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

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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  
10 dysfunctional sleep-related cognitions, and spent less time in bed during weeknights ( $p<.05$ ).  
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.

16

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

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

20  
21 Participating in competitive elite sport can be a stressful experience due to a range of  
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-Gauthier, 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 under-  
33 recovery, prolonged exposure to excessively high training loads coupled with high perceived  
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-Gauthier, Guillet-Descas, & Gustafsson, 2016).

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

46 initiated activities (proactive recovery) can be systematically used to optimize situational  
47 conditions and to build up and refill personal resources and buffers” (p. 22). An increasing  
48 interest for recovery-related issues has been observed in coaches, although their knowledge of  
49 efficient recovery strategies and monitoring tools is still limited (Simijanovic, Hooper,  
50 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  
56 performance impairment (Halson, 2014). Second, significant links have been established  
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,  
61 2007). Fourth, previous research in non-athlete populations has shown that people suffering  
62 from burnout symptoms not only report poorer subjective sleep quality, but also have less  
63 favorable objective sleep patterns, as measured via electroencephalography (EEG) (Brand,  
64 Beck, Hatzinger, et al., 2010; Ekstedt, Soderstrom, et al., 2006; Söderström, Ekstedt,  
65 Akerstedt, Nilsson, & Axelsson, 2004). Finally, previous investigations have highlighted that  
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).

68         Despite these salient relationships, our current understanding of the relationship  
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),  
73 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;  
77 Gustafsson et al., 2011). Nevertheless, Raedeke's (1997) conceptualization of athlete burnout  
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-  
88 Gauthier, Oger, Guillet, & Martin-Krumm, 2010; Raedeke, Arce, De Francisco, Seoane, &  
89 Ferraces, 2013; Raedeke & Smith, 2001).

90         However, researchers have also emphasized several weaknesses of the ABQ  
91 (Gustafsson, Lundkvist, Podlog, & Lundkvist, 2016). According to Gustafsson et al. (2016),  
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 ABQ dimensions (e.g., sense of  
95 accomplishment with self-efficacy), and (c) little evidence exists that the three ABQ  
96 dimensions influence each other over time, as might be expected from a theoretical point of  
97 view (Lundkvist et al., 2018). Moreover, one fundamental limitation of the ABQ is that no  
98 reliable cut-offs have been developed to categorize participants in terms of burnout symptom  
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

102 wants to address. For instance, if the focus of a project is on comparing levels with existing  
103 data or looking at the changes of the three dimensions over time in a set context, then the  
104 ABQ would be well suited. However, if the purpose is to explore burnout as a health issue in  
105 athletes, a measure that sets the results in relation to cut-offs of clinical samples would seem  
106 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  
119 reported sleep parameters and (b) objectively assessed measures of sleep continuity (e.g. sleep  
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.

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

130 Söderström, Jeding, Ekstedt, Perski, & Åkerstedt, 2012), we hypothesized that athletes above  
131 the cut-off for clinically relevant burnout would report significantly more subjective sleep  
132 complaints and more dysfunctional sleep-related cognitions than athletes below this cut-off.  
133 Second, we hypothesized that athletes above the clinical burnout threshold would have less  
134 favorable objective sleep patterns than their peers scoring below the cut-off (Ekstedt, M., et  
135 al., 2006), although some studies in this area did not yield significant results (e.g., Söderström  
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).

140

141

## **Methods**

### **Participants and procedures**

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

157

158 In total, 257 adolescents (163 males and 94 females; age:  $M=16.8$  years,  $SD=1.4$ ) took  
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  
161 and athletes who participated in the follow-up did not differ with regard to any of the potential  
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  
167 willing to take part in the objective sleep assessments.

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  
173 fatigue (six items: e.g., “I feel physically drained.”), cognitive weariness (five items: e.g., “I  
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-  
182 Melamed Burnout Questionnaire (an earlier version of the SMBM) as a clinically relevant  
183 level of burnout. This cut-off is based on a comparison of 319 burnout patients and 319  
184 controls (general population), and placed 83.4% of the patients above the cut, and 86.5% of

185 the controls below the cut. Internal consistency of the overall index was satisfactory in the  
186 present 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,  
195 difficulties maintaining sleep, early morning awakening, increased daytime sleepiness, low  
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.

203 ***Self-reported time spent in bed and sleep onset latency.*** To assess time spent in bed (as a  
204 proxy of sleep duration) on weekdays and weekend days, we asked participants when they  
205 usually go to bed and when they usually get up in the morning. We counted Sunday, Monday,  
206 Tuesday, Wednesday and Thursday nights as weekday nights, Friday and Saturday as  
207 weekend nights. Moreover, we asked participants to report how long it usually takes them to  
208 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

213 Schlafgestörter = Questionnaire to assess personality traits of people suffering from sleep  
214 disturbances) (Hoffmann, Rasch, & Schnieder, 1996). The FEPS II consists of two subscales  
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 SOMNOwatch<sup>TM</sup>, 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

241 analyzed sleep parameters according to the definitions in the standard program described by  
242 Lauer et al. (Lauer, Riemann, Wiegand, & Berger, 1991). In the present study, we examined  
243 the following parameters: total sleep time, sleep efficiency (SE), sleep onset latency (SOL),  
244 number of awakenings after sleep onset, stages 1—4, light sleep (stages 1 and 2), slow wave  
245 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 self-  
250 reported height in m<sup>2</sup>), educational level (high school vs. vocational educational and training),  
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  
263 (ANOVAs) and  $\chi^2$ -tests, we examined differences in potential confounders between students  
264 with burnout scores above versus below the clinically relevant cut-off score of the SMBM  
265 ( $\geq 4.40$ ). Third, we calculated a series of ANOVAs to examine how participants with versus  
266 without clinically relevant burnout symptoms differ with regard to subjective and objective  
267 sleep. In case of unequal group sizes, we repeated ANOVAs with Welch and Brown-Forsythe  
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  
270 interpreted effect sizes as follows (Cohen, 1988): Small:  $\eta^2$  from .01 to .058, medium:  $\eta^2$   
271 from .059 to .137, and large:  $\eta^2 \geq .138$ . Finally, to gain insights into the reciprocal  
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,  
281 we considered the following goodness-of-fit indices: (i) chi-square statistics ( $\chi^2$ ), (ii)  
282 Comparative Fit Index (CFI), (iii) Tucker Lewis Index (TLI), and (iv) root mean squared error  
283 of approximation (RMSEA) with 90% confidence interval (CI). Following the  
284 recommendations of McDonald and Ho (2002), CFI and TLI values close to .95 or greater  
285 and RMSEA values near or below .08 represent good model-fit. We considered  $\Delta\chi^2$  statistics  
286 to compare the fit of different models. Following Comrey and Lee (1992), standardized factor  
287 loadings of  $\geq .71$  were interpreted as excellent,  $\geq .63$  as very good,  $\geq .55$  as good,  $\geq .45$  as fair,  
288 and  $< .32$  as poor.

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®, whereas AMOS (version 24, IBM  
292 Corporation, Armonk, NY, USA) for Windows® was used for structural equation modelling.

293

294

## Results

295

### 296 **Description of study population**

297 Table 1 provides a detailed description of the study population, including all social,  
298 demographic and behavioral background variables, which were also considered as potential  
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

### 303 **Descriptive statistics and prevalence rates**

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

### 311 **Group differences with regard to potential confounders**

312 Based on ANOVAs and  $\chi^2$ -tests, we did not find any statistically significant differences in  
313 social, demographic or behavioral confounders between students above versus below the  
314 critical SMBM score (all  $p$ s 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  
322 scores ( $n=9$ , 8%),  $\chi^2(1, N=257)=11.9, p=.001, \phi=.211$ . Moreover, as shown in Table 2,

323 students above the critical SMBM score reported more insomnia symptoms and were more  
324 likely to engage in dysfunctional sleep-related cognitions (focusing, rumination).  
325 Furthermore, students with clinically relevant burnout symptoms spent less time in bed during  
326 weekday nights. Although we found a significant difference in prolonged sleep onset latency  
327 both during weekday and weekend nights, this difference was no longer significant when we  
328 repeated the ANOVAs with Welch or Brown-Forsythe procedures.

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

335

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

337 Table 2 shows that students above versus below the critical cut-off for clinically relevant  
338 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  
342 good model fit:  $\chi^2/df = 1.42$ ,  $p < .001$ , CFI = .956, TLI = .944, RMSEA = .047, 90% CI =  
343 .032 to .060. All observed variables significantly loaded on their respective factors,  $p < .05$ .

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  
346 constrained to be equal across measurement occasions. As shown by the non-significant  $\Delta\chi^2$   
347 score ( $p = .673$ ), the model fit remained stable after holding factor loadings constant:  $\chi^2/df =$   
348 1.40,  $p < .001$ , CFI = .957, TLI = .948, RMSEA = .045, 90% CI = .030 to .058.

349 Figure 1 illustrates the findings of the cross-lagged panel analysis. Again, we  
350 compared a default model ( $\chi^2/df = 1.42$ ,  $p < .001$ , CFI = .956, TLI = .944, RMSEA = .047,

351 90% CI = .032 to .060) to a model with invariant factor loadings over time ( $\chi^2/df = 1.42, p <$   
352  $.001, CFI = .956, TLI = .944, RMSEA = .047, 90\% CI = .032 to .060$ ). The goodness-of-fit  
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  
356 baseline ( $\Psi = .43, p < .001$ ) and follow-up ( $\Psi = .46, p < .001$ ). Furthermore, burnout  
357 symptoms ( $\beta = .54, p < .001$ ) and insomnia symptoms ( $\beta = .51, p < .001$ ) showed a relatively  
358 high stability over time. Finally, higher baseline burnout symptoms predicted more frequent  
359 insomnia symptoms across time ( $\beta = .27, p < .001$ ). The path from baseline insomnia to  
360 burnout symptoms at follow-up pointed in the same direction ( $\beta = .07$ ), but was not  
361 statistically significant ( $p = .413$ ).

362

363

### 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.

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

379 critical burnout levels. Our findings show that between 12 and 14 percent of the students  
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  
408 complaints and more dysfunctional sleep-related cognitions than athletes below this cut-off,  
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  
431 students (Brand, Gerber, et al., 2010) and highlighted in cognitive models of insomnia  
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,

435 the fact that dysfunctional cognitions are associated with impaired sleep supports the notion  
436 that a positive cognitive mindset, reflected by a mentally tough attitude (e.g., seeing problems  
437 as a challenge, feeling in control over one's life, tendency to stay committed even if not  
438 everything works as intended) is associated with a decreased likelihood of subjective and  
439 objective sleep impairments (Brand et al., 2013), and fewer burnout symptoms (Gerber et al.,  
440 2015).

441 Our second hypothesis was that athletes with clinically relevant symptoms of burnout  
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 eye 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  
461 subjective sleep measures, we did not detect any significant differences for objective sleep.  
462 This indicates that there was only limited correspondence between subjective and objective

463 sleep impairments among young elite athletes. Such a dissociation between subjective and  
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

491 still in an early stage (Bonnar, Bartel, Koakoschke, & Lang, 2018). Based on ten existing  
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

519 acceptance-based interventions (Ong, Ulmer, & Manber, 2012). Finally, although previous  
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  
529 eligible students participated in the data assessment, and that the sample included both male  
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  
536 generalizability of our findings. First, our sample included only students attending classes at  
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  
543 only selected if they had relatively low burnout scores (SMBM < 3). Accordingly, groups  
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  
548 Burnout Questionnaire (an earlier version of the SMBM), and (c) some of the original SMBM  
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  
562 whether similar cross-sectional and longitudinal relationships with subjective and objective  
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  
571 the assessment of insomnia symptoms and dysfunctional sleep-related cognitions, whereas  
572 sleep quality was not explicitly assessed. According to Harvey, Stinson, Whitaker, Moskowitz  
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

### **Declaration of interest**

591 "The authors declare that they have no competing interests."

592

### **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

Metric variables	Baseline (N=257; all participants)		Baseline (N=50; participants involved in sleep- EEG assessment)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
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
Categorical variables	<i>n</i>	%	<i>n</i>	%
Sex				
Girls	94	36.6	20	40.0
Boys	163	63.4	30	60.0
Educational level				
High school	184	71.6	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

All participants	Below cut-off (n=226)		Above cut-off (n=31)		F	p	$\eta^2$
	M	SD	M	SD			
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

Participants involved in sleep-EEG assessment	Below cut-off (n=26)		Above cut-off (n=24)		F	p	$\eta^2$
	M	SD	M	SD			
Insomnia	5.7	3.9	11.9	5.6	21.1	.000	.305
Rumination	2.7	1.0	3.6	0.9	12.6	.001	.208
Focussing	2.3	0.8	3.0	0.8	10.9	.002	.186
Times spent in bed: weekdays (h/night)	7.5	0.7	7.2	0.5	3.9	.054	.075
Time spent in bed: weekend (h/night)	9.3	0.9	9.7	1.2	2.0	.163	.043
SOL: weekdays (min)	18.3	11.3	28.2	28.5	2.7	.107	.053
SOL: weekend (min)	15.4	7.9	23.6	27.3	2.1	.155	.044

Sleep-EEG pattern	M	SD	M	SD	F	p	$\eta^2$
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).

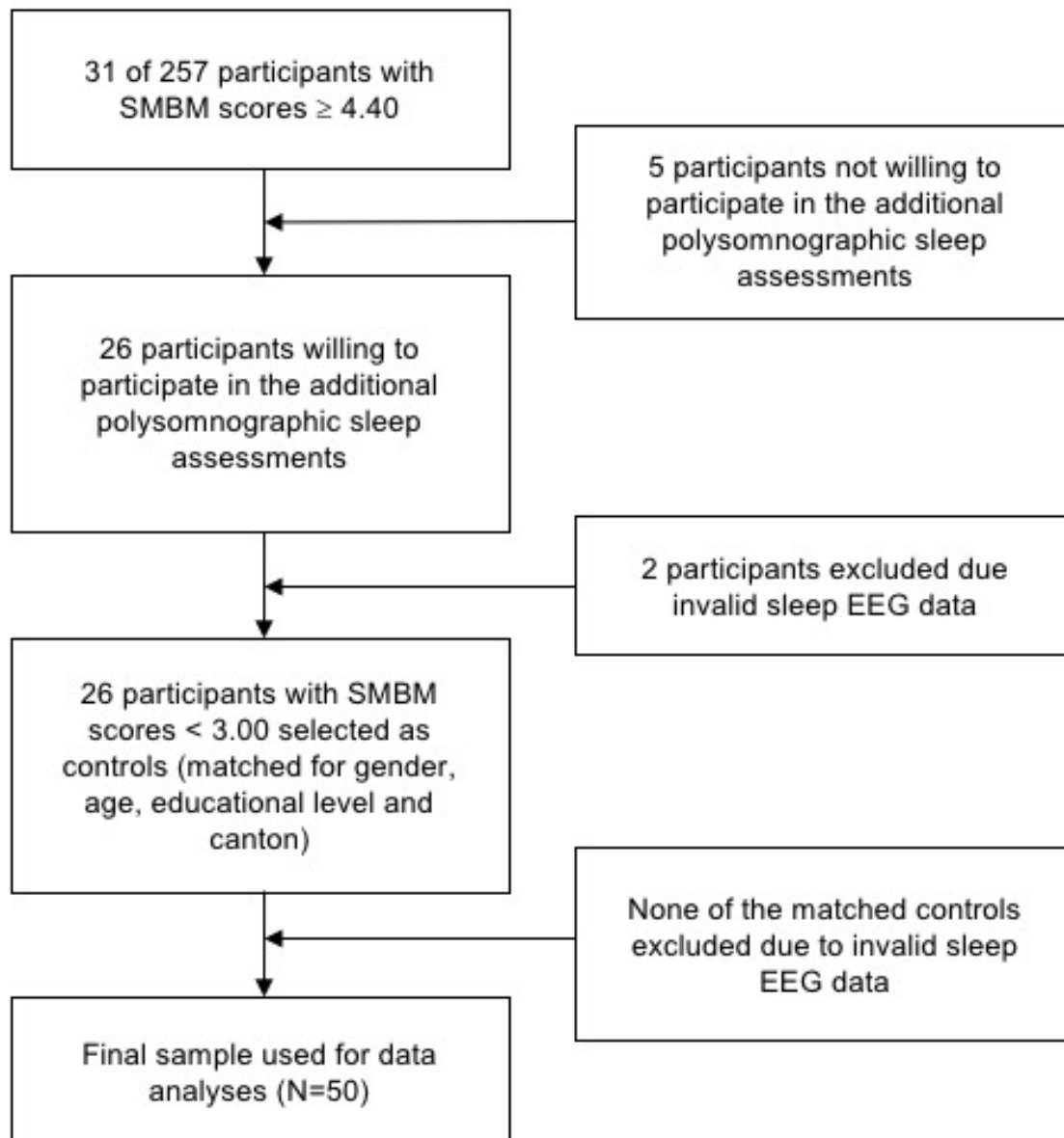
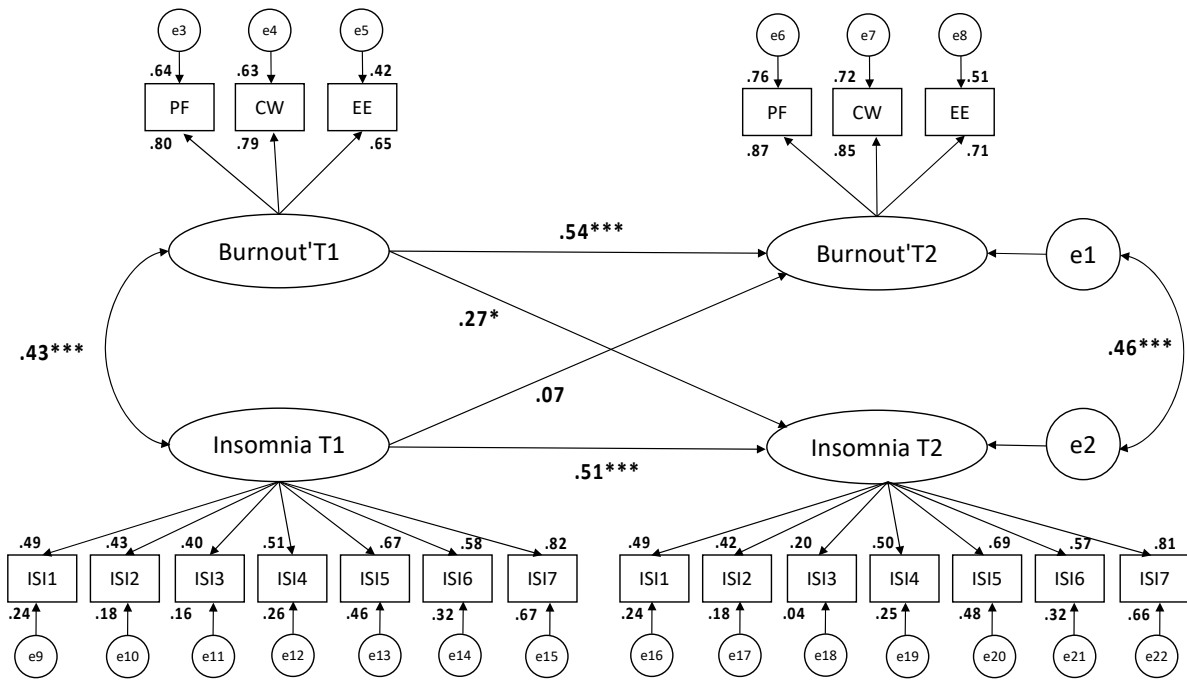


Figure 1. Filtering of participants in the high and low burnout groups for the additional EEG monitoring



The following residual errors were allowed to correlate: e3@e6, e4@e7, e5@e8, e9@e16, e10@e17, e11@e18, e12@e19, e13@e20, e14@e21, e15@e22 (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