

149   Material) also included an evaluation of the numerous variables within a professional

150   football team environment (i.e. non-exercise stressors such as press conferences)

151   which could potentially affect recovery following training or match play (Nédélec et

152   al., 2013a). The morning section was used to ascertain information about the

153   previous night's sleep including questions relating to "restfulness" (sleep quality: 1 =

154   very restful, 5 = not at all restful), "reasons for un-restfulness", details about sleep

155   disturbances (if they were present), the duration of total sleep time and a short scale

156   of general perceptual recovery (0 = not recovered at all, 6 = fully recovered; (Kölling

157   et al., 2014)). Total sleep time was calculated as:

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159   [(Δ of sleep duration between bedtime and time of wake) – duration of

160   sleep onset latency – total wake episode duration]

161   E.g. [(23:15-07:15) – 15 min – 15 min] = 7 h 30 min of sleep.

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163   Comparatively, the evening section asked closed-response questions such as

164   how "relaxed" and "exhausted" the players felt, how they rated their "overall

165   performance" for the day, whether they slept during the day (naps; this was

166   calculated outside total sleep time at night), and then required them to provide open-

167   response details of any "additional stress or non-exercise loads" they experienced

168   that day. In addition, if participants played in a match, they provided details

169   regarding kick-off time, personal playing time, sessional rating of perceived exertion

170   (s-RPE = min played x RPE (Borg, 1998; Foster et al., 2001), match location (home

171   or away), result (win, lose, draw), sleeping location (home, hotel, other) and travel

172   duration from stadium to place of sleep (all closed response questions). When

173   players trained, but didn't play, they provided s-RPE.

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Statistical Analyses

Data are presented as means ± standard deviations (SD) for sleep-wake times, sleep duration, sleep onset latency, wake episodes, wake episode duration, sleep restfulness and recovery. Means ± SD were also used to describe the internal load from both training and matches (min of activity x RPE) and the average non-exercise induced stress (scale 0-100). The percentage (%) of each answer for the closed response questions relating to "tenseness", "exhaustion", "general overall performance" was calculated. For comparative statistics, three different conditions were assessed: Training day (TD), day match (DM; matches which concluded before 6 pm) and night match (NM; matches which kicked off after 6 pm). Differences between conditions (TD vs. DM, DM vs. NM, NM vs. TD) for sleep-wake times, sleep duration, sleep onset latency, wake episodes, wake episode duration, sleep restfulness and recovery were evaluated using independent *t-tests*. Additional descriptive data that listed reasons for un-restfulness were used for the presentation of individual case reports. All statistical analyses were calculated using SPSS (v27, SPSS Inc., Chicago, IL, USA) with significance set at $P<0.05$. Furthermore, standardised effect size (Cohen's *d*; ES) analyses were used to interpret the magnitude of the mean differences between conditions for all sleep and recovery parameters with $d < 0.20$ (trivial), $d = 0.20$ (small), $d = 0.50$ (medium), $d \geq 0.80$ (large) (Cohen, 1988).

3. RESULTS

Sleep variables

All sleep variables are presented in Table 1, with mean and individual data for sleep duration for TD, DM and DM in Figure 1. Bedtime was significantly later for NM

200 compared to both DM (+ 189 min; P<0.001, d=2.61) and TD (+ 248 min; P <0.001,

201 d = 3.70) and for DM compared to TD (+ 59 min; P = 0.002, d = 1.95), whilst time

202 of awakening was significantly earlier for TD compared to both DM (- 45 min; P

203 <0.001, d = 2.01) and NM (- 70 min; P <0.001, d = 2.45). Sleep onset latency was

204 significantly greater for NM compared to TD (+ 10 min; P = 0.01, d = 1.60) but not

205 different between DM and NM (P = 0.38, d = 0.64) or TD and DM, despite a large

206 ES present (P = 0.14, d = 0.96). Sleep duration for NM was significantly less than

207 DM (- 157 min; P <0.001, d = 3.71) and TD (- 181 min; P <0.001, d = 4.31),

208 although there were no differences between DM and TD (P = 0.11, d = 0.60). No

209 significant differences were evident between any condition for wake episodes (P

210 >0.05). Sleep restfulness was significantly poorer following NM than both TD (P

211 <0.001, d = 3.56) and DM (P = 0.002, d = 3.16).

212

213   ****************INSERT TABLE 1****************

214

215   ****************INSERT FIGURE 1****************

216

217 *Subjective responses to exercise (training and matches)*

218 All subjective wellness responses for TD, DM and NM are presented in Table 2.

219 Perceptual recovery the following morning for NM was significantly less than both

220 TD (P <0.001, d = 3.09) and DM (P = 0.002, d = 1.78), whilst TD was significantly

221 different to DM (P = 0.04, d = 1.31). Subjective exercise load was significantly

222 greater for both DM and NM than TD (both P <0.001; DM: d = 4.04; NM: d = 4.79),

223 although there were no significant differences between DM and NM (P = 0.14, d =

224 0.74). Comparatively, players ranked perceptual performance similar across

225 conditions (Table 2). Players did not provide sufficient amount of details regarding

226 match location (home or away), result (win, lose, draw), sleeping location (home,

227 hotel, other) and travel duration from stadium to place of sleep (these questions were

228 optional), thus these analyses was abandoned.

229

230   ******************INSERT TABLE 2****************

231

232 *Individual case reports*

233 As a practical example of the individualised nature of sleep responses, individual

234 nightly sleep responses for four separate players (A-D), including duration and

235 occurrences and reasons for 'average-poor restfulness', are presented in Figure 2.

236 For instance, mean sleep duration for Player A was 476 ± 75 min (range 260-510

237 min) for TD, with the player reporting 'average-poor restfulness' on ten occasions all

238 of which the reason was given due to 'newborn children'.

239

240   *****************INSERT FIGURE 2****************

241

242 **4. DISCUSSION**

243 The present investigation aimed to monitor the sleeping patterns of elite football

244 players and to assess when reductions in sleep indices occurred; in addition to the

245 perceptual recovery status. The main finding of this study was the significant

246 reduction in sleep duration and later bedtime following NM compared to both TD

247 and DM. Following these NM, there was also a significant reduction in perceived

248 recovery compared to both DM and TD. Players subjectively reported several

249 reasons for poor sleep such as children, nervousness, pain and adrenaline following a

250 match. Overall, our results suggest that elite football players lose sleep and report

251 reduced perceptual recovery following night match play; however players appear to

252 report adequate sleep durations (i.e. 7-10 h; (National-Sleep-Foundation, 2013)) and

253 qualities following training days and day matches.

254   Bedtime and total sleep duration were extended and reduced respectively

255 following NM, supporting the idea that sleep indices are likely dependent on the

256 situational demands and scheduling of the particular sport (Juliff et al., 2014;

257 Sargent, Lastella, Halson, & Roach, 2014). These present observations of reduced

258 sleep quantity in elite footballers are supported by objective evidence that elite rugby

259 union players sleep less on game compared to non-game nights (Eagles, Mclellan,

260 Hing, Carloss, & Lovell, 2014). Furthermore, professional Australian soccer players

261 can lose 2-4 h of sleep following matches compared to non-match nights (Fowler et

262 al., 2014) and a recent study states that 52.3% of elite (individual and team-sport)

263 athletes subjectively report sleep disturbances following a late match or training

264 session (Juliff et al., 2014). Comparatively, sleep duration on TD and following DM

265 was within the presumed normal healthy range of 7-10 h in our study (National-

266 Sleep-Foundation, 2013). Furthermore, match loads (calculated from s-RPE) were

267 similar between DM and NM. Thus, these data would suggest that there are

268 particular nuances about a night match (compared to a day match) which cause this

269 reduction in sleep duration outside reasons arising from the match/exercise itself.

270 The most predictable reason for this would be the pure extension of a later bedtime

271 caused by the timing of the match. The later bedtime coupled with an increased need

272 for wakefulness following NM compared to TD or DM at the same time (Nédélec et

273 al., 2013b) likely explains the reduced sleep durations. Additionally, the evening

274 exposure to light (depending on seasonal period) could also prolong sleep onset and

275   reduce total sleep time (Malone, 2011). Another factor which is harder to control and

276   report, but may play just as an important role, could be socialising (Fullagar,

277   Duffield, Skorski, White, et al., 2015). Collectively, these data suggest that although

278   'normal' player sleep patterns may be sufficient, under specific circumstances (i.e.

279   night matches) there are cases for reduced sleep durations in professional footballers.

280   Following a similar trend to sleep duration, there were also significant

281   reductions in perceptual recovery following NM compared to TD and DM. Since no

282   difference was evident for subjective exercise loads between DM and NM, it might

283   be speculated this subsequent altered recovery state could be attributed to the

284   reduction in sleep quantity. Indeed, sleep deprivation following exercise can lead to

285   reductions in the recovery of psychological or perceptual performance (Fullagar,

286   Duffield, Skorski, Coutts, et al., 2015; Skein et al., 2013). For instance, Fowler and

287   colleagues (2014) reported significant reductions in sleep duration and quality in six

288   professional footballers, along with an impaired stress-recovery balance, on the night

289   of a match compared to the night prior for away matches. The present result of a

290   reduction in perceptual recovery may represent concerns for the practitioner,

291   especially since the competitive match load may suggest the homeostatic need for

292   recovery sleep would be higher compared to rest days (Romyn, Robey, Dimmock,

293   Halson, & Peeling, 2015); and this appears to not have been provided here. Although

294   speculative, this could have important repercussions for players during subsequent

295   training and competition where this reduction in wellbeing could unnecessarily add

296   to an already suppressed overall psychological state. However, at present our

297   knowledge regarding the effect of a suppressed psychological state on the overall

298   recovery profile through subsequent training sessions is limited, especially with

299   regards to sleep loss. More research which focuses on the interaction between sleep

300 loss and psychological fatigue is required, especially in elite footballers, and whether

301 any subsequent associations affect the acute recovery-stress balance and ensuing

302 performance.

303   Sleep is certainly an individual response, and grouping players may not

304 capture the nuances of such individuality. Consequently we depict this in Figure 2,

305 where four players mean sleep duration ranged from 460-581 min, with some players

306 sleeping 2 h more than others on any given TD. Similarly, players reasons for

307 'average - unrestfulness' varied with contrasting answers such as 'newborn children'

308 (Player A) and 'urination' (Player B). Clearly in this context these two players will

309 need contrasting approaches in order to address these issues. We believe this is a

310 good example of how very simple data could potentially inform and change practice.

311 Further analysis and presentation of individual cases within original scientific

312 publications in the football science field is a proposal that is supported by coaches

313 and practitioners. Indeed, quantifying, predicting and the overall understanding of

314 the inter-individual differences in the magnitude of responses' to matches or training

315 ("the individual response") is gaining considerable applied and scientific interest

316 (Hecksteden, 2015). All players reported reductions in sleep duration following NM.

317 Thus, an improvement in sleep indices through such measures as sleep hygiene

318 protocols following night matches may seem advisable for these players. Indeed,

319 sleep hygiene protocols have been shown improve sleep duration and perceived

320 soreness in elite tennis players (Duffield, Murphy, Kellett, & Reid, 2014); however,

321 evidence of their efficacy in football is lacking. Another possible management

322 strategy would be to implement napping strategies to supplement sleep, repay sleep

323 debt and possibly improve the subsequent performance (Waterhouse, Atkinson,

324 Edwards, & Reilly, 2007).

325   Although the primary aim of the present investigation was to monitor the

326   subjective sleeping patterns of elite football players, an additional focus was to

327   identify any potential factors within their environment which could possibly

328   contribute to poor sleeping quality. Juliff et al. (2014) reported from a sample of 283

329   individual and team sport athletes the main reasons responsible for poor sleep were

330   'thoughts about the competition' and 'nervousness'. The players in our study also

331   reported 'nervousness' as one of the most common problems for average-poor sleep

332   restfulness during TD, along with 'unfamiliar sleeping environment' and 'urination'.

333   For DM and NM, 'strenuous game', 'pain' and 'adrenaline after a game' were

334   consistently present. Whilst the existing data set does not have the strength to

335   determine whether a relationship (either correlation or causative) exists between

336   these reasons for un-restfulness and various sleep indices, the description of these

337   issues may provide important insight for practitioners or coaches. For instance, in

338   Figure 2 it can be observed that Player A had higher mean sleep durations for TD

339   (~8 h); however, there were some nights where he lost almost 4 h (lowest 4.3 h).

340   This high variation was attributed to Player A's newborn children, with the player

341   listing this ten times throughout the duration of the study. This provides a good

342   practical example of additional issues which may not come under the realm of the

343   'normally' considered reasons for disturbances to sleep quality and duration.

344   One of the limitations of the present study was the use of a subjective

345   measure (online survey) of sleep. Such a measure makes it difficult to estimate sleep

346   quantity and quality compared to objective measurements, including actigraphy and

347   the 'gold standard' polysomnography (PSG). Indeed, previous work has shown

348   subjective measurements can be imprecise (Kawada, 2008) and can be influenced by

349   mood, memory bias and personality characteristics (Jackowska, Dockray, Hendrickx,

350 & Steptoe, 2011). However, it has been shown that respondents are capable of

351 estimating total sleep duration with significant accuracy (Armitage, Trivedi,

352 Hoffmann, & Rush, 1997). Furthermore, subjective measurements of sleep are

353 preferred within these elite football environments as they are less invasive or

354 burdening than actigraphy or PSG. The present study entailed a fairly short sampling

355 period (21 d), though still longer than other reported actigraphy data. However, we

356 acknowledge this makes it difficult to extrapolate our results, especially across

357 different time points throughout a season. Furthermore, the sample size used in this

358 study was low, limiting the significance of the results; however this is not

359 uncommon in studies with professional players. Indeed, it should be acknowledged

360 that all players were first division elite players, making these results very practically

361 applicable to elite football. Finally, players were comprised from different teams and

362 countries where situations relating to team environment (e.g. travel, style and

363 intensity of training) can differ.

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367 **<u>Conclusion</u>**

368 The primary findings of this study were the significant reduction in sleep duration

369 and later bedtime following NM compared to both TD and DM. Following NM,

370 there was also a significant reduction in perceived recovery compared to both DM

371 and TD. Players subjectively reported several reasons for poor sleep such as

372 children, nervousness, and pain and adrenaline following a match. More research is

373 required to objectively quantify and confirm that TD results in 'normal' sleep

374 durations, similarly that this sleep volume is severely hampered following NM. In

375 addition, the effect of reduced sleep duration and quality on the recovery of exercise

376 performance following NM in elite players is warranted. The present findings

377 suggest elite players lose significant amounts of sleep volume and quality following

378 NM; however these variables appear within healthy ranges for TD and DM.

379

380 **PERSPECTIVE**

381 Our results suggest that elite soccer players have normal sleep durations during

382 training and match days; however, they lose sleep and report reduced perceptual

383 recovery following night match play. Thus, suitable intervention strategies (e.g. sleep

384 hygiene, napping the following day) following these night matches should be

385 investigated forthwith to alleviate these issues. Practitioners should also be aware of

386 the possible altered physiological load in subsequent training sessions following

387 sleep loss. This is obviously dependant on numerous factors including scheduling,

388 travel and team/coach preference. Furthermore, it is important to understand the

389 intra-individual variability in sleep requirement and duration. Given some players

390 will respond differently to sleep compromising situations, such as a NM, considering

391 the monitoring of sleep for periods during the season and interpreting worthwhile

392 changes in data on the individual level would appear the most beneficial practice for

393 elite players.

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400 the construction phase of the questionnaire. Parts of the questionnaire were based

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416 **REFERENCES:**

417 Armitage, R., Trivedi, M., Hoffmann, R., & Rush, A. J. (1997). Relationship

418   between objective and subjective sleep measures in depressed patients and

419   healthy controls. *Depression and Anxiety, 5*, 97-102. doi:

420   10.1002/(SICI)1520-6394(1997)5:2<97::AID-DA6>3.0.CO;2-2

421 Borg, G. (1998). *Borg's perceived exertion and pain scales* (Vol. viii). Champaign,

422   IL, US: Human Kinetics.

423 Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2nd ed

424   ed.). Hillsdale: Lawrence Erlbaum.

425 Duffield, R., Murphy, A., Kellett, A., & Reid, M. (2014). Recovery from repeated

426   on-court tennis sessions: combining cold-water immersion, compression, and

427   sleep recovery interventions. *Int J Sports Physiol Perform, 9*(2), 273-282.

428   doi: 10.1123/ijspp.2012-0359

429 Eagles, A., Mclellan, C., Hing, W., Carloss, N., & Lovell, D. (2014). Changes in

430   sleep quantity and efficiency in professional rugby union players during

431   home based training and match-play. *J Sports Med Phys Fitness, [Epub*

432   *ahead of print].* doi: Retrieved from

433   http://www.ncbi.nlm.nih.gov/pubmed/?term=Changes+in+sleep+quantity+an

434   d+efficiency+in+professional+rugby+union+players+during+home+based+tr

435   aining+and+match-play

436 Edwards, B. J., & Waterhouse, J. (2009). Effects of one night of partial sleep

437   deprivation upon diurnal rhythms of accuracy and consistency in throwing

438   darts. *Chronobiol Int, 26*(4), 756-768. doi: 10.1080/07420520902929037

439 Erlacher, D., Ehrlenspiel, F., Adegbesan, O. A., & Galal El-Din, H. (2011). Sleep

440   habits in German athletes before important competitions or games. *J Sports*

441   *Sci, 29*(8), 859-866. doi: 10.1080/02640414.2011.565782

442 Foster, C., Florhaug, J., Franklin, J., Gotschall, L., Hrovatin, L., Parker, S., . . .

443   Dodge, C. (2001). A New Approach to Monitoring Exercise Training. *J*

444   *Strength Cond Res, 15*(1), 109-115

445 Fowler, P., Duffield, R., & Vaile, J. (2014). Effects of domestic air travel on

446   techincal and tactical performance and recovery in soccer. *Int J Sport Physiol*

447   *Perform, 9*(3), 378-386. doi: 10.1123/IJSPP.2013-0484

448 Fullagar, H., Duffield, R., Skorski, S., Coutts, A., Julian, R., & Meyer, T. (2015).

449   Sleep and Recovery in Team Sport: Current Sleep-related Issues Facing

450   Professional Team-sport Athletes. *Int J Sport Physiol Perform, [Epub ahead*

451   *of print]*

452 Fullagar, H., Duffield, R., Skorski, S., White, D., Bloomfield, J., Kölling, S., &

453   Meyer, T. (2015). Sleep, Travel and Recovery Responses of National

454   Footballers During and Following Long-Haul International Air Travel. *Int J*

455   *Sports Physiol Perform, [Epub ahead of print]*. doi: Retrieved from

456   http://www.ncbi.nlm.nih.gov/pubmed/25946072

457 Jackowska, M., Dockray, S., Hendrickx, H., & Steptoe, A. (2011). Psychosocial

458   factors and sleep efficiency: Discrepancies between subjective and objective

459   evaluations of sleep. *Psychosomatic Med, 73*, 810-816. doi:

460   10.1097/PSY.0b013e3182359e77

461 Jarraya, S., Jarraya, M., Chtourou, H., & Souissi, N. (2013). Effect of time of day

462   and partial sleep deprivation on the reaction time and the attentional

463   capacities of the handball goalkeeper. *Biol Rhythm Res*, 1-9. doi:

464   10.1080/09291016.2013.787685

465 Juliff, L. E., Halson, S. L., & Peiffer, J. J. (2014). Understanding sleep disturbance in

466   athletes prior to important competitions. *J Sci Med Sport, 18*(1), 13-18. doi:

467   10.1016/j.jsams.2014.02.007

468 Kawada, T. (2008). Agreement rates for sleep/wake judgments obtained via

469   accelerometer and sleep diary: A comparison. *Behav Res Methods, 40*, 1026-

470   1029. doi: 10.3758/BRM.40.4.1026

471 Kölling, S., Endler, S., Ferrauti, A., Meyer, T., & Kellmann, M. (2015). Comparing

472   Subjective with Objective Sleep Parameters via Multi-Sensory Actigraphy in

Physical Education Students. *Behav Sleep Med, [Epub ahead of print]*. doi:

Retrieved from

https://www.researchgate.net/publication/277268526_Comparing_Subjective

_with_Objective_Sleep_Parameters_via_Multi-

Sensory_Actigraphy_in_Physical_Education_Students

Kölling, S., Hitzschke, B., Holst, T., Ferrauti, A., Meyer, T., Pfeiffer, M., &

Kellmann, M. (2014). Validity of the Acute Recovery and Stress Scale –

Training monitoring of the German junior national field hockey team. *Int J*

Sports Sci Coach, (Epub ahead of print). doi:

https://www.researchgate.net/publication/277269380_Validity_of_the_Acute

_Recovery_and_Stress_Scale__Training_Monitoring_of_the_German_Junior

_National_Field_Hockey_Team

Malone, S. K. (2011). Early to bed, early to rise?: An exploration of adolescent sleep

hygiene practices. *J School Nursing, 27*(5), 348-354. doi:

10.1177/1059840511410434

Meyer, T., Wegmann, M., Poppendieck, W., & Fullagar, H. H. K. (2014).

Regenerative interventions in professional football. *Sport Orthop Traumatol,*

30, 112-118. doi: Retrieved from

http://www.sciencedirect.com/science/article/pii/S0949328X14000672

National-Sleep-Foundation. (2013). *Sleep in America poll: Exercise and sleep*.

Retrieved from

http://sleepfoundation.org/sites/default/files/RPT336%20Summary%20of%2

0Findings%2002%2020%202013.pdf

496 Nédélec, M., McCall, A., Carling, C., Legall, F., Berthoin, S., & Dupont, G. (2012).

497   Recovery in Soccer: Part I. *Sports Med, 42*(12), 997-1015. doi:

498   10.2165/11635270-000000000-00000

499 Nédélec, M., McCall, A., Carling, C., Legall, F., Berthoin, S., & Dupont, G. (2013a).

500   Recovery in Soccer: Part II. *Sports Med, 43*(1), 9-22

501 Nédélec, M., McCall, A., Carling, C., Legall, F., Berthoin, S., & Dupont, G. (2013b).

502   Recovery in soccer: Part II-recovery strategies. *Sports Med, 43*(1), 9-22. doi:

503   10.1007/s40279-012-0002-0

504 Reyner, L. A., & Horne, J. A. (2013). Sleep restriction and serving accuracy in

505   performance tennis players, and effects of caffeine. *Physiol Behav, 120*, 93-

506   96. doi: 10.1016/j.physbeh.2013.07.002

507 Roach, G. D., Schmidt, W. F., Aughey, R. J., Bourdon, P. C., Soria, R., Claros, J. C.

508   J., . . . Sargent, C. (2013). The sleep of elite athletes at sea level and high

509   altitude: a comparison of sea-level natives and high-altitude natives

510   (ISA3600). *Br J Sports Med, 47*, i114-i120. doi: 10.1136/bjsports-2013-

511   092843

512 Robey, E., Dawson, B., Halson, S., Gregson, W., Goodman, C., & Eastwood, P.

513   (2013). Sleep quantity and quality in elite youth soccer players: A pilot study.

514   *Eur J Sport Sci*, 1-8. doi: 10.1080/17461391.2013.843024

515 Romyn, G., Robey, E., Dimmock, J., Halson, S., & Peeling, P. (2015). Sleep, anxiety

516   and electronic device use by athletes in the training and competition

517   environments. *Eur J Sport Sci, [Epub ahead of print]*

518 Samuels, C. (2008). Sleep, recovery, and performance: The new frontier in high-

519   performance athletics. *Neurol Clin, 26*(1), 169-180. doi:

520   10.1016/j.ncl.2007.11.012

521   Sargent, C., Lastella, M., Halson, S., & Roach, G. (2014). The impact of training

522   schedules on the sleep and fatigue of elite athletes. *Chronobiol Int, 31*(10),

523   1160-1168

524   Skein, Duffield, R., Minett, G., Snape, A., & Murphy, A. (2013). The effect of

525   overnight sleep deprivation after competitive rugby league matches on

526   postmatch physiological and perceptual recovery. *Int J Sport Physiol*

527   *Perform, 8*, 556-564

528   Waterhouse, J., Atkinson, G., Edwards, B., & Reilly, T. (2007). The role of a short

529   post-lunch nap in improving cognitive, motor, and sprint performance in

530   participants with partial sleep deprivation. *J Sports Sci, 25*(14), 1557-1566

531

532

533

534

535

536   **<u>Supplementary Material</u>**

537   <u>Morning Questionnaire</u>

538   1. Which questionnaire do you want to fill out now?

539   Please select the appropriate questionnaire from:

540

541   Questionnaire "Morning"

542   Questionnaire "Evening"

543

544   2a. Good morning, how restful was your sleep?

545   Please tick:

546

547	1-	1= very
548	2-	2= pretty
549	3-	3= average
550	4-	4= hardly
551	5-	5= not at all

552

553 If players answer any of the bottom three answers they go to 2b.

554

555 2b. If your sleep wasn't very restful, what was the reason?

556 Please tick the reasons. Multiple answers are possible!

557   unfamiliar sleeping environment

558   nervousness,

559   pain

560   Hunger / thirst

561   urination

562   jetlag

563   hotel bed

564   strenuous game

565   other

566

567 3. How long did it take for you to fall asleep after you turned off the lights and went to bed?

568 Although this is difficult to estimate, please try your best. Please indicate your approximate estimate
569 of the duration in minutes (e.g. 15):

570 ....

571 4a. Did you wake up at all during the night? This includes any interruptions to your sleep.

572 Please tick:

573 Yes

574 No

575

576 If players answer YES, they move onto 4b.

577

578 4b. How many times did you wake up and what was the total duration?

579 Please specify the frequency and approximate duration:

580 ....

581 How often were you awake at night?

582 ....

583 How long in total (time in minutes e.g. 25)?

584 ....

585 5. When did you finally wake up?

586 Please enter the time (24 hr hour format e.g. 07:00):

587 ....

588 6. When did you get out of bed?

589 Please enter the time (24 hr hour format e.g. 07:10):

590 ....

591 7. Short scale for recovery. The following deals with your general recovery state. The rating "applies
592 fully" symbolizes the highest ever reached recovery state.

593 General recovery state

594 (e.g. recovered, rested, physically relaxed)?

595 0 does not at all apply (not recovered at all)

596 1

597 2

598 3

599 4

600 5

601 6 applies fully (fully recovered)

602

603 Evening Questionnaire

604 1. Which questionnaire do you want to fill out now?

605 Please select the appropriate questionnaire from:

606

607 Questionnaire "Morning"

608 Questionnaire "Evening"

609

610 2. Good evening, how tense do you feel right now?

611 Please tick:

612

613 tense

614 pretty tense

615	rather tense
616	rather relaxed
617	pretty relaxed
618	relaxed
619	
620	3. How was your overall general performance today?
621	Please tick:
622	good
623	pretty good
624	rather good
625	rather poor
626	pretty bad
627	bad
628	
629	4. Did you feel exhausted today?
630	Please tick:
631	no
632	a little
633	quite
634	very
635	5a. Did you sleep during the day today?
636	Please tick:
637	yes
638	no
639	
640	If players answer YES, they move to 5b.
641	
642	5b. How long and when did you sleep during the day?
643	Please indicate the length and the starting time of your nap:
644	....
645	Approximate duration in minutes (e.g. 45):
646	....

647   Start time (in 24 hr format e.g. 14:00):

648   ....

649

650   6a. Did you play a match today?

651   Please tick:

652   yes

653   no

654

655   If players answer yes, they proceed to answer 6b-6h. If no, proceed to 7.

656

657   6b. When did the match begin?

658   Please tick:

659   Start before 16:00 local time

660   Before 18:00 local time

661   18:00-19:30 local time

662   After 19:30 local time

663

664   6c. How long did you personally play for?

665   Please indicate the duration in minutes (e.g. 90):

666

667   6d. How physically exerting did you find the match?

668   Please enter your subjective assessment of the intensity of the game (CR -10 scale by Borg) :

669

670   0 rest

671   1 very easy

672   2 easy

673   3 moderately

674   4 somewhat hard

675   5 hard

676   6

677   7 very hard

678   8

679 9

680 10 extremely difficult (maximum)

681

682 6e. What was the result of the match (for your team)?

683 Please tick:

684

685 Win

686 Loss

687 Draw

688

689 6f. Where was the match played?

690 Please tick:

691 Home

692 Away

693

694 6h. Where are you sleeping tonight?

695 Please tick:

696 Home

697 Hotel

698 Other:

699 6h. How long was the trip from the stadium to your place of sleep?

700 Please indicate the approximate duration in minutes (e.g. 60):

701

702 Players who played a match skip to 8. Question 7 is designed for training days.

703

704 7. How long did your other sports activities last today (e.g. training, not including matches)?

705 Please indicate the approximate duration in minutes (e.g. 15):

706

707 8. How physically exerting did you feel about your sports activities today?

708 Please enter your subjective assessment of the intensity of the training day on (CR -10 scale by Borg):

709

710 0 rest

711	1 very easy
712	2 easy
713	3 moderate
714	4 somewhat hard
715	5 hard
716	6
717	7 very hard
718	8
719	9
720	10 extremely difficult (maximum)
721	
722	9a. Did you use any recovery measures today (e.g. massage, cryotherapy, sauna, electrotherapy,
723	compression garments, etc.)?
724	Please tick:
725	Yes
726	No
727	
728	If players answer YES, move to 9b. if not, to 10.
729	
730	9b. Which recovery measures did you use today and for how long?
731	Please tick the appropriate recovery measure (you can choose more than one) and enter the respective
732	approximate duration in minutes (e.g. 15):
733	
734	Active recovery in the swimming pool / hot tub
735	Acupuncture
736	Breathing techniques
737	Cool -down activities
738	Debriefing (Structured conversation with the trainer)
739	Self- massage (possibly with Foam Roller etc)
740	Ice bath (cold water bath)
741	Electrostimulation (EMS)
742	Cold chamber
743	Cold shower

744 Compression Clothing

745 Contrast shower (hot and cold alternately)

746 Massage by physio

747 Pharmacological actions

748 Meditation

749 Food supplements

750 Progressive Muscle Relaxation

751 Sauna

752 Stretching / stretching afterwards

753 Vibration, and vibration massage

754 Other:

755 Other:

756 Other:

757

758 10a. Did you experience any additional stress/loads today not associated with physical exercise (non-
759 sporting strain: e.g. work commitments, testing, travel, sponsors appointment, personal, press
760 conferences, etc.)?

761 Please tick:

762 Yes

763 No

764

765 If YES, players move to 10b. If not, move to 11.

766

767 10b. What additional stressors/loads did you experience today?

768 Please indicate the nature of the non-sporting strain.

769 Multiple answers are possible!

770 ....

771

772 10c. How much stress did you feel due to these non-sporting loads?

773 Please move the slider to the appropriate position:

774 no stress   ....I..maximum possible stress

775

776 11. When did you go to bed, or when will you go to bed?

777   Try to do your best to estimate

778   Please specify the exact time (in 24 hr format e.g. 22:15):

779   ....

780

781

782