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

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Abstract

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

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

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

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

Getting sufficient and restoring sleep is a promising strategy to foster recovery. First, among athletes, disturbed sleep has been identified as a key symptom of overtraining (a syndrome which has a certain overlap with burnout, but which places a stronger focus on performance-related and physiological factors; for more details regarding the difference between overtraining and burnout see: Kellmann et al., 2017; Meeussen et al., 2013) and performance impairment (Halson, 2014). Second, significant links have been established between sleep, recovery, and performance among high-level athletes (Fullagar et al., 2015; Samuels, 2008). Third, outside the realm of elite sport, a large body of evidence shows that favorable sleep facilitates recovery from work-related stress and thus prevents the development of burnout symptoms (Sonnenschein, Sorbi, van Doornen, Schaufeli, & Maas, 2007). Fourth, previous research in non-athlete populations has shown that people suffering from burnout symptoms not only report poorer subjective sleep quality, but also have less favorable objective sleep patterns, as measured via electroencephalography (EEG) (Brand, Beck, Hatzinger, et al., 2010; Ekstedt, Soderstrom, et al., 2006; Söderström, Ekstedt, Akerstedt, Nilsson, & Axelsson, 2004). Finally, previous investigations have highlighted that improvements in burnout symptoms are closely related to improvements in subjective and objective sleep quality (Ekstedt, Soderstrom, & Akerstedt, 2009; Sonnenschein et al., 2007).

Despite these salient relationships, our current understanding of the relationship between sleep and burnout in athletes is limited. Although a previous study carried out in Finland showed that compared to healthy controls, athletes suffering from severe overtraining did not differ with regard to nocturnal heart rate variability (as an indicator of autonomic nervous system imbalance during sleep) (Hynynen, Uusitalo, Konttinen, & Rusko, 2006), empirical studies in this area are still sparse. Accordingly, the purpose of the present study was to expand on the current literature by shedding light on the relationship between (subjective and objective) sleep and burnout among young elite athletes.

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

However, researchers have also emphasized several weaknesses of the ABQ (Gustafsson, Lundkvist, Podlog, & Lundkvist, 2016). According to Gustafsson et al. (2016), the important aspects are that (a) the definition upon which the ABQ is based, is derived neither from clinical observation nor theory, (b) considerable overlap with other psychological constructs exists between some of the ABQ dimensions (e.g., sense of 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 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 severity. Given this background, Gustafsson, Madigan, and Lundkvist (2017) argued that the ABQ has been adopted somewhat uncritically by the scientific community, although the 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.

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

In the present study, we addressed the following research questions First, we sought to identify the number of young elite athletes exhibiting clinically relevant symptoms of burnout and insomnia. Second, we examined whether athletes above versus below the cut-off for 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 efficiency, number of awakenings) and architecture (e.g. time spent in different sleep stages). Third, we examined the extent to which burnout symptoms predicted poor sleep over time, and vice versa. Addressing these research questions is important to better understand the extent to which sleep is an issue among young athletes with and without clinically relevant burnout symptoms. Furthermore, the findings will help us clarify whether subjective sleep complaints are reflected in objectively assessed sleep indicators. Finally, this study will provide deeper insights regarding the temporal interplay between burnout symptoms and 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 the cut-off for clinically relevant burnout would report significantly more subjective sleep 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 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 et al., 2004). Third, we expected a reciprocal relationship between burnout and sleep, in the sense that high initial burnout levels would predict increased sleep complaints over time, and that poor initial sleep would be associated with increased burnout at follow-up (Armon, 2009; Pagnin et al., 2014).

Methods

Participants and procedures

Students were eligible for this longitudinal study if they attended sport classes at Swiss Olympic partner schools in the North-Western, German-speaking part of Switzerland. These classes are designed to facilitate the coordination of elite sport and school life (e.g., lower number of lessons per week, extended school duration). We informed all students that participation was voluntary, and ensured all participants confidentiality. Furthermore, we collected informed written consent before the beginning of the data assessment. We collected data in November-December 2016, and after a 6-month follow-up period in May-June 2017 (using the same instruments at baseline and follow-up). All students completed a written questionnaire, consisting of a battery of internationally accepted psychological instruments (see below for more details). We obtained ethical approval from the local ethics committee to ensure that all procedures were in line with current Swiss legal requirements. Moreover, all procedures met the ethical requirements defined in the declaration of Helsinki and its later amendments. To ensure that students above versus below the cut-off for clinically relevant burnout symptoms did not differ with regard to background variables, we selected students 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 part in the baseline assessment. Of these, 197 athletes (125 boys and 73 girls; age: *M*=16.83, *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 confounders or main study variables ($p > .05$). Furthermore, 50 athletes (30 boys, 20 girls; age: *M*=17.2, *SD*=1.6) provided valid sleep-EEG data (24 students with clinically relevant burnout symptoms). Further information about how athletes were filtered in the high and low burnout groups for the additional EEG monitoring is provided in Figure 1. As shown in Figure 1, five participants of those with clinically relevant burnout symptoms were not willing to take part in the objective sleep assessments.

Measures

Assessment of burnout symptoms

We used the 14-item Shirom-Melamed Burnout Measure (SMBM) (Lerman et al., 1999) to 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 feel I am not thinking clearly.”), and emotional exhaustion (three items: e.g., “I feel I am unable to be sensitive to the needs of coworkers and customers.”). For the emotional exhaustion subscale, we adapted the wording of the items to increase suitability for adolescents. Thus, we used a more open formulation to refer to people in general instead of coworkers and customers. Students responded to the items on a 7-point Likert scale ranging from 1 (*never or almost never*) to 7 (*always or almost always*). We calculated the mean score to obtain an overall index, with higher scores reflecting higher burnout symptoms. Based on the work of Lundgren-Nilsson et al. (2012), we considered a score of ≥4.40 on the Shirom-Melamed Burnout Questionnaire (an earlier version of the SMBM) as a clinically relevant 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 the controls below the cut. Internal consistency of the overall index was satisfactory in the present sample, with a Cronbach's alpha of .92.

Assessment of subjective sleep parameters

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

Dysfunctional sleep-related cognitions. Dysfunctional cognitive processes play an important role in the exacerbation and perpetuation of insomnia (Brand, Gerber, Pühse, & Holsboer-Trachsler, 2010). In the present study, we assessed dysfunctional sleep-related cognitions with the FEPS II (Fragebogen zur Erfassung allgemeiner Persönlichkeitsmerkmale

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

Assessment of objective sleep parameters

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

Assessment of potential confounders

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

Statistical analyses

First, we calculated descriptive statistics (*M*, *SD*) and frequencies (*n*, %) to describe the study sample and identify the number of participants with clinically relevant levels of burnout and insomnia symptoms. We present statistics separately for the total sample and for those participants who were selected for the EEG-assessments. Second, using analyses of variance (ANOVAs) and χ^2-tests, we examined differences in potential confounders between students with burnout scores above versus below the clinically relevant cut-off score of the SMBM (≥4.40). Third, we calculated a series of ANOVAs to examine how participants with versus 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 procedures. With regard to subjective sleep, we performed the analyses separately for the total sample and the subsample selected for the sleep EEG recordings. For ANOVAs, we interpreted effect sizes as follows (Cohen, 1988): Small: η^2 from .01 to .058, medium: η^2 from .059 to .137, and large: $\eta^2 \geq .138$. Finally, to gain insights into the reciprocal associations between burnout and insomnia symptoms, we tested cross-lagged panel models using the structural equation approach. As recommended by Anderson and Gerbing (Anderson & Gerbing, 1988), we adopted a two-step approach. We first specified the associations between the measured and latent variables, bidirectional associations (covariances) between the latent variables, and invariance of factor loadings and intercepts over time in the initial measurement model. We then calculated the full structural model. We defined the latent burnout via the three SMBM subscales, to reduce the number of variables in the model and to keep the degrees of freedom reasonable. We allowed measurement errors to 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 (χ^2), (ii) Comparative Fit Index (CFI), (iii) Tucker Lewis Index (TLI), and (iv) root mean squared error 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 and RMSEA values near or below .08 represent good model-fit. We considered $\Delta\chi^2$ statistics to compare the fit of different models. Following Comrey and Lee (1992), standardized factor loadings of ≥.71 were interpreted as excellent, ≥.63 as very good, ≥.55 as good, ≥.45 as fair, and <.32 as poor.

An alpha level of $p<.05$ was determined across all analyses. Descriptive statistics, frequencies, χ^2-tests and ANOVAs were performed with SPSS® (version 24, IBM Corporation, Armonk, NY, USA) for Apple Mac®, whereas AMOS (version 24, IBM Corporation, Armonk, NY, USA) for Windows® was used for structural equation modelling.

Results

Description of study population

Table 1 provides a detailed description of the study population, including all social, demographic and behavioral background variables, which were also considered as potential confounders. As can be seen, the sample of students selected for the sleep-EEG assessments showed no significant differences in demographic and behavioural variables compared to the full sample of elite athletes.

Descriptive statistics and prevalence rates

At baseline, 31 athletes (12%) reported clinically relevant burnout symptoms (SMBM ≥ 4.40), whereas 28 athletes (11%) exhibited clinically relevant insomnia symptoms (ISI ≥15). At follow-up, 27 athletes (14%) reported clinically relevant burnout, whereas 8 athletes (4%) exhibited clinically relevant insomnia symptoms. Descriptive statistics for all the outcome variables at baseline are shown in Table 2, separately for athletes above versus below the SMBM cut-off.

Group differences with regard to potential confounders

Based on ANOVAs and χ^2-tests, we did not find any statistically significant differences in social, demographic or behavioral confounders between students above versus below the critical SMBM score (all *p*s were > .05), both in the full sample and the subsample selected for the sleep-EEG recordings. As a consequence, we did not consider any of these factors as a covariate in the ANOVAs to test group differences in subjective and objective sleep parameters.

Group differences with regard to subjective sleep parameters

In the full sample, students with clinically relevant burnout symptoms were more likely to 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, ϕ=.211. Moreover, as shown in Table 2, students above the critical SMBM score reported more insomnia symptoms and were more likely 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.

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 *p*s were > .05).

Test of reciprocal relationships between burnout and insomnia symptoms

The initial measurement model (see Supplementary Online Material, Figure S1) provided good model fit: χ^2/df = 1.42, $p < .001$, CFI = .956, TLI = .944, RMSEA = .047, 90% CI = .032 to .060. All observed variables significantly loaded on their respective factors, $p < .05$. With three exceptions, most factor loadings were fair (≥ .45) or good (≥ .55), indicating that 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 $\Delta\chi^2$ score ($p = .673$), the model fit remained stable after holding factor loadings constant: χ^2/df = 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 compared a default model (χ^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 (χ^2/df = 1.42, p < .001, CFI = .956, TLI = .944, RMSEA = .047, 90% CI = .032 to .060). The goodness-of-fit indices pointed towards adequate model fit, and the $\Delta\chi^2$ score (p = .673) indicates that the model fit remained good after controlling for invariant factor loadings across time. Figure 1 shows that there was a significant association between burnout and insomnia symptoms at baseline (Ψ = .43, p < .001) and follow-up (Ψ = .46, p < .001). Furthermore, burnout symptoms (β = .54, p < .001) and insomnia symptoms (β = .51, p < .001) showed a relatively high stability over time. Finally, higher baseline burnout symptoms predicted more frequent insomnia symptoms across time (β = .27, p < .001). The path from baseline insomnia to burnout symptoms at follow-up pointed in the same direction (β = .07), but was not statistically significant (p = .413).

Discussion

Our findings provide important insights into the relationship between burnout and sleep among elite athletes, an association which has not been examined to date. The key findings are that athletes with clinically relevant burnout symptoms report significantly more insomnia symptoms, report more dysfunctional sleep-related cognitions (focusing and rumination), spend less time in bed during weekday nights, and report higher sleep onset latency, both during weeknights and weekend nights. No significant differences were found with regard to objective sleep parameters. Finally, a cross-lagged panel analysis showed that moderately strong cross-sectional links exist between burnout and insomnia symptoms. Burnout predicted increased insomnia symptoms, indicating that burnout should be seen as a potential cause 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 reported SMBM scores above the critical threshold (≥ 4.40). Moreover, we found that up to 11 percent experienced clinically relevant insomnia symptoms. The prevalence of clinically relevant insomnia symptoms dropped to 4 percent at follow-up; this may be attributable to seasonal variations in insomnia symptoms associated with day length (Friborg, Bjorvatn, Amponsah, & Pallesen, 2012; Wirz-Justice, Graw, Kräuchi, & Wacker, 2003). We did not find any baseline differences in clinically relevant insomnia symptoms between athletes who completed the follow-up (11%) and those who dropped out from T1 to T2 (10%). Our findings reveal that compared to adolescents attending normal school classes (7%), clinically relevant burnout levels were more prevalent in our sample if the same definition and cut-offs are used to estimate burnout (Elliot et al., 2015). This highlights that stress is an important issue among young elite athletes, and that specific measures are needed for this specific target population to either make their lives less stressful or to promote personal and social resources that enable them to more successfully cope with stress.

The prevalence of moderate to severe insomnia symptoms was comparable to estimates from more general adolescent populations (around 10%) (Johnson, Roth, Schultz, & Breslau, 2006). This confirms that young elite athletes are just as likely to develop sleep complaints as less trained peers, although regular physical activity has previously been associated with positive sleep outcomes in this age group (Lang et al., 2016). Researchers have emphasized that adolescence is a period of increased risk for developing sleep complaints. For instance, adolescents still need 9 to 10 hours of sleep per night (Moore & Meltzer, 2008), although during school nights, their sleep duration often varies between only 6.5-8.5 hours per night (Mercer, Merritt, & Cowell, 1998), with delayed bed times (Millman, 2005), and an increasing discrepancy between school nights and weekend nights (Dahl & Lewin, 2002). In the present sample, the mean duration of sleep was approximately 7 hours, which is below current age-specific recommendations (8.5-10 hours/night) (Feinberg, 2013).

Three hypotheses were tested, and each of these will now be considered separately. Support was found for our first hypothesis, which stated that athletes above the cut-off for clinically relevant burnout symptoms would report significantly more subjective sleep complaints and more dysfunctional sleep-related cognitions than athletes below this cut-off, in line with findings previously reported in studies of working adults (Brand, Beck, Hatzinger, et al., 2010; Ekstedt, Soderstrom, et al., 2006; Söderström et al., 2012). Moreover, although not specifically tested in the present study, several mechanisms have been suggested in the scientific literature to explain these relationships. These mechanisms should be tested more systematically in future research in athlete samples. For instance, Ekstedt and colleagues (2006) suggested that burnout may result in an increased activation of the hypothalamo-pituitary-adrenal (HPA) axis, which may contribute to the development of sleep complaints. Ekstedt et al. (2006) further suggested that burnout is associated with an over-secretion of proinflammatory cytokines, which in turn stimulate the HPA axis. Moreover, previous research has shown that some of these cytokines (e.g., tumor necrosis factor-alpha and interleukin-6) are directly linked with somnolence and fatigue, whereas experimentally induced sleep reductions result in increased proinflammatory cytokine levels (von Känel, Bellingrath, & Kudielka, 2008). From a psychological point of view, Söderström et al. (2004) argued that people with high burnout levels report more subjective problems associated with nocturnal awakenings. This may explain why burnout patients report higher sleepiness and more fatigue at most times of the day during weekdays, without relief during weekends (Ekstedt, Soderstrom, et al., 2006). Söderström and colleagues (2004) found that among adult workers, high burnout was associated with an increased tendency to think about work during leisure time. This is in line with studies showing that a strong relationship exists between burnout and decreased life satisfaction (Brand, Beck, Hatzinger, et al., 2010; Gerber et al., 2015), and supports our finding that participants with clinically relevant burnout levels report significantly more dysfunctional sleep-related cognitions. As shown previously in university students (Brand, Gerber, et al., 2010) and highlighted in cognitive models of insomnia (Harvey, 2002), ruminating about unresolved problems and focusing on difficulties associated with getting sufficient and satisfactory sleep can have a strong negative impact on sleep 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 would exhibit poorer objective sleep patterns compared to their peers. Our results did not support this hypothesis. Young elite athletes with clinically relevant burnout symptoms did not differ from matched peers with lower burnout symptoms, which is at odds with previously reported findings in adults (Ekstedt, Soderstrom, et al., 2006). For instance, Ekstedt, Soderstrom, et al. (2006) found more arousal and sleep fragmentation, more wake time and stage-1 sleep, lower sleep efficiency, less slow wave sleep and rapid eye movement sleep, and a lower delta power density in nonrapid eye movement sleep in "burnout patients" compared to healthy controls. However, their population of interest cannot be directly compared with ours. Although these authors used a cut-off score for burnout that was similar to ours (SMBM > 4.50), their participants were adults on full-time sick leave (and were thus likely to suffer from stronger and longer-lasting burnout symptoms). Nevertheless, our findings are in line with a study conducted by Söderström et al. (2004) with relatively healthy adults, in which few differences in objective sleep occurred between participants with "high" versus "low" burnout symptoms. While Söderström et al. (2004) found that those with high burnout showed higher total arousal, no significant differences were found for sleep efficiency, sleep onset latency, sleep stages 1-4 or REM sleep. However, in their study, they used an SMBM cut-off ≥ 2.75 to classify participants in the high burnout group. This difference makes it difficult to compare their results with ours. In summary, whereas we found significant 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. This indicates that there was only limited correspondence between subjective and objective sleep impairments among young elite athletes. Such a dissociation between subjective and objective sleep has been described previously (Gerber, Colledge, et al., 2016; Lemola, Ledermann, & Friedman, 2013), and appears to reflect two fundamental different neurocognitive and neuroendocrine pathways of neuroendocrine sleep regulation (Steiger, Dresler, Kluge, & Schüssler, 2013). Further, it is also conceivable that the mismatch between subjective and objective sleep might be due to the fact that the subjective sleep measures referred to the previous two weeks, and that subjective sleep assessment took place before the sleep-EEG assessment. In future studies it seems worthwhile to include sleep diary data to ensure that the timeframes of the subjective and objective sleep measures correspond with each other.

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

Given that burnout symptoms predict insomnia symptoms, the question of how we can prevent sleep complaints among young elite athletes, especially among athletes who perceive 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 intervention studies aimed at increasing performance and/or recovery through sleep interventions, Bonnar et al. (2018) concluded that sleep extension was the most beneficial approach, whereas napping, sleep hygiene and post-exercise recovery strategies produced mixed results. Their review also suggests that sleep disturbances often occur during regular training periods due to poor sleep hygiene (e.g., late training or game sessions) or as a response to heavy training workloads (e.g., functional over-reaching). In addition, prior to competitions, temporary sleep disturbances may occur because usual sleep routines are interrupted (e.g., traveling, jet-lag, hotel bed, noise) or because of feelings of anxiety prior to competition. They therefore conclude that more comprehensive sleep interventions are needed, with a special focus on athletes. More specifically, Bonnar et al. suggest that such a program would ideally be organized by a trained sleep educator in a series of seminar-type classes (approximately 1 hour per week for 4 consecutive weeks), and would include contents such as educational material, motivational tasks, and cognitive and behavioral strategies. Prior research has shown that the seminar format can be successfully implemented at schools (Bonnar et al., 2015). Furthermore, including cognitive and behavioral components seems important, as previous studies revealed that cognitive-behavioral therapy (CBT) interventions are among the most efficient approaches to improve sleep, and particularly dysfunctional sleep-related cognitions (Edinger & Means, 2005; Manber et al., 2012; Schutte-Rodin, Broch, Buysse, Dorsey, & Sateia, 2008). Because such a program would focus on all athletes in a class (not only those with high burnout levels or insomnia symptoms), Bonnar et al. (2018) emphasize that the baseline and follow-up assessment should not only assesses the effectiveness of the delivered program, but also include screening for athletes with sleep complaints that need to be treated individually (e.g., generally high insomnia symptoms, high pre-competition anxiety, obstructive sleep apnea). With such an approach, an overload of the educational contents can be avoided, whereas it is still possible to identify athletes who need more intensive and professional care. Alternative approaches towards improving sleep among athletes might be adopting the “third wave of behavior therapies”, using mindfulness and acceptance-based interventions (Ong, Ulmer, & Manber, 2012). Finally, although previous research has shown that adolescents who respect sleep hygiene rules report higher sleep quality and lower sleepiness during the day (Kira, Maddison, Hull, Blunden, & Olds, 2014; Rigney et al., 2015; Wolfson, Harkins, Johnson, & Marco, 2015), sleep hygiene as a standalone treatment is not recommended to address behavioral sleep issues (Morgenthaler et al., 2006). Nevertheless, as shown by Harada et al. (2016), sleep hygiene practices might have an indirect positive effect on athletes' performance and recovery by encouraging earlier bedtimes, and thus lengthening sleep duration.

The strengths of our study were that we used a representative sample of young elite 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 and female athletes, athletes from different grades, with different educational levels, as well as athletes from various sports. Moreover, both subjective and objective sleep data was assessed, and clinically relevant cut-offs were used to classify students with high burnout and insomnia levels. Furthermore, longitudinal data was available to address issues associated with cause and effect.

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 Swiss Olympic partner schools. Because these classes aim at facilitating the combination of school and elite sport, it might be that stress levels are higher among young elite athletes not attending these classes. Thus, more research is needed to see if our findings can be replicated in wider populations of young elite athletes. Second, objective sleep data was only assessed for a smaller sample. Thus, our sample might have been under-powered to detect effects of 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 differed substantially in burnout symptoms, while we used a matching procedure to ensure that the two groups were similar with regard to gender, age, educational level and canton. Third, we acknowledge that (a) the SMBM was originally developed for adult workers, (b) 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 items were changed to make the instrument more suitable for an adolescent/student sample. Accordingly, we admit that the best suited cut-off of the SMBM for young people remains to be established in future research. Currently, however, this cut-off is the only empirically-derived cut-off available, and we preferred using such a cut-off to an arbitrarily set threshold. Fourth, we only considered the overall SMBM index in the present data analyses. However, this seemed justified because the categorization into "high" versus "low" burnout was based on the overall index. Furthermore, since the depleted energetic resources assessed by the SMBM can be subsumed under the umbrella of Hobfoll's Conservation of Resources (COR) theory (Hobfoll & Shirom, 2000), calculating an overall mean score is theoretically justified, which is not the case for other burnout measures such as the Maslach Burnout Inventory (MBI) (Shirom & Melamed, 2006). Fifth, there is still little known about the relationship between burnout and sleep among elite athletes. Thus, although we used the SMBM to assess 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 sleep parameters are found when the ABQ is used. The ABQ remains the most widely used instrument in athlete burnout research. Sixth, the wording of the items only allowed for the calculation of time spent in bed, and does not provide information about (self-perceived) sleep duration and sleep efficiency. Rather, time spent in bed could reflect a combination of sleep, rest and sexual activities. We therefore suggest that more precise items should be used in future studies to obtain a more accurate estimate of participants' self-reported sleep duration. However, it is important to note that sleep duration and sleep efficiency were measured 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 sleep quality was not explicitly assessed. According to Harvey, Stinson, Whitaker, Moskovitz and Virk (2008) insomnia symptoms and sleep quality are distinct constructs, although they may have some potential overlap. Eighth, because athletes from various sports took part in this study, it was not possible to ensure that data collection took place during the same phases of the athletes' seasonal training. Finally, we used a relatively simple one-channel EEG-device and only assessed data once, which entails the risk for possible first-night effects. Thus, for future studies it is recommended to include at least one night of habituation, to perform sleep EEG-recordings across several nights, and to include both weekday and weekend nights in the objective sleep assessment.

Conclusion

In the present study, between 12 and 14% of young elite athletes reported clinically relevant burnout symptoms, whereas 4 to 11% reported clinically relevant insomnia symptoms. Athletes with clinically relevant burnout were more likely to report insomnia symptoms. Moreover, baseline burnout symptoms predicted increased insomnia symptoms over time. Cognitive-behavioral interventions for dysfunctional sleep-related cognitions might be a promising measure to reduce subjective sleep complaints.

Declaration of interest

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

Figure legends

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

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

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Table 1. Description of study population

	Baseline (N=257; all participants)		Baseline (N=50; participants involved in sleep-EEG assessment)	
Metric variables	*M*	*SD*	*M*	*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
Categorical variables	*n*	%	*n*	%
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

	Below cut-off (n=226)		Above cut-off (n=31)				
All participants	*M*	*SD*	*M*	*SD*	*F*	*p*	η^2
Insomnia	8.1	4.5	11.2	5.1	12.8	.000[a]	.048
Rumination	2.8	0.9	3.6	0.8	22.7	.000[b]	.082
Focussing	2.5	0.8	3.1	0.8	17.9	.000[c]	.066
Times spent in bed: weekdays (h/night)	7.4	0.8	7.1	0.6	5.2	.024[d]	.020
Time spent in bed: weekend (h/night)	9.3	1.2	9.6	1.4	1.8	.183[e]	.007
SOL: weekdays (min)	17.9	15.3	25.8	25.7	6.0	.015[f]	.023
SOL: weekend (min)	16.3	15.2	23.1	24.0	4.38	.037[g]	.018

	Below cut-off (n=26)		Above cut-off (n=24)				
Participants involved in sleep-EEG assessment	*M*	*SD*	*M*	*SD*	*F*	*p*	η^2
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*	η^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: [a-d]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). [e]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). [f-g]Levene's test of homogeneity of variances is significant (p < .05). No group differenced found (p > .05) if using robust tests of equality of means (Welch- and Brown-Forsythe-tests).

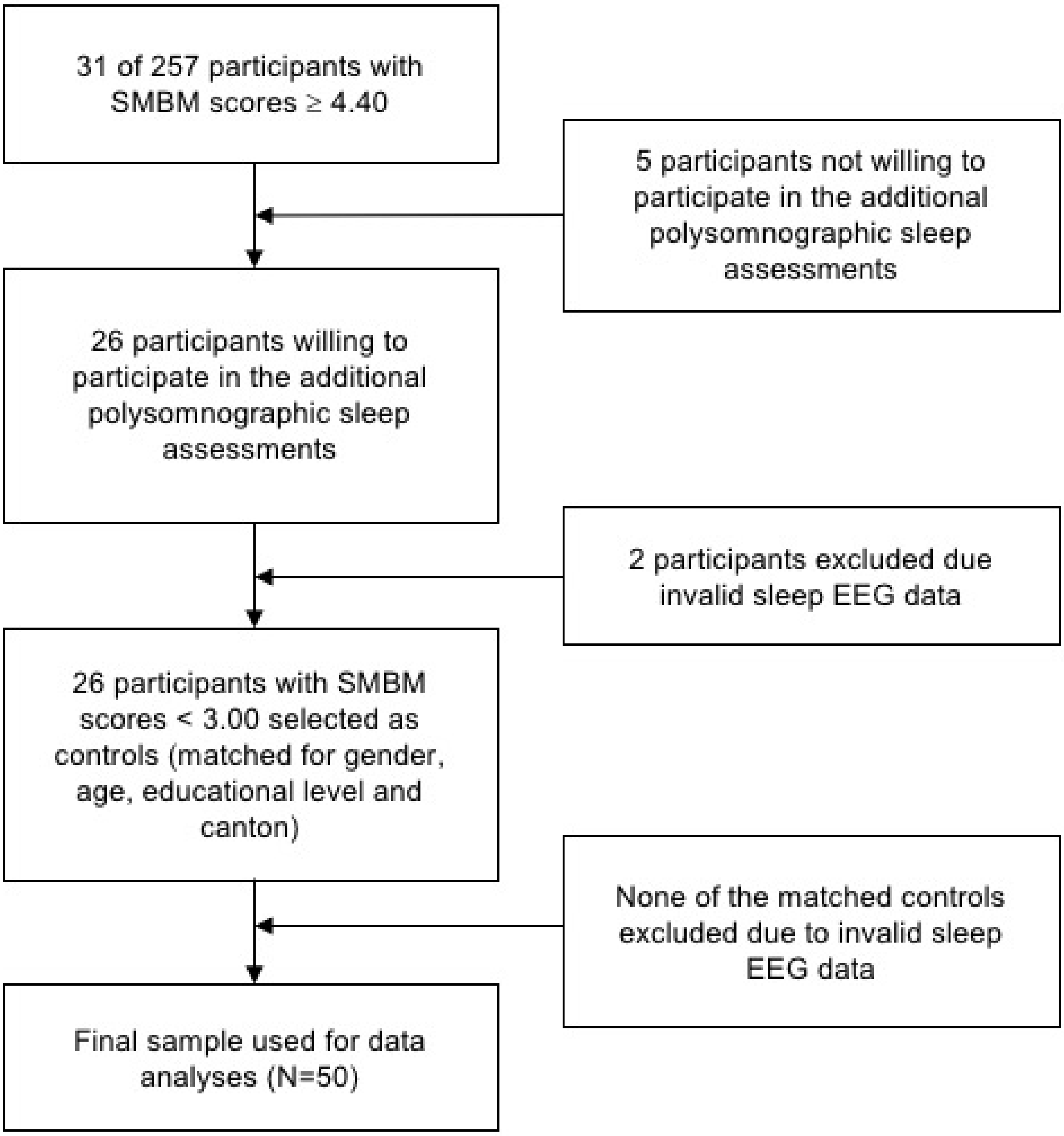
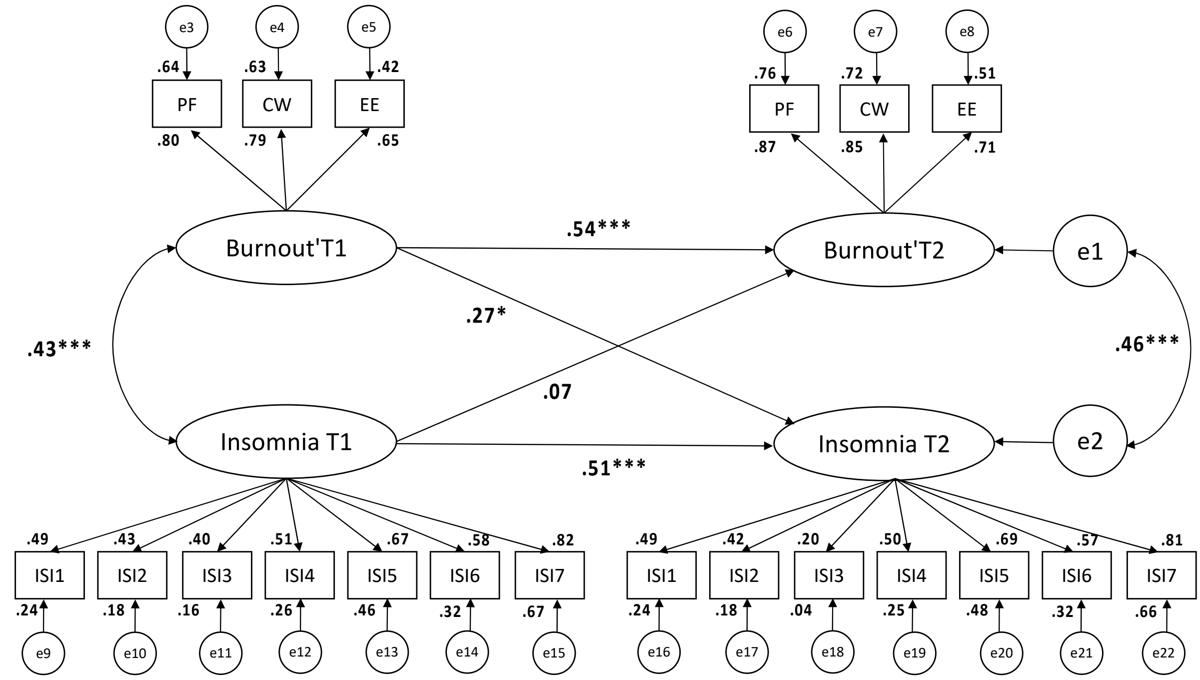


Figure 1. Filtering of participants in the high and low burnout groups for the additional EEG monitoring



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