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Gerber, Marcus, Best, Simon,

Meerstetter, Fabienne, Isoard-Gautheur, Sandrine, Gustafsson, Henrik, Bianchi, Renzo, Madigan, Daniel J. ORCID logoORCID: https://orcid.org/0000-0002-9937-1818, Colledge, Flora, Ludyga, Sebastian, Holsboer-Trachsler, Edith and Brand, Serge (2018) Cross-sectional and longitudinal associations between athlete burnout, insomnia and polysomnographic indices in young elite athletes. Journal of Sport & Exercise Psychology.

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#### Final draft post-refereeing

## Cross-sectional and longitudinal associations between athlete burnout, insomnia and polysomnographic indices in young elite athletes

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This study has been conducted without external funding. We thank Vladimir Djurdjevic and Marielle König from the Psychiatric Clinics (UPK), Center for Affective, Stress and Sleep Disorders, University of Basel, Basel, Switzerland, for the analysis of the sleep polygraphs.

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Accepted for publication in: Journal of Sport and Exercise Psychology (19 September 2018)

#### 1 Abstract

2 Few studies have examined the association between sleep and burnout symptoms in elite 3 athletes. We recruited 257 young elite athletes ( $M_{age}=16.8$  years) from Swiss Olympic partner 4 schools. Of these, 197 were re-assessed six months later. Based on the first assessment, 24 5 participants with clinically relevant burnout symptoms volunteered to participate in a 6 polysomnographic examination and were compared to 26 (matched) healthy controls. 7 Between 12-14% of young elite athletes reported burnout symptoms of potential clinical 8 relevance, whereas 4-11% reported clinically relevant insomnia symptoms. Athletes with 9 clinically relevant burnout symptoms reported significantly more insomnia symptoms, more dysfunctional sleep-related cognitions, and spent less time in bed during weeknights (p < .05). 10 11 However, no significant differences were found for objective sleep parameters. A cross-12 lagged panel analysis showed that burnout positively predicted self-reported insomnia 13 symptoms. Cognitive-behavioral interventions to treat dysfunctional sleep-related cognitions 14 might be a promising measure to reduce subjective sleep complaints among young elite 15 athletes.

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17 Keywords: burnout; EEG; insomnia; polysomnography; rumination; sleep complaints

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### Cross-sectional and longitudinal associations between athlete burnout, insomnia and polysomnographic indices in young elite athletes

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Participating in competitive elite sport can be a stressful experience due to a range of 21 22 organizational (e.g., selection processes), non-organizational (e.g., pressure from coach) or 23 competitive (e.g., high performance expectations) stressors (Fletcher & Hanton, 2003; 24 Mellalieu, Neil, Hanton, & Fletcher, 2009). This also applies to junior elite sport, as young 25 elite athletes may encounter issues related to being an adolescent (e.g. increasing 26 responsibility and social pressures), being a student (e.g. increasing school demands), and 27 being an athlete (e.g. increasing training loads) (Gustafsson, Kenttä, & Hassmén, 2011; 28 Isoard-Gautheur, Guillet-Descas, Gaudreau, & Chanal, 2015). Kellmann and colleagues 29 (Kellmann, Kölling, & Pelka, 2017) emphasized that, in order to become a successful elite 30 athlete, several years of hard training are required, which is not possible without being 31 strongly motivated and highly committed towards one's sport (Lemyre, Roberts, & Stray-32 Gundersen, 2007). While it is possible for elite athletes to cope with short periods of underrecovery, prolonged exposure to excessively high training loads coupled with high perceived 33 34 stress can have negative consequences (Meeusen et al., 2013). Moreover, previous research 35 has shown that exposure to chronic stress increases athletes' likelihood of reporting 36 overtraining (Kenttä & Hassmen, 2002),-overuse injuries (Oyen, Klungland Torstveit, & 37 Sundgot-Borgen, 2009), and burnout symptoms (Cresswell & Eklund, 2006). In youth sport, 38 this is critical because overtraining, injury and burnout may lead to early dropout of aspiring 39 athletes (Isoard-Gautheur, Guillet-Descas, & Gustafsson, 2016).

Scholars have underscored the importance of efficient recovery to maintain optimal
performance and to support psychological well-being despite exposure to elevated levels of
stress (Kellmann, 2010; Vaile, Halson, Gill, & Dawson, 2008). Following Kellmann and
Kallus (2001), recovery corresponds to "an inter-individual and intra-individual multi-level
(e.g., psychological, physiological, social) process in time for the re-establishment of
performance abilities. Recovery includes an action-oriented component, and those self-

initiated activities (proactive recovery) can be systematically used to optimize situational
conditions and to build up and refill personal resources and buffers" (p. 22). An increasing
interest for recovery-related issues has been observed in coaches, although their knowledge of
efficient recovery strategies and monitoring tools is still limited (Simijanovic, Hooper,
Leveritt, Kellmann, & Rynne, 2009).

51 Getting sufficient and restoring sleep is a promising strategy to foster recovery. First, 52 among athletes, disturbed sleep has been identified as a key symptom of overtraining (a 53 syndrome which has a certain overlap with burnout, but which places a stronger focus on 54 performance-related and physiological factors; for more details regarding the difference 55 between overtraining and burnout see: Kellmann et al., 2017; Meeussen et al., 2013) and performance impairment (Halson, 2014). Second, significant links have been established 56 57 between sleep, recovery, and performance among high-level athletes (Fullagar et al., 2015; 58 Samuels, 2008). Third, outside the realm of elite sport, a large body of evidence shows that 59 favorable sleep facilitates recovery from work-related stress and thus prevents the 60 development of burnout symptoms (Sonnenschein, Sorbi, van Doornen, Schaufeli, & Maas, 2007). Fourth, previous research in non-athlete populations has shown that people suffering 61 62 from burnout symptoms not only report poorer subjective sleep quality, but also have less favorable objective sleep patterns, as measured via electroencephalography (EEG) (Brand, 63 64 Beck, Hatzinger, et al., 2010; Ekstedt, Soderstrom, et al., 2006; Söderström, Ekstedt, Akerstedt, Nilsson, & Axelsson, 2004). Finally, previous investigations have highlighted that 65 66 improvements in burnout symptoms are closely related to improvements in subjective and 67 objective sleep quality (Ekstedt, Soderstrom, & Akerstedt, 2009; Sonnenschein et al., 2007). Despite these salient relationships, our current understanding of the relationship 68 69 between sleep and burnout in athletes is limited. Although a previous study carried out in 70 Finland showed that compared to healthy controls, athletes suffering from severe overtraining 71 did not differ with regard to nocturnal heart rate variability (as an indicator of autonomic 72 nervous system imbalance during sleep) (Hynynen, Uusitalo, Konttinen, & Rusko, 2006),

raise empirical studies in this area are still sparse. Accordingly, the purpose of the present study

74 was to expand on the current literature by shedding light on the relationship between

75 (subjective and objective) sleep and burnout among young elite athletes.

76 Scholars have defined athlete burnout in various ways (Eklund & Cresswell, 2007; Gustafsson et al., 2011). Nevertheless, Raedeke's (1997) conceptualization of athlete burnout 77 78 as a gradually developing syndrome has led to a certain consensus among researchers. In line 79 with Maslach and Jackson's (1981) definition of occupational burnout, Raedeke (1997) 80 defined athlete burnout as a multidimensional syndrome consisting of three components, 81 namely (i) emotional and physical exhaustion (a perceived depletion of emotional and 82 physical resources beyond that associated with training and competition), (ii) reduced sense of 83 accomplishment (a tendency to evaluate oneself negatively in terms of sport abilities and 84 achievement), and (iii) sport devaluation (the development of a cynical attitude towards 85 involvement in elite sport). These three dimensions are generally assessed with the Athlete 86 Burnout Questionnaire (ABQ; Raedeke & Smith, 2009), an instrument having shown 87 acceptable psychometric properties in previous research (Guedes & de Souza, 2016; Isoard-Gautheur, Oger, Guillet, & Martin-Krumm, 2010; Raedeke, Arce, De Francisco, Seoane, & 88 Ferraces, 2013; Raedeke & Smith, 2001). 89

90 However, researchers have also emphasized several weaknesses of the ABQ (Gustafsson, Lundkvist, Podlog, & Lundkvist, 2016). According to Gustafsson et al. (2016), 91 92 the important aspects are that (a) the definition upon which the ABQ is based, is derived 93 neither from clinical observation nor theory, (b) considerable overlap with other 94 psychological constructs exists between some of the ABO dimensions (e.g., sense of 95 accomplishment with self-efficacy), and (c) little evidence exists that the three ABQ dimensions influence each other over time, as might be expected from a theoretical point of 96 97 view (Lundkvist et al., 2018). Moreover, one fundamental limitation of the ABQ is that no reliable cut-offs have been developed to categorize participants in terms of burnout symptom 98 99 severity. Given this background, Gustafsson, Madigan, and Lundkvist (2017) argued that the 100 ABQ has been adopted somewhat uncritically by the scientific community, although the 101 choice of a research instrument should depend on the research question that a researcher

wants to address. For instance, if the focus of a project is on comparing levels with existing
data or looking at the changes of the three dimensions over time in a set context, then the
ABQ would be well suited. However, if the purpose is to explore burnout as a health issue in
athletes, a measure that sets the results in relation to cut-offs of clinical samples would seem
more useful.

107 In line with this notion, we decided to use the Shirom-Melamed Burnout Measure 108 (SMBM) (Lerman et al., 1999) in the present study to assess burnout. The SMBM is an 109 internationally accepted instrument, based on Melamed et al.'s (1992) conceptualization of 110 burnout, defining burnout as a multidimensional construct characterized by emotional 111 exhaustion, physical fatigue, and cognitive weariness. An advantage of this instrument is that 112 it is associated with a validated cut-off score that allows investigators to estimate clinically 113 relevant symptoms of burnout in reference to the ICD-10 criteria for 'other reactions to severe 114 stress' (Lundgren-Nilsson, Jonsdottir, Pallant, & Ahlborg, 2012).

115 In the present study, we addressed the following research questions First, we sought to 116 identify the number of young elite athletes exhibiting clinically relevant symptoms of burnout 117 and insomnia. Second, we examined whether athletes above versus below the cut-off for 118 clinically relevant burnout symptoms differed from each other with regard to (a) subjectively reported sleep parameters and (b) objectively assessed measures of sleep continuity (e.g. sleep 119 120 efficiency, number of awakenings) and architecture (e.g. time spent in different sleep stages). 121 Third, we examined the extent to which burnout symptoms predicted poor sleep over time, 122 and vice versa. Addressing these research questions is important to better understand the 123 extent to which sleep is an issue among young athletes with and without clinically relevant 124 burnout symptoms. Furthermore, the findings will help us clarify whether subjective sleep 125 complaints are reflected in objectively assessed sleep indicators. Finally, this study will 126 provide deeper insights regarding the temporal interplay between burnout symptoms and 127 subjective sleep complaints among elite athletes.

We tested the following hypotheses: First, based on findings from studies examining
adult workers (Brand, Beck, Hatzinger, et al., 2010; Ekstedt, Soderstrom, et al., 2006;

Söderström, Jeding, Ekstedt, Perski, & Åkerstedt, 2012), we hypothesized that athletes above 130 the cut-off for clinically relevant burnout would report significantly more subjective sleep 131 132 complaints and more dysfunctional sleep-related cognitions than athletes below this cut-off. Second, we hypothesized that athletes above the clinical burnout threshold would have less 133 134 favorable objective sleep patterns than their peers scoring below the cut-off (Ekstedt, M., et al., 2006), although some studies in this area did not yield significant results (e.g., Söderström 135 136 et al., 2004). Third, we expected a reciprocal relationship between burnout and sleep, in the 137 sense that high initial burnout levels would predict increased sleep complaints over time, and 138 that poor initial sleep would be associated with increased burnout at follow-up (Armon, 2009; 139 Pagnin et al., 2014).

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#### Methods

#### 142 Participants and procedures

143 Students were eligible for this longitudinal study if they attended sport classes at Swiss 144 Olympic partner schools in the North-Western, German-speaking part of Switzerland. These 145 classes are designed to facilitate the coordination of elite sport and school life (e.g., lower 146 number of lessons per week, extended school duration). We informed all students that 147 participation was voluntary, and ensured all participants confidentiality. Furthermore, we 148 collected informed written consent before the beginning of the data assessment. We collected 149 data in November-December 2016, and after a 6-month follow-up period in May-June 2017 150 (using the same instruments at baseline and follow-up). All students completed a written 151 questionnaire, consisting of a battery of internationally accepted psychological instruments 152 (see below for more details). We obtained ethical approval from the local ethics committee to 153 ensure that all procedures were in line with current Swiss legal requirements. Moreover, all 154 procedures met the ethical requirements defined in the declaration of Helsinki and its later 155 amendments. To ensure that students above versus below the cut-off for clinically relevant 156 burnout symptoms did not differ with regard to background variables, we selected students 157 below the cut-off purposely (matched for gender, age, educational level and canton).

In total, 257 adolescents (163 males and 94 females; age: *M*=16.8 years, *SD*=1.4) took 158 159 part in the baseline assessment. Of these, 197 athletes (125 boys and 73 girls; age: M=16.83, 160 SD=1.40) completed the follow-up data assessment. Dropout analyses revealed that dropouts and athletes who participated in the follow-up did not differ with regard to any of the potential 161 162 confounders or main study variables (p > .05). Furthermore, 50 athletes (30 boys, 20 girls; 163 age: M=17.2, SD=1.6) provided valid sleep-EEG data (24 students with clinically relevant 164 burnout symptoms). Further information about how athletes were filtered in the high and low 165 burnout groups for the additional EEG monitoring is provided in Figure 1. As shown in 166 Figure 1, five participants of those with clinically relevant burnout symptoms were not willing to take part in the objective sleep assessments. 167

168

#### 169 Measures

#### 170 Assessment of burnout symptoms

171 We used the 14-item Shirom-Melamed Burnout Measure (SMBM) (Lerman et al., 1999) to 172 measure burnout symptoms. The SMBM is composed of three subscales labelled physical fatigue (six items: e.g., "I feel physically drained."), cognitive weariness (five items: e.g., "I 173 174 feel I am not thinking clearly."), and emotional exhaustion (three items: e.g., "I feel I am 175 unable to be sensitive to the needs of coworkers and customers."). For the emotional 176 exhaustion subscale, we adapted the wording of the items to increase suitability for 177 adolescents. Thus, we used a more open formulation to refer to people in general instead of 178 coworkers and customers. Students responded to the items on a 7-point Likert scale ranging 179 from 1 (never or almost never) to 7 (always or almost always). We calculated the mean score 180 to obtain an overall index, with higher scores reflecting higher burnout symptoms. Based on 181 the work of Lundgren-Nilsson et al. (2012), we considered a score of  $\geq$ 4.40 on the Shirom-Melamed Burnout Questionnaire (an earlier version of the SMBM) as a clinically relevant 182 183 level of burnout. This cut-off is based on a comparison of 319 burnout patients and 319 controls (general population), and placed 83.4% of the patients above the cut, and 86.5% of 184

the controls below the cut. Internal consistency of the overall index was satisfactory in thepresent sample, with a Cronbach's alpha of .92.

187

#### 188 Assessment of subjective sleep parameters

189 Insomnia symptoms. We assessed insomnia symptoms with the Insomnia Severity Index 190 (ISI) (Morin, Belleville, Belanger, & Ivers, 2011), a brief screening measure of insomnia and 191 an outcome measure in treatment research. Responses are given on a five-point Likert scale, 192 from 0 (not at all) to 4 (very much), and refer to the previous two weeks. The seven items of 193 the ISI take into consideration the criteria for insomnia of the Diagnostic and Statistical 194 Manual of Mental Disorders, Revised 4th Edition, by measuring difficulty in falling asleep, difficulties maintaining sleep, early morning awakening, increased daytime sleepiness, low 195 196 daytime performance, low satisfaction with sleep, and worrying about sleep (American 197 Psychiatric Association, 2000). Evidence for the validity and reliability of this instrument in 198 adolescents has been presented previously (Gerber, Lang, et al., 2016). We summed up items 199 to build an overall score, with higher scores reflecting more insomnia symptoms. Following 200 Morin et al. (Morin et al., 2011), we considered scores of  $\geq 15$  as clinically relevant (moderate 201 to severe insomnia). Internal consistency of the overall index was satisfactory in the present 202 sample, with a Cronbach's alpha of .78.

Self-reported time spent in bed and sleep onset latency. To assess time spent in bed (as a
proxy of sleep duration) on weekdays and weekend days, we asked participants when they
usually go to bed and when they usually get up in the morning. We counted Sunday, Monday,
Tuesday, Wednesday and Thursday nights as weekday nights, Friday and Saturday as
weekend nights. Moreover, we asked participants to report how long it usually takes them to
fall asleep on weekday and weekend nights.

209 *Dysfunctional sleep-related cognitions*. Dysfunctional cognitive processes play an important

210 role in the exacerbation and perpetuation of insomnia (Brand, Gerber, Pühse, & Holsboer-

- 211 Trachsler, 2010). In the present study, we assessed dysfunctional sleep-related cognitions
- 212 with the FEPS II (Fragebogen zur Erfassung allgemeiner Persönlichkeitsmerkmale

Schlafgestörter = Questionnaire to assess personality traits of people suffering from sleep 213 disturbances) (Hoffmann, Rasch, & Schnieder, 1996). The FEPS II consists of two subscales 214 215 assessing respondents' levels of focusing (a person's tendency to continuously think about 216 difficulties in getting to sleep, maintaining sleep, waking up early in the morning, and/or 217 experiencing increased daytime sleepiness) and rumination (a person's proneness to worry 218 about and feel preoccupied with unresolved problems). These two factors are considered to 219 impact on the development and persistence of sleep problems (Hoffmann et al., 1996). We 220 assessed five items per subscale, with response options ranging from 1 (not at all true) to 5 221 (completely true). The higher the subscale scores, the more the respondent is presumed to 222 engage in dysfunctional sleep-related cognitions. The FEPS II proved to be suitable for both 223 insomnia patients and healthy subjects (Brand, Hermann, Muheim, Beck, & Holsboer-224 Trachsler, 2008). Internal consistency of the overall index was satisfactory in the present 225 sample, with a Cronbach's alpha of .85 for focusing and .73 for rumination.

226

#### 227 Assessment of objective sleep parameters

228 To assess sleep parameters objectively, we performed sleep EEG assessments on a weekday 229 night, using a portable EEG-recording device (Fp2-A1; electrooculogram; electromyogram; 230 SOMNOwatchTM, Randersacker, Germany). These simple sleep-EEG devices provide 231 satisfactory data in previous studies involving adolescent samples (Brand, Beck, Gerber, 232 Hatzinger, & Holsboer-Trachsler, 2010; Kalak et al., 2012). During data collection, 233 participants were allowed to sleep at home in familiar surroundings, a major advantage of a 234 portable sleep-EEG device. On the day of data collection, we instructed participants to follow 235 regular school schedules and to adhere to their normal evening routines. To limit the risk that 236 objective sleep patterns are influenced by acute effects of exercise (Brand et al., 2014), we 237 asked participants not to engage in training activities or competitions on the day of the EEG 238 assessment. Previously trained research assistants prepared the device for use in the evening 239 (between 7.30 and 9.00 p.m.). Two blinded experienced raters then visually analysed the sleep 240 polygraphs according to standard procedures (Rechtschaffen & Kales, 1968). They then

analyzed sleep parameters according to the definitions in the standard program described by
Lauer et al. (Lauer, Riemann, Wiegand, & Berger, 1991). In the present study, we examined
the following parameters: total sleep time, sleep efficiency (SE), sleep onset latency (SOL),
number of awakenings after sleep onset, stages 1—4, light sleep (stages 1 and 2), slow wave
sleep (stages 3 and 4), and REM-sleep.

246

#### 247 Assessment of potential confounders

248 In the present study, we considered the following potential confounders: Gender (male vs 249 female), age, body mass index (BMI; self-reported body weight in kg divided through selfreported height in  $m^2$ ), educational level (high school vs. vocational educational and training), 250 251 type of sport (team vs. individual sport), nationality (Swiss vs. foreign), training load, time 252 spent for competitions, years participating in competitive sport, current injury (yes vs. no), 253 and use of medication (yes vs. no). Most of the students who used medication reported that 254 they used oral contraceptives, dietary supplements (e.g., iron, magnesium, vitamin D), or 255 drugs for acne. None of the indicated drugs were associated with known negative side effects 256 on sleep.

257

#### 258 Statistical analyses

259 First, we calculated descriptive statistics (M, SD) and frequencies (n, %) to describe the study 260 sample and identify the number of participants with clinically relevant levels of burnout and 261 insomnia symptoms. We present statistics separately for the total sample and for those 262 participants who were selected for the EEG-assessments. Second, using analyses of variance (ANOVAs) and  $\chi^2$ -tests, we examined differences in potential confounders between students 263 264 with burnout scores above versus below the clinically relevant cut-off score of the SMBM  $(\geq 4.40)$ . Third, we calculated a series of ANOVAs to examine how participants with versus 265 266 without clinically relevant burnout symptoms differ with regard to subjective and objective sleep. In case of unequal group sizes, we repeated ANOVAs with Welch and Brown-Forsythe 267 268 procedures. With regard to subjective sleep, we performed the analyses separately for the total

269 sample and the subsample selected for the sleep EEG recordings. For ANOVAs, we interpreted effect sizes as follows (Cohen, 1988): Small:  $\eta^2$  from .01 to .058, medium:  $\eta^2$ 270 from .059 to .137, and large:  $\eta^2 \ge .138$ . Finally, to gain insights into the reciprocal 271 272 associations between burnout and insomnia symptoms, we tested cross-lagged panel models 273 using the structural equation approach. As recommended by Anderson and Gerbing 274 (Anderson & Gerbing, 1988), we adopted a two-step approach. We first specified the 275 associations between the measured and latent variables, bidirectional associations 276 (covariances) between the latent variables, and invariance of factor loadings and intercepts 277 over time in the initial measurement model. We then calculated the full structural model. We 278 defined the latent burnout via the three SMBM subscales, to reduce the number of variables in 279 the model and to keep the degrees of freedom reasonable. We allowed measurement errors to 280 autocovary across the two measurement occasions. To examine the suitability of our model, we considered the following goodness-of-fit indices: (i) chi-square statistics ( $\chi^2$ ), (ii) 281 Comparative Fit Index (CFI), (iii) Tucker Lewis Index (TLI), and (iv) root mean squared error 282 283 of approximation (RMSEA) with 90% confidence interval (CI). Following the recommendations of McDonald and Ho (2002), CFI and TLI values close to .95 or greater 284 and RMSEA values near or below .08 represent good model-fit. We considered  $\Delta \chi^2$  statistics 285 to compare the fit of different models. Following Comrey and Lee (1992), standardized factor 286 287 loadings of  $\geq$ .71 were interpreted as excellent,  $\geq$ .63 as very good,  $\geq$ .55 as good,  $\geq$ .45 as fair, and <.32 as poor. 288 289 An alpha level of p < .05 was determined across all analyses. Descriptive statistics, 290 frequencies,  $\chi^2$ -tests and ANOVAs were performed with SPSS® (version 24, IBM

291 Corporation, Armonk, NY, USA) for Apple Mac<sup>®</sup>, whereas AMOS (version 24, IBM

292 Corporation, Armonk, NY, USA) for Windows® was used for structural equation modelling.

293

**Results** 295 **Description of study population** 296 297 Table 1 provides a detailed description of the study population, including all social, demographic and behavioral background variables, which were also considered as potential 298 299 confounders. As can be seen, the sample of students selected for the sleep-EEG assessments 300 showed no significant differences in demographic and behavioural variables compared to the 301 full sample of elite athletes. 302 **Descriptive statistics and prevalence rates** 303 304 At baseline, 31 athletes (12%) reported clinically relevant burnout symptoms (SMBM  $\geq$ 305 4.40), whereas 28 athletes (11%) exhibited clinically relevant insomnia symptoms (ISI  $\geq$ 15). 306 At follow-up, 27 athletes (14%) reported clinically relevant burnout, whereas 8 athletes (4%) 307 exhibited clinically relevant insomnia symptoms. Descriptive statistics for all the outcome 308 variables at baseline are shown in Table 2, separately for athletes above versus below the 309 SMBM cut-off. 310 Group differences with regard to potential confounders 311 Based on ANOVAs and  $\chi^2$ -tests, we did not find any statistically significant differences in 312 313 social, demographic or behavioral confounders between students above versus below the 314 critical SMBM score (all ps were > .05), both in the full sample and the subsample selected 315 for the sleep-EEG recordings. As a consequence, we did not consider any of these factors as a 316 covariate in the ANOVAs to test group differences in subjective and objective sleep 317 parameters. 318 319 Group differences with regard to subjective sleep parameters 320 In the full sample, students with clinically relevant burnout symptoms were more likely to 321 report moderate to severe insomnia symptoms (n=9, 29%) than peers with lower burnout scores (n=9, 8%),  $\chi^2(1, N=257)=11.9$ , p=.001,  $\phi=.211$ . Moreover, as shown in Table 2, 322

students above the critical SMBM score reported more insomnia symptoms and were morelikely to engage in dysfunctional sleep-related cognitions (focusing, rumination).

Furthermore, students with clinically relevant burnout symptoms spent less time in bed during
weekday nights. Although we found a significant difference in prolonged sleep onset latency
both during weekday and weekend nights, this difference was no longer significant when we
repeated the ANOVAs with Welch or Brown-Forsythe procedures.

We found a similar pattern of results in the subsample selected for the sleep-EEG recordings. Again, participants with elevated burnout symptoms reported significantly more insomnia symptoms and more dysfunctional sleep-related cognitions. For time spent in bed and sleep onset latency, the findings exhibited the same trend as for the full sample. However, due to the smaller sample size, no significant differences occurred, although the effect sizes were stronger in the subsample of athletes selected for the sleep EEG-assessment.

335

#### 336 Group differences with regard to objective sleep parameters

Table 2 shows that students above versus below the critical cut-off for clinically relevant burnout did not differ in any of the objectively assessed sleep parameters (all *ps* were > .05).

339

#### 340 Test of reciprocal relationships between burnout and insomnia symptoms

341 The initial measurement model (see Supplementary Online Material, Figure S1) provided good model fit:  $\chi^2/df = 1.42$ , p < .001, CFI = .956, TLI = .944, RMSEA = .047, 90% CI = 342 .032 to .060. All observed variables significantly loaded on their respective factors, p < .05. 343 344 With three exceptions, most factor loadings were fair ( $\geq$  .45) or good ( $\geq$  .55), indicating that 345 the observed variables represented the latent constructs quite well. Next, factor loadings were constrained to be equal across measurement occasions. As shown by the non-significant  $\Delta \chi^2$ 346 score (p = .673), the model fit remained stable after holding factor loadings constant:  $\chi^2/df =$ 347 348 1.40, *p* < .001, CFI = .957, TLI = .948, RMSEA = .045, 90% CI = .030 to .058. Figure 1 illustrates the findings of the cross-lagged panel analysis. Again, we 349

350 compared a default model ( $\chi^2/df = 1.42$ , p < .001, CFI = .956, TLI = .944, RMSEA = .047,

90% CI = .032 to .060) to a model with invariant factor loadings over time ( $\chi^2/df = 1.42$ , p < 1.42351 .001, CFI = .956, TLI = .944, RMSEA = .047, 90% CI = .032 to .060). The goodness-of-fit 352 353 indices pointed towards adequate model fit, and the  $\Delta \chi^2$  score (p = .673) indicates that the 354 model fit remained good after controlling for invariant factor loadings across time. Figure 1 355 shows that there was a significant association between burnout and insomnia symptoms at baseline ( $\Psi = .43, p < .001$ ) and follow-up ( $\Psi = .46, p < .001$ ). Furthermore, burnout 356 357 symptoms ( $\beta = .54$ , p < .001) and insomnia symptoms ( $\beta = .51$ , p < .001) showed a relatively high stability over time. Finally, higher baseline burnout symptoms predicted more frequent 358 359 insomnia symptoms across time ( $\beta = .27, p < .001$ ). The path from baseline insomnia to burnout symptoms at follow-up pointed in the same direction ( $\beta = .07$ ), but was not 360 361 statistically significant (p = .413).

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#### Discussion

364 Our findings provide important insights into the relationship between burnout and sleep 365 among elite athletes, an association which has not been examined to date. The key findings 366 are that athletes with clinically relevant burnout symptoms report significantly more insomnia 367 symptoms, report more dysfunctional sleep-related cognitions (focusing and rumination), 368 spend less time in bed during weekday nights, and report higher sleep onset latency, both 369 during weeknights and weekend nights. No significant differences were found with regard to 370 objective sleep parameters. Finally, a cross-lagged panel analysis showed that moderately 371 strong cross-sectional links exist between burnout and insomnia symptoms. Burnout predicted 372 increased insomnia symptoms, indicating that burnout should be seen as a potential cause 373 rather than a consequence of insomnia symptoms.

Previous studies using the Athlete Burnout Questionnaire (ABQ) estimated the
prevalence for athlete burnout to range between 1 and 10% (Gustafsson, DeFreese, &
Madigan, 2017). However, ABQ-based prevalence estimates must be interpreted cautiously,
because no previously validated cut-off scores exist for this measure. Using the SMBM, our
study provides a more trustworthy estimate of how many young elite athletes suffer from

critical burnout levels. Our findings show that between 12 and 14 percent of the students 379 380 reported SMBM scores above the critical threshold ( $\geq 4.40$ ). Moreover, we found that up to 381 11 percent experienced clinically relevant insomnia symptoms. The prevalence of clinically 382 relevant insomnia symptoms dropped to 4 percent at follow-up; this may be attributable to 383 seasonal variations in insomnia symptoms associated with day length (Friborg, Bjorvatn, 384 Amponsah, & Pallesen, 2012; Wirz-Justice, Graw, Kräuchi, & Wacker, 2003). We did not 385 find any baseline differences in clinically relevant insomnia symptoms between athletes who 386 completed the follow-up (11%) and those who dropped out from T1 to T2 (10%). Our 387 findings reveal that compared to adolescents attending normal school classes (7%), clinically 388 relevant burnout levels were more prevalent in our sample if the same definition and cut-offs 389 are used to estimate burnout (Elliot et al., 2015). This highlights that stress is an important 390 issue among young elite athletes, and that specific measures are needed for this specific target 391 population to either make their lives less stressful or to promote personal and social resources 392 that enable them to more successfully cope with stress.

393 The prevalence of moderate to severe insomnia symptoms was comparable to 394 estimates from more general adolescent populations (around 10%) (Johnson, Roth, Schultz, & 395 Breslau, 2006). This confirms that young elite athletes are just as likely to develop sleep 396 complaints as less trained peers, although regular physical activity has previously been 397 associated with positive sleep outcomes in this age group (Lang et al., 2016). Researchers 398 have emphasized that adolescence is a period of increased risk for developing sleep 399 complaints. For instance, adolescents still need 9 to 10 hours of sleep per night (Moore & 400 Meltzer, 2008), although during school nights, their sleep duration often varies between only 401 6.5-8.5 hours per night (Mercer, Merritt, & Cowell, 1998), with delayed bed times (Millman, 402 2005), and an increasing discrepancy between school nights and weekend nights (Dahl & 403 Lewin, 2002). In the present sample, the mean duration of sleep was approximately 7 hours, 404 which is below current age-specific recommendations (8.5-10 hours/night) (Feinberg, 2013). 405 Three hypotheses were tested, and each of these will now be considered separately. 406 Support was found for our first hypothesis, which stated that athletes above the cut-off for

407 clinically relevant burnout symptoms would report significantly more subjective sleep complaints and more dysfunctional sleep-related cognitions than athletes below this cut-off, 408 409 in line with findings previously reported in studies of working adults (Brand, Beck, 410 Hatzinger, et al., 2010; Ekstedt, Soderstrom, et al., 2006; Söderström et al., 2012). Moreover, 411 although not specifically tested in the present study, several mechanisms have been suggested 412 in the scientific literature to explain these relationships. These mechanisms should be tested 413 more systematically in future research in athlete samples. For instance, Ekstedt and colleagues 414 (2006) suggested that burnout may result in an increased activation of the hypothalamo-415 pituitary-adrenal (HPA) axis, which may contribute to the development of sleep complaints. 416 Ekstedt et al. (2006) further suggested that burnout is associated with an over-secretion of 417 proinflammatory cytokines, which in turn stimulate the HPA axis. Moreover, previous 418 research has shown that some of these cytokines (e.g., tumor necrosis factor-alpha and 419 interleukin-6) are directly linked with somnolence and fatigue, whereas experimentally 420 induced sleep reductions result in increased proinflammatory cytokine levels (von Känel, 421 Bellingrath, & Kudielka, 2008). From a psychological point of view, Söderström et al. (2004) 422 argued that people with high burnout levels report more subjective problems associated with 423 nocturnal awakenings. This may explain why burnout patients report higher sleepiness and 424 more fatigue at most times of the day during weekdays, without relief during weekends 425 (Ekstedt, Soderstrom, et al., 2006). Söderström and colleagues (2004) found that among adult 426 workers, high burnout was associated with an increased tendency to think about work during 427 leisure time. This is in line with studies showing that a strong relationship exists between 428 burnout and decreased life satisfaction (Brand, Beck, Hatzinger, et al., 2010; Gerber et al., 429 2015), and supports our finding that participants with clinically relevant burnout levels report 430 significantly more dysfunctional sleep-related cognitions. As shown previously in university students (Brand, Gerber, et al., 2010) and highlighted in cognitive models of insomnia 431 432 (Harvey, 2002), ruminating about unresolved problems and focusing on difficulties associated 433 with getting sufficient and satisfactory sleep can have a strong negative impact on sleep 434 quality, and may function as a mediator between stress and insomnia symptoms. Moreover,

the fact that dysfunctional cognitions are associated with impaired sleep supports the notion
that a positive cognitive mindset, reflected by a mentally tough attitude (e.g., seeing problems
as a challenge, feeling in control over one's life, tendency to stay committed even if not
everything works as intended) is associated with a decreased likelihood of subjective and
objective sleep impairments (Brand et al., 2013), and fewer burnout symptoms (Gerber et al.,
2015).

Our second hypothesis was that athletes with clinically relevant symptoms of burnout 441 442 would exhibit poorer objective sleep patterns compared to their peers. Our results did not 443 support this hypothesis. Young elite athletes with clinically relevant burnout symptoms did 444 not differ from matched peers with lower burnout symptoms, which is at odds with previously 445 reported findings in adults (Ekstedt, Soderstrom, et al., 2006). For instance, Ekstedt, 446 Soderstrom, et al. (2006) found more arousal and sleep fragmentation, more wake time and 447 stage-1 sleep, lower sleep efficiency, less slow wave sleep and rapid eye movement sleep, and 448 a lower delta power density in nonrapid eve movement sleep in "burnout patients" compared 449 to healthy controls. However, their population of interest cannot be directly compared with 450 ours. Although these authors used a cut-off score for burnout that was similar to ours (SMBM 451 > 4.50), their participants were adults on full-time sick leave (and were thus likely to suffer 452 from stronger and longer-lasting burnout symptoms). Nevertheless, our findings are in line 453 with a study conducted by Söderström et al. (2004) with relatively healthy adults, in which 454 few differences in objective sleep occurred between participants with "high" versus "low" 455 burnout symptoms. While Söderström et al. (2004) found that those with high burnout 456 showed higher total arousal, no significant differences were found for sleep efficiency, sleep 457 onset latency, sleep stages 1-4 or REM sleep. However, in their study, they used an SMBM 458 cut-off  $\geq 2.75$  to classify participants in the high burnout group. This difference makes it 459 difficult to compare their results with ours. In summary, whereas we found significant 460 differences between students with high versus low burnout symptoms across most of our subjective sleep measures, we did not detect any significant differences for objective sleep. 461 462 This indicates that there was only limited correspondence between subjective and objective

sleep impairments among young elite athletes. Such a dissociation between subjective and 463 464 objective sleep has been described previously (Gerber, Colledge, et al., 2016; Lemola, 465 Ledermann, & Friedman, 2013), and appears to reflect two fundamental different 466 neurocognitive and neuroendocrine pathways of neuroendocrine sleep regulation (Steiger, 467 Dresler, Kluge, & Schüssler, 2013). Further, it is also conceivable that the mismatch between 468 subjective and objective sleep might be due to the fact that the subjective sleep measures 469 referred to the previous two weeks, and that subjective sleep assessment took place before the 470 sleep-EEG assessment. In future studies it seems worthwhile to include sleep diary data to 471 ensure that the timeframes of the subjective and objective sleep measures correspond with 472 each other.

473 Finally, we found only partial support for our third hypothesis. Thus, while our 474 findings show that high initial burnout levels predict increased sleep complaints over time, we 475 only found a weak (and non-significant) link between poor initial sleep and increased burnout 476 at follow-up (Armon, 2009; Pagnin et al., 2014). Thus, whereas our findings support the 477 results of a study with 1356 apparently healthy adults, in which burnout significantly 478 contributed to the prediction of the development of new insomnia after 18 months of follow-479 up (Armon, Shirom, Shapira, & Melamed, 2008), our results are also at odds with a study 480 among 388 working individuals, in which insufficient sleep (< 6 hours/night) predicted 481 burnout across a 2-year period. Although speculative, we assume that the non-significant 482 prospective path between baseline burnout level and insomnia symptoms at follow-up might 483 be attributable to the fact that we used a relatively short follow-up period (6 months). 484 Moreover, structural equation modelling is a relatively conservative approach to test 485 reciprocity, because baseline levels are systematically controlled for, leaving only limited 486 amounts of variance to be explained through the cross-lagged paths. Nevertheless, we also 487 acknowledge that it is possible that this association simply does not exist in this population. 488 Given that burnout symptoms predict insomnia symptoms, the question of how we can 489 prevent sleep complaints among young elite athletes, especially among athletes who perceive

490 high levels of burnout, arises. A recent systematic review showed that research in this area is

still in an early stage (Bonnar, Bartel, Koakoschke, & Lang, 2018). Based on ten existing 491 492 intervention studies aimed at increasing performance and/or recovery through sleep 493 interventions, Bonnar et al. (2018) concluded that sleep extension was the most beneficial 494 approach, whereas napping, sleep hygiene and post-exercise recovery strategies produced 495 mixed results. Their review also suggests that sleep disturbances often occur during regular 496 training periods due to poor sleep hygiene (e.g., late training or game sessions) or as a 497 response to heavy training workloads (e.g., functional over-reaching). In addition, prior to 498 competitions, temporary sleep disturbances may occur because usual sleep routines are 499 interrupted (e.g., traveling, jet-lag, hotel bed, noise) or because of feelings of anxiety prior to 500 competition. They therefore conclude that more comprehensive sleep interventions are 501 needed, with a special focus on athletes. More specifically, Bonnar et al. suggest that such a 502 program would ideally be organized by a trained sleep educator in a series of seminar-type 503 classes (approximately 1 hour per week for 4 consecutive weeks), and would include contents 504 such as educational material, motivational tasks, and cognitive and behavioral strategies. Prior 505 research has shown that the seminar format can be successfully implemented at schools 506 (Bonnar et al., 2015). Furthermore, including cognitive and behavioral components seems 507 important, as previous studies revealed that cognitive-behavioral therapy (CBT) interventions 508 are among the most efficient approaches to improve sleep, and particularly dysfunctional 509 sleep-related cognitions (Edinger & Means, 2005; Manber et al., 2012; Schutte-Rodin, Broch, 510 Buysse, Dorsey, & Sateia, 2008). Because such a program would focus on all athletes in a 511 class (not only those with high burnout levels or insomnia symptoms), Bonnar et al. (2018) 512 emphasize that the baseline and follow-up assessment should not only assesses the 513 effectiveness of the delivered program, but also include screening for athletes with sleep 514 complaints that need to be treated individually (e.g., generally high insomnia symptoms, high 515 pre-competition anxiety, obstructive sleep apnea). With such an approach, an overload of the 516 educational contents can be avoided, whereas it is still possible to identify athletes who need 517 more intensive and professional care. Alternative approaches towards improving sleep among 518 athletes might be adopting the "third wave of behavior therapies", using mindfulness and

acceptance-based interventions (Ong, Ulmer, & Manber, 2012). Finally, although previous 519 520 research has shown that adolescents who respect sleep hygiene rules report higher sleep 521 quality and lower sleepiness during the day (Kira, Maddison, Hull, Blunden, & Olds, 2014; 522 Rigney et al., 2015; Wolfson, Harkins, Johnson, & Marco, 2015), sleep hygiene as a 523 standalone treatment is not recommended to address behavioral sleep issues (Morgenthaler et 524 al., 2006). Nevertheless, as shown by Harada et al. (2016), sleep hygiene practices might have 525 an indirect positive effect on athletes' performance and recovery by encouraging earlier 526 bedtimes, and thus lengthening sleep duration.

527 The strengths of our study were that we used a representative sample of young elite 528 athletes attending sport classes at Swiss Olympic partner schools, that almost 90% of all eligible students participated in the data assessment, and that the sample included both male 529 530 and female athletes, athletes from different grades, with different educational levels, as well 531 as athletes from various sports. Moreover, both subjective and objective sleep data was 532 assessed, and clinically relevant cut-offs were used to classify students with high burnout and 533 insomnia levels. Furthermore, longitudinal data was available to address issues associated 534 with cause and effect.

535 Despite these advantages, some shortcomings should be mentioned that may limit the generalizability of our findings. First, our sample included only students attending classes at 536 537 Swiss Olympic partner schools. Because these classes aim at facilitating the combination of 538 school and elite sport, it might be that stress levels are higher among young elite athletes not 539 attending these classes. Thus, more research is needed to see if our findings can be replicated 540 in wider populations of young elite athletes. Second, objective sleep data was only assessed 541 for a smaller sample. Thus, our sample might have been under-powered to detect effects of 542 small or moderate magnitude. Nevertheless, it is important to remember that controls were only selected if they had relatively low burnout scores (SMBM < 3). Accordingly, groups 543 544 differed substantially in burnout symptoms, while we used a matching procedure to ensure 545 that the two groups were similar with regard to gender, age, educational level and canton. 546 Third, we acknowledge that (a) the SMBM was originally developed for adult workers, (b)

547 the cut-off was derived from a sample of Swedish employees, based on the Shirom-Melamed Burnout Questionnaire (an earlier version of the SMBM), and (c) some of the original SMBM 548 549 items were changed to make the instrument more suitable for an adolescent/student sample. 550 Accordingly, we admit that the best suited cut-off of the SMBM for young people remains to 551 be established in future research. Currently, however, this cut-off is the only empirically-552 derived cut-off available, and we preferred using such a cut-off to an arbitrarily set threshold. 553 Fourth, we only considered the overall SMBM index in the present data analyses. However, 554 this seemed justified because the categorization into "high" versus "low" burnout was based 555 on the overall index. Furthermore, since the depleted energetic resources assessed by the 556 SMBM can be subsumed under the umbrella of Hobfoll's Conservation of Resources (COR) 557 theory (Hobfoll & Shirom, 2000), calculating an overall mean score is theoretically justified, 558 which is not the case for other burnout measures such as the Maslach Burnout Inventory 559 (MBI) (Shirom & Melamed, 2006). Fifth, there is still little known about the relationship 560 between burnout and sleep among elite athletes. Thus, although we used the SMBM to assess 561 burnout symptoms in our study, we acknowledge that it would be interesting to examine whether similar cross-sectional and longitudinal relationships with subjective and objective 562 563 sleep parameters are found when the ABQ is used. The ABQ remains the most widely used 564 instrument in athlete burnout research. Sixth, the wording of the items only allowed for the 565 calculation of time spent in bed, and does not provide information about (self-perceived) sleep 566 duration and sleep efficiency. Rather, time spent in bed could reflect a combination of sleep, 567 rest and sexual activities. We therefore suggest that more precise items should be used in 568 future studies to obtain a more accurate estimate of participants' self-reported sleep duration. 569 However, it is important to note that sleep duration and sleep efficiency were measured 570 objectively as part of the EEG-assessments. Seventh, in the present study, our focus was on the assessment of insomnia symptoms and dysfunctional sleep-related cognitions, whereas 571 572 sleep quality was not explicitly assessed. According to Harvey, Stinson, Whitaker, Moskovitz 573 and Virk (2008) insomnia symptoms and sleep quality are distinct constructs, although they 574 may have some potential overlap. Eighth, because athletes from various sports took part in

575	this study, it was not possible to ensure that data collection took place during the same phases
576	of the athletes' seasonal training. Finally, we used a relatively simple one-channel EEG-
577	device and only assessed data once, which entails the risk for possible first-night effects.
578	Thus, for future studies it is recommended to include at least one night of habituation, to
579	perform sleep EEG-recordings across several nights, and to include both weekday and
580	weekend nights in the objective sleep assessment.
581	
582	Conclusion
583	In the present study, between 12 and 14% of young elite athletes reported clinically
584	relevant burnout symptoms, whereas 4 to 11% reported clinically relevant insomnia
585	symptoms. Athletes with clinically relevant burnout were more likely to report insomnia
586	symptoms. Moreover, baseline burnout symptoms predicted increased insomnia symptoms
587	over time. Cognitive-behavioral interventions for dysfunctional sleep-related cognitions might
588	be a promising measure to reduce subjective sleep complaints.
589	
590	Declaration of interest
591	"The authors declare that they have no competing interests."
592	
593	Figure legends
594	Figure 1. Filtering of participants in the high and low burnout groups for the additional EEG
595	monitoring
596	Figure 2. Factor loadings, correlations between latent factors (double-headed arrows) and
597	associations between latent constructs over time (single-headed arrows) of the cross-lagged
598	panel model
599	
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### Table 1. Description of study population

	Base	line	Baseline		
	(N=257; all participants)		(N=50; participants involved in sleep-		
			EEG assessment)		
Metric variables	М	SD	М	SD	
Age (in years)	16.8	1.4	17.2	1.6	
Height	175.2	9.3	174.0	8.0	
Weight	66.6	10.7	65.3	8.9	
BMI	21.6	2.3	21.5	2.3	
Time spent in training (in hours/week)	14.7	7.0	16.2	7.9	
Time spent in competitions (in hour/week)	2.5	2.4	2.4	2.5	
Experience in competitive sports (in years)	7.8	3.1	7.8	2.8	
		0/		0/	
	n	%	n	%	
Sex	0.4		00	40.0	
Girls	94	36.6	20	40.0	
Boys	163	63.4	30	60.0	
Educational level	40.4	74.0		70.0	
High school	184	/1.6	39	78.0	
Vocational education and training	73	28.4	11	22.0	
Nationality					
Swiss	241	93.7	49	98.0	
Foreign	16	6.3	1	2.0	
Sport					
Team	121	47.1	24	48.0	
Single	136	52.9	26	52.0	
Injury					
Yes	55	21.4	6	12.0	
No	202	78.6	44	88.0	
Medication					
Yes	63	24.5	9	18.0	
No	194	75.5	41	82.0	

Table 2. Differences in outcomes variables at baseline between students above versus below the cut-
off for clinically relevant burnout

	Below cut-off		Above cut-off				
	(n=226)		(n=31)				
All participants	M	SD	M	SD	F	р	η²
Insomnia	8.1	4.5	11.2	5.1	12.8	.000 <sup>a</sup>	.048
Rumination	2.8	0.9	3.6	0.8	22.7	.000 <sup>b</sup>	.082
Focussing	2.5	0.8	3.1	0.8	17.9	.000 <sup>c</sup>	.066
Times spent in bed: weekdays (h/night)	7.4	0.8	7.1	0.6	5.2	.024 <sup>d</sup>	.020
Time spent in bed: weekend (h/night)	9.3	1.2	9.6	1.4	1.8	.183 <sup>e</sup>	.007
SOL: weekdays (min)	17.9	15.3	25.8	25.7	6.0	.015 <sup>f</sup>	.023
SOL: weekend (min)	16.3	15.2	23.1	24.0	4.38	.037 <sup>g</sup>	.018
	Below cut-off		Above cut-off				
Derticinents involved in clean FFC	(n=∠	(0)	(n=24)		~		2
Participants involved in sleep-EEG	M	5D	IVI	5D	F	p	η²
	57	3.0	11.0	5.6	21.1	000	305
Pumination	27	1.0	3.6	0.0	126	.000	202
Focussing	2.1	0.8	3.0	0.9	10.0	.001	.200
Times epent in had, weakdays (h/night)	2.5	0.0	7.0	0.0	2.0	.002	075
Times spent in bed: weekdays (n/night)	7.5	0.7	1.2	0.5	3.9	.054	.075
Time spent in bea: weekena (n/night)	9.3	0.9	9.7	1.2	2.0	.103	.043
SOL. weekdays (min)	10.3	11.3	20.2	20.0	2.1	.107	.053
SOL: weekend (min)	15.4	7.9	23.6	27.3	2.1	.155	.044
Sleep-EEG pattern	М	SD	М	SD	F	р	η²
Total sleep time (h:min)	6:57	0:43	7:05	0:50	0.5	.500	.010
Sleep efficiency	91.3	7.2	92.7	3.0	0.8	.326	.017
SOL (h:min)	0:17	0:18	0:14	0:09	0.5	.485	.010
Number of awakenings	10.5	5.0	11.4	6.9	0.3	.607	.006
Stage 1 sleep (h:min)	0:14	0.08	0:16	0:13	0.4	.528	.008
Stage 1 sleep (%)	3.5	2.1	3.3	1.3	0.1	.734	.002
Stage 2 sleep (h:min)	3:34	0:47	3:45	0:38	0.9	.348	.018
Stage 2 sleep (%)	50.8	8.4	53.0	7.6	0.9	.348	.018
Stage 3 sleep (h:min)	0:27	0:11	0:27	0:09	0.0	.854	.001
Stage 3 sleep (%)	6.5	2.7	6.4	2.4	0.1	.811	.001
Stage 4 sleep (h:min)	1:08	0:27	1:04	0:26	0.2	.622	.005
Stage 4 sleep (%)	18.4	10.8	15.2	6.0	1.7	.203	.034
Light sleep (h:min)	3:48	0:49	3:59	0:42	0.8	.387	.016
Light sleep (%)	54.3	9.0	56.3	8.3	0.7	.418	.014
Deep sleep (h:min)	1:35	0.26	1:31	0:27	0.3	.574	.007
Deep sleep (%)	23.2	7.4	21.5	6.3	0.7	.409	.014
REM-sleep (h:min)	1:34	0:21	1:35	0:32	0.3	.865	.001
REM-sleep (%)	22.5	4.6	22.2	6.7	0.1	.827	.001

*Note.* SOL=Sleep onset latency. EEG=Electroencephalography. REM-sleep=Rapid eye movement sleep. Due to unequal group sizes, we calculated Levene's test of homogeneity of variances and robust tests of equality of means (Welch- and Brown-Forsythe-tests). The results of these tests are presented as superscripts: <sup>a-d</sup>Levene's test of homogeneity of variances is not significant (p > .05). Group differences remain significant (p < .05) if using robust tests of equality of means (Welch- and Brown-Forsythe-tests). <sup>e</sup>Levene's test of homogeneity of variances is not significant (p > .05). No group difference found (p > .05) if using robust tests of equality of means (Welch- and Brown-Forsythe-tests). <sup>f-g</sup>Levene's test of homogeneity of variances is significant (p < .05). No group difference found (p > .05) if using robust tests of equality of means (Welch- and Brown-Forsythe-tests). <sup>f-g</sup>Levene's test of homogeneity of variances is significant (p < .05). No group difference found (p > .05) if using robust tests of equality of means (Welch- and Brown-Forsythe-tests).



Figure 1. Filtering of participants in the high and low burnout groups for the additional EEG monitoring



The'following residual'errors were allowed to correlate:'e3@6,'e4@7,'e5@8,'e9@16,'e10@17,'e11@18,'e12@19,'e13@20,'e14@21,'e15@22'(correlations not'shown)

Figure 2. Factor loadings, correlations between latent factors (double-headed arrows) and associations between latent constructs over time (single-headed arrows) of the cross-lagged panel model