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RESEARCH ARTICLE

Is unemployment associated with inefficient sleep habits? A cohort study using objective sleep measurements

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Summary

Unemployed people could be at risk of developing inefficient sleep habits by spending excessive time in bed, as they lack a structuring activity. This could impact their mental health and reintegration into labour. This study aims to analyse possible associations between employment status and sleep parameters using actigraphy. Subjects (148 employed and 50 unemployed) were drawn from a German population-based cohort. Sleep parameters were measured with the SenseWear Bodymedia Pro 3 armband. Comparison of means concerning sleep duration, sleep efficiency, time of sleep and sleep fragmentation was performed separately for week days and weekends. Multiple linear regression analysis was performed to analyse group differences controlling for covariates. Finally, we defined cut-off scores for each sleep variable, and analysed the distribution of subjects above and below these values. Unemployed people did not sleep significantly longer than employed people. However, on week days, they displayed night sleep efficiency reduced by on average > 5% points, they lay down for 28 min longer, had later mid sleep time (38 min) and sleep offset (55 min), as well as more frequent awakenings after sleep onset accounting for being awake 28 min longer (all $p \le 0.005$). Sleep in unemployed subjects compared with employed subjects aged 41–64 years was less efficient, more fragmented and shifted to a later point of the night. Results support prior findings that unemployment has a negative influence on sleep quality. Unemployed individuals could benefit from intervention programmes aiming at the adoption of healthier sleep habits.

KEYWORDS
actigraphy, diurnal sleep, German cohort, health behaviour, LIFE Health Adult

1 | INTRODUCTION

In the general population, disadvantaged socio-economic characteristics such as unemployment and low educational level have been shown to be associated with sleep problems (Grandner et al., 2010; Maeda et al., 2019; Patel et al., 2015; Schlack, Hapke, Maske, Busch, & Cohrs, 2013; Wu et al., 2018). So far, little research has been carried out concerning the sleep structure of unemployed people. Due to the lack of a daily routine, this population could be at risk of developing disturbed sleep habits such as spending excessive time in bed or napping during the day, and thus losing a regular day–night rhythm. It is reasonable to assume that a loss of daily structure is unfavourable for the wellbeing of the unemployed (Krueger & Mueller, 2012), which in turn could negatively affect efforts for reintegration into the labour market. Unemployed people could thus be at risk of entering a vicious circle in which unemployment and unhealthy behaviours maintain and reinforce each other (Hollederer & Voigtländer, 2016; Virtanen, Janlert, & Hammarström, 2013).

Associations between unemployment and poor sleep have been found in a population-based study in rural China (Wu et al., 2018). According to a Japanese population survey, unemployed people showed a significantly elevated risk of insomnia-related symptoms, especially those without mental disorders (Maeda et al., 2019). In US samples, unemployment was found to be associated with more sleep complaints (Grandner et al., 2010) and longer sleep duration (Basner, Spaeth, & Dinges, 2014). Unemployment, low household income and low education level were predictors of long sleep duration in a Hispanic population (Patel et al., 2015). Later bedtimes, later times of waking up and longer sleep duration were also found post-retirement (Hagen, Barnet, Hale, & Peppard, 2016).

The aforementioned studies used subjective measurements of sleep quality (e.g. telephone surveys, self-rating scales), which are likely to be biased. To our knowledge, there are no studies looking into the association between unemployment and sleep habits using objective assessment of sleep. Comparison studies have shown differences between subjective (self-reported) and objective measurements (actigraphy) of sleep parameters, with total sleep time frequently being overreported (Cespedes et al., 2016; Lauderdale, Knutson, Yan, Liu, & Rathouz, 2008; Van den Berg et al., 2008), and correlations concerning sleep-onset latency (SOL) and wake after sleep onset (WASO) being moderate to low (Kreutz, Müller, Schmidt, & Steindorf, 2021; Kölling, Endler, Ferrauti, Meyer, & Kellmann, 2016; Lockley, Skene, & Arendt, 1999). Actigraphy has been reported to be a valid and reliable tool to measure sleep parameters in different target groups, comparable to the gold standard of polysomnography (de Zambotti, Baker, & Colrain, 2015; Roane, Van Reen, Hart, Wing, & Carskadon, 2015; Sharif & Bahamman, 2013), with excellent validity for total sleep time and good validity for sleep efficiency and WASO (Alsaadi et al., 2014).

This study aimed to analyse possible associations between employment status and sleep parameters using actigraphy in a German population sample. Our research question was whether unemployed people exhibit different sleep habits, for example by sleeping longer or less efficiently, than employed subjects. We used an explorative approach as the current literature is mostly based on subjective sleep assessments, which commonly differ from objective measurements, as explained above. We also aimed to investigate whether differences between the two groups are influenced by the type of day (working week or weekend day), as they are likely linked to the presence or absence of paid work, for which reason sleep parameters are likely less impacted on weekend nights.

2 | METHODS

2.1 | Ethics statement

Subjects were drawn from the large-scale research project “LIFE” (Leipzig Research Centre for Civilization Diseases; Loeffler et al., 2015), which is a population-based cohort of 10,000 adults (age range 40–79 years) randomly recruited in Leipzig (district), Germany. The objectives of LIFE are to assess the prevalence and incidence of common disease risk factors, early subclinical disease phenotypes and manifest clinical disorders as well as to investigate the complex associations between these and their dependence on lifestyles and genetic predisposition. The participants of LIFE underwent a core assessment with extensive phenotyping assessments including medical history taking and sociodemographic interviews. A subgroup of the subjects participated in a one-week actigraphic assessment, which will be described in detail in the section “Actigraphy”.

All subjects gave written informed consent to participate in the LIFE study. The procedures were conducted according to the Declaration of Helsinki and approved by the ethics committee of the University of Leipzig (registration-number: 263–2009–14122009).

2.2 | Subjects

The sample for our study was drawn from the LIFE database based on different criteria. From all LIFE-participants, a subset of 3,267 datasets, for which the information needed (especially actigraphy assessment) was available, was defined. From this subset, participants were included if they were between 41 and 64 years old (working age population) and if their actigraphic data were considered usable after a first check. To make sure our sample of the unemployment condition truly consisted of unemployed people who could be employed, further exclusion criteria were: being in training, a housewife or househusband, a civilian servant, on maternity leave, in early retirement or in minor employment (less than 15 hr per week). This led to a sample of 1,558 datasets, which were then subject to further exclusion criteria. These included having been diagnosed with a major neurological condition (Parkinson's disease, multiple sclerosis, stroke and epilepsy), coronary insufficiency, depression (CES-D score ≥ 16 points), having suffered from a myocardial infarction, currently undergoing cancer treatment and/or currently taking psychotropic medication strongly affecting sleep (benzodiazepines, hypnotics, anxiolytics, certain antidepressants), as these physical and mental disorders can have a severe influence on sleep behaviour. After this step, our sample consisted of 1,235 datasets. The next step was to exclude subjects whose sleep had deviated from their usual habits or who had been working in shifts. Deviation from usual habits was identified through the answers of subjects to three questions asking whether their sleep pattern during actigraphic assessment had differed from their usual sleep habits concerning time, duration and quality of sleep. Of the remaining 907 datasets, we only included those for which at least 4 week days (night–day cycles) and at least 1 weekend day were available (for details on the actigraphy evaluation, see below). Using these criteria, we identified 577 suitable datasets for our study, of which 527 belonged to employed participants working at least 15 hr per week, and 50 belonged to unemployed participants, not working at all.

To improve group comparability regarding certain covariates likely to influence sleep, we performed nearest-neighbour matching using R-based SPSS extension bundle psmatching 3.04 (Thoemmes, 2012). Propensity scores were calculated from a generalised additive model with loosened assumptions. The propensity of each subject being classified as unemployed was calculated based on a logistic regression model with the following covariates: age (years), gender (m/f), educational level (no degree, vocational degree, applied degree, university degree) and family status (married, divorced/separated, widowed, single). Age has an influence on sleep, as older healthy adults have a more superficial, less consolidated sleep, go to bed earlier compared with younger ages (Münch, 2014) and have lesser sleep efficiency (Luca et al., 2015) and quality, with delayed sleep onset, more fragmented sleep and early awakenings (Foley et al., 1995). Gender, educational level and family status had been selected as covariates, as male gender, higher educational level and never having been married have been associated with shorter (self-assessed) sleep duration (Antillón, Lauderdale, & Mullahy, 2014). Additionally, alcohol consumption was used as a covariate due to its often-demonstrated effects on sleep quality and duration (Ebrahim, Shapiro, Williams, & Fenwick, 2013), as well as the season of the year during which sleep had been assessed, as sleep duration has been shown to be generally longer in autumn/winter (Allebrandt et al., 2014; Lehnkering & Siegmund, 2007).

Participants with and without employment were matched on the propensity scores with an Unemployed versus Employed ratio of 1:3. Matching was done without replacement. Exact matching was carried out for gender. Using this method, we identified a sample of n = 150 Employed and n = 50 Unemployed. Two subjects had to be excluded from the employment group a posteriori: one subject because actigraphy data suggested that night shifts had been worked; and another subject because sleep classification at the weekend seemed impacted by off-body periods overlapping with bedtimes stated in the sleep diary. However, also after exclusion of those individuals, employed and unemployed participants were comparable concerning all covariates and the number of days of actigraphy (Table 1).

2.3 | Actigraphy

Sleep parameters were measured objectively with the SenseWear Bodymedia Pro 3 armband (BodyMedia). This device, attached to subjects' upper arm, records data on 2-axis acceleration, heat flux, skin temperature and galvanic skin response. Data can be exported with a temporal resolution of 1 min. An algorithm based on these sensory parameters makes it possible to identify periods of sleep or rest (lying down without sleeping). An off-body detection makes it possible to identify removal of the actigraph. The SenseWear armband accurately detects sleep time, sleep efficiency and WASO, as shown in several validation studies with different target groups (Alsaadi et al., 2014; O'Driscoll, Turton, Copland, Strauss, & Hamilton, 2013; Sharif & BaHamman, 2013; Shin, Swan, & Chow, 2015) in which the armband's results were comparable to those of polysomnography (Sharif & BaHammam, 2013).

Actigraphic raw data were processed separately for each subject. Subjects kept a sleep diary in parallel. This served as a basis to tag night sleep intervals (NSIs) and daytime intervals (DTIs) in the actigraphic data, making it possible to distinguish night sleep from daytime activity. A night–day cycle was defined as the period between two starting points of a sleep interval (e.g. the period when the subjects went to bed on Wednesday night until they went to bed on Thursday night). Only night–day cycles with a total wearing time of at least 20 hr and without recording gaps in the NSI were utilised for the subsequent analyses. Datasets not containing at least 4 night–day cycles during the week (i.e. starting on a Sunday, Monday, Tuesday, Wednesday or Thursday night) and at least 1 night–day cycle on the weekend (starting on a Friday or Saturday night) were excluded from subsequent analyses. The final datasets contained on average 6.27 analysable night–day cycles per person (standard deviation [SD]: 0.59; range: 5–7 night–day cycles).

Night sleep parameters were recorded during NSIs and comprised the following.

- Rest duration (RD; time lying down, sleeping or not, as classified by the actigraph during the night).
- Total sleep duration (SD; night-time sleep duration from sleep onset to sleep offset, regardless of wake times during the night).
- Sleep efficiency (SE = SD/RD; in %).
- Mid-sleep time (MST; average between sleep onset and offset at night).
- Sleep offset (SOff; end of time classified as sleep).
- SOL (time period between start of NSI and sleep onset).
- Number of awakenings after sleep onset (NWAKE; amount of awakenings lasting at least 5 min between sleep onset and sleep offset).
- WASO (sum of minutes classified as wake between sleep onset and sleep offset).

TABLE 1 Descriptive statistics of the sample groups

	Overall	Employment status: Employed (N = 148)	Employment status: Unemployed (N = 50)	p
Gender				
Males	57.6%	57.4%	58.0%	0.944[c]
Females	42.4%	42.6%	42.0%	
Age (years)	56.4 (± 5.0)	56.4 (± 4.6)	55.6 (± 6.0)	0.830[a]
Education				
No degree	0.5%	0.7%	0.0%	0.408[d]
Vocational	68.7%	68.2%	70.0%	
Applied	11.1%	9.5%	16.0%	
University	19.7%	21.6%	14.0%	
Family status				
Married	61.1%	63.5%	54.0%	0.374[d]
Divorced/separated	19.2%	18.9%	20.0%	
Widowed	14.1%	13.5%	16.0%	
Single	5.6%	4.1%	10.0%	
Alcohol (g day^{-1})	14.2 (± 16.9)	14.2 (± 17.4)	13.9 (± 15.3)	0.906[b]
Season				
Winter	31.3%	31.8%	30.0%	0.895[c]
Spring	28.3%	29.1%	26.0%	
Summer	16.7%	15.5%	20.0%	
Autumn	23.7%	23.6%	24.0%	
Days of actigraphy	6.73 (± 0.28)	6.73 (± 0.28)	6.72 (± 0.27)	0.811[b]

For age, alcohol and days of actigraphy, means and standard deviations are displayed. For the other variables, distributions are displayed. *p*-values stemming from different tests are displayed for each variable: [a]*t*-test for independent sample comparison; [b]Mann–Whitney *U*-test; [c]Chi-square test; [d]Fisher's exact test.

Additionally to night sleep parameters, we computed sleep parameters for the entire day, which took into account time lying down and/or napping during the day. These parameters are the following.

- Total sleep duration in the night–day cycle.
- Total rest duration (= time lying down) in the night–day cycle.

All parameters were calculated separately for each day of the week. Then the average of each parameter was calculated for the total period of actigraphy.

2.4 | Statistical analysis

First, we compared Employed and Unemployed subjects regarding the different sleep parameters, without considering the covariates *age*, *gender*, *educational level* or *family status*. T-tests were used for independent sample comparisons, Welch-tests in case of unequal variances and Mann–Whitney *U*-tests in case of non-normal distribution of the dependent variable. MANOVAs were used to identify a possible moderating effect of the kind of day (week days versus weekends), with *employment status* being the independent variable.

After that, multiple linear regression analysis was performed to verify whether differences between Employed and Unemployed regarding sleep parameters would persist even when controlling for covariates. This way, *employment status*, *age*, *gender* and *educational level* could be analysed as possible predictors for different sleep habits. *Family status* was excluded as a predictor because of significant associations with *age* ($p < 0.001$) and *gender* ($p < 0.001$). *Alcohol consumption* and *season* were excluded due to significant associations with *gender* (Mann–Whitney *U*-test $p < 0.001$ resp. Chi-square test $p = 0.036$). Because there was only one subject belonging to the category of *educational level* “no degree”, this category was merged with the category “vocational degree”.

In an exploratory analysis, we defined cut-off scores for the classification of high or low values regarding *sleep duration*, *sleep efficiency*, *number of awakenings after sleep onset* and other sleep parameters (Table 4). Although diagnostic criteria exist for various sleep disorders, there are hardly any generally accepted definitions of what should be considered healthy sleep (Watson et al., 2015). Therefore, we used clinically relevant gradations that still allowed a meaningful subdivision of the overall sample (e.g. a sleep onset within 15 min is considered inconspicuous by both patients and physicians, and only about 15% of our sample had SOLs above this value). The proportion of subjects of each of the two groups (employed versus unemployed individuals) having values below or above these cut-off scores was computed. Chi-square tests were used to check whether group differences in the distribution of high and low values were statistically significant.

All statistical tests were two-sided ($\alpha = 0.05$). All statistical analyses were conducted using SPSS statistical software (version 20.0; SPSS) for Windows.

3 | RESULTS

3.1 | Sample characteristics

Descriptive statistics for the sample as well as for the two groups Employed and Unemployed are displayed in Table 1. The two groups are equal regarding the distribution of gender, and comparable regarding *educational level*, *family status*, *alcohol consumption* and *season of the year*. There was no significant association between the variable *employment status* and the different covariables.

3.2 | Group comparisons – main effect of the employment status on sleep parameters

Table 2 provides the mean and SD of each selected parameter for Unemployed and Employed subjects, as well as the *p*-values stemming from *t*-tests, Welch-tests and Mann–Whitney *U*-tests, respectively. The comparison of mean values of the two groups shows only a significant difference in *sleep duration* (SD) between Employed and Unemployed subjects when considering sleep of the whole night–day cycle on week days. When considering week days only, group comparison showed that Unemployment compared with Employment was associated with *lying down* (RD) 59 min more during a night–day cycle and 29 min more during the NSI only (total period: 8 hr 34 min versus 7 hr 35 min; $p < 0.001$; NSI: 7 hr 43 min versus 7 hr 14 min; $p = 0.004$), SE reduced by 5.7 percentage points (76.5 versus 82.2; $p = 0.002$), 38 min later MST (03:15 hours versus 02:37 hours; $p < 0.001$), waking up 55 min later in the morning (SOff; 07:04 hours versus 06:09 hours; $p < 0.001$), 3 min longer SOL (13 min versus 10 min; $p = 0.035$), more frequent NWAKE (3.47 times versus 2.52 times; $p = 0.001$) accumulating to 28 min more WASO (1 hr 26 min versus 58 min; $p < 0.001$; Table 2). These differences are not present on weekends.

3.3 | Linear regression model – employment status as a predictor for sleep parameters

Table 3 provides R^2, regression coefficients and *p*-values for the multiple linear regression model including *employment status*, *age*, *gender* and *educational level* as covariates.

The multiple linear regression model confirms the findings for group comparisons (except for SOL) when controlling for *age*, *gender* and *employment status*: on week days but not on weekends Unemployment is a significant predictor for longer RD ($p = 0.002$), lower SE ($p < 0.001$), later MST ($p < 0.001$), later SOff ($p < 0.001$), more frequent NWAKE ($p < 0.001$) and longer WASO ($p < 0.001$) during the night, as well as longer RD ($p < 0.001$) and longer SD ($p = 0.020$) concerning the whole night–day cycle.

3.4 | MANOVA – interaction effects of employment status and type of day

Because, for most parameters, differences between Employed and Unemployed subjects appeared during the week but not on the weekend, a MANOVA was used to verify whether the type of day (week versus weekend) had a significant moderating effect. This was not the case for SOL: no differences between week and weekend nights had been found for this parameter. However, there were significant interaction effects between employment status and the type of day for RD ($p < 0.001$) and SD ($p = 0.020$) during the NSI, SE ($p < 0.001$), MST ($p = 0.025$), SOff ($p < 0.001$), NWAKE ($p < 0.001$) and WASO ($p < 0.001$), as well as for RD ($p < 0.001$) and SD ($p = 0.006$) during the total night–day cycle. For all these parameters except night sleep duration, the differences between Employed and Unemployed were significantly smaller on weekends than during the week. The effect of the type of day was different for night SD: here, Employed and Unemployed subjects showed no differences during the week, but Employed subjects slept longer on the weekend than Unemployed. Figures 1–4 depict the differences between Employed and Unemployed according to type of day with respect to night SD (Figure 1), SE (Figure 2), NWAKE (Figure 3) and MST (Figure 4).

3.5 | Distribution of subjects above or below defined cut-off scores for sleep parameters

Because the comparison of means does not give an impression of abnormal sleep patterns possibly occurring in individual subjects, we defined cut-off scores for every sleep parameter and explored the proportions of subjects presenting values above or below these values. We used Chi-square tests to determine whether distributions differ significantly between the two groups. Table 4 gives an overview of the cut-off scores for each parameter as well as the corresponding proportion of subjects in each of the two groups having values below or above these scores.

Concerning RD in the NSI, the percentage of individuals with low values (less than 7 hr) was significantly higher in the group of Employed subjects compared with Unemployed subjects on week days (40.5% versus 24.0%), whereas the inverse was the case on weekends (16.2% versus 30.0%). When considering the complete night–day cycle, the differences are only significant on week days, with a larger proportion of Unemployed subjects lying down for

TABLE 2 Comparison of means for sleep parameters between the two groups

	Total days					Week days					Weekend days				
	Employed		Unemployed			Employed		Unemployed			Employed		Unemployed		
	Mean	SD	Mean	SD	*p*	Mean	SD	Mean	SD	*p*	Mean	SD	Mean	SD	*p*
RD (NSI) (hr:min)	7:29	0:52	7:45	0:57	0.073[a]	7:14	0:59	7:43	1:03	**0.004**[a]	8:06	1:07	7:48	1:04	0.105[a]
SD (NSI) (hr:min)	6:15	0:54	6:11	1:08	0.679[c]	6:04	0:56	6:06	1:08	0.798[a]	6:44	1:15	6:22	1:20	0.085[a]
SE (%)	82.0	9.3	77.4	11.1	**0.010**[c]	82.2	9.5	76.5	11.3	**0.002**[c]	81.4	10.7	79.7	11.8	0.355[a]
MST (hr:min)	2:55	0:54	3:27	1:01	**0.001**[a]	2:37	1:00	3:15	1:05	**< 0.001**[a]	3:40	0:58	3:57	1:08	0.089[a]
SOff (hr:min)	6:34	1:03	7:16	1:09	**< 0.001**[a]	6:09	1:12	7:04	1:14	**< 0.001**[a]	7:37	1:08	7:44	1:13	0.519[a]
SOL (hr:min)	0:09	0:08	0:13	0:11	**0.033**[b]	0:10	0:11	0:13	0:13	**0.035**[b]	0:09	0:07	0:13	0:13	0.170[b]
NWAKE (*n*)	2.65	1.40	3.34	1.60	**0.010**[b]	2.52	1.44	3.47	1.79	**0.001**[b]	2.97	1.71	3.02	1.54	0.646[b]
WASO (hr:min)	1:01	0:39	1:21	0:45	**0.004**[b]	0:58	0:40	1:26	0:49	**< 0.001**[b]	1:09	0:46	1:11	0:45	0.668[b]
Total RD (NSI + DTI) (hr:min)	7:54	0:59	8:37	1:24	**0.002**[c]	7:35	1:07	8:34	1:31	**< 0.001**[c]	8:39	1:21	8:42	1:26	0.667 [a]
Total SD (NSI + DTI) (hr:min)	6:30	0:55	6:44	1:17	0.223[c]	6:15	0:57	6:40	1:19	**0.048**[c]	7:04	1:19	6:55	1:24	0.502[a]

p-values are stemming from [a]*t*-test for independent sample comparison; [b]Mann–Whitney *U*-test; [c]Welch-Test, respectively. *p*-values are bold where they are less than the significance level cut-off of 0.05.

DTI, daytime interval; MST, mid-sleep time (average between sleep onset and offset during night sleep interval); NSI, night sleep interval; NWAKE, number of wake after sleep onset (number of awakenings lasting at least 5 min after sleep onset between sleep onset and sleep offset); RD, rest duration (time lying down during NSI); SD, sleep duration (between sleep onset and offset, regardless of awakenings); SE, sleep efficiency (= SD/RD); SOff, sleep offset (end of time classified as sleep during NSI); SOL, sleep-onset latency (time period between start of NSI and sleep onset); WASO, sum of minutes classified as awake between sleep onset and sleep offset.

TABLE 3 Linear regression model: predictors of sleep parameters

Variable	R^2	Regression coefficient β (*p*-value) Empl. status (ref.: Employed)	Age	Gender (ref.: male)	Applied degree (ref.: no applied degree)	University degree (ref.: lower educational level)
Total days						
RD	0.057	1,011.031 (0.057)	**−101.323 (0.029)**	706.050 (0.130)	−441.955 (0.551)	42.963 (0.942)
SD	0.031	−244.425 (0.672)	−17.736 (0.724)	**1,190.447 (0.020)**	−24.755 (0.976)	126.821 (0.843)
SE	0.065	**−4.728 (0.004)**	0.225 (0.109)	1.912 (0.178)	1.808 (0.423)	0.847 (0.475)
MST	0.094	**2,049.550 (< 0.001)**	−9.978 (0.835)	510.982 (0.294)	−115.580 (0.881)	**1,442.964 (0.020)**
SOff	0.139	**2,670.485 (< 0.001)**	−69.342 (0.207)	**1,138.910 (0.041)**	−263.843 (0.765)	**1,825.035 (0.010)**
SOL	0.035	**221.790 (0.020)**	**−19.160 (0.021)**	−64.839 (0.439)	−94.837 (0.477)	−28.479 (0.787)
NWAKE	0.062	**0.709 (0.004)**	−0.034 (0.109)	−0.122 (0.563)	−0.265 (0.433)	−0.124 (0.643)
WASO	0.065	**1,261.829 (0.002)**	−46.947 (0.186)	−344.523 (0.337)	−338.802 (0.553)	−98.097 (0.828)
Total RD	0.103	**2,580.633 (< 0.001)**	**−141.757 (0.014)**	−149.496 (0.796)	−735.300 (0.424)	−539.334 (0.459)
Total SD	0.023	874.942 (0.153)	−47.388 (0.373)	625.181 (0.246)	−166.715 (0.846)	−311.713 (0.646)
Week days						
RD	0.071	**1,832.777 (0.002)**	−90.389 (0.080)	698.178 (0.182)	−790.526 (0.342)	229.355 (0.727)
SD	0.028	193.928 (0.743)	−12.364 (0.810)	**1,158.829 (0.027)**	−131.998 (0.874)	327.593 (0.618)
SE	0.078	**−5.853 (< 0.001)**	0.216 (0.133)	1.728 (0.234)	2.346 (0.310)	0.795 (0.664)
MST	0.104	**2,397.960 (< 0.001)**	0.458 (0.993)	660.853 (0.217)	−213.788 (0.801)	**1,604.621 (0.018)**
SOff	0.171	**3,499.062 (< 0.001)**	−66.767 (0.278)	**1,377.684 (0.028)**	−523.053 (0.598)	**2,252.134 (0.005)**
SOL	0.019	211.992 (0.075)	−18.173 (0.079)	−40.854 (0.696)	−105.879 (0.524)	−40.702 (0.757)
NWAKE	0.095	**0.976 (< 0.001)**	−0.040 (0.068)	−0.185 (0.407)	−0.390 (0.271)	−0.096 (0.731)
WASO	0.095	**1,695.273 (< 0.001)**	−46.092 (0.211)	−311.257 (0.404)	−551.335 (0.353)	−68.707 (0.884)
Total RD	0.117	**3,580.164 (< 0.001)**	−105.953 (0.100)	−26.759 (0.967)	−1,011.302 (0.329)	−365.189 (0.656)
Total SD	0.034	**,1476.757 (0.020)**	−26.614 (0.629)	−654.116 (0.242)	−202.766 (0.819)	−253.387 (0.719)
Weekend days						
RD	0.056	−1,093.885 (0.096)	**−141.341 (0.014)**	638.034 (0.269)	380.348 (0.679)	−453.382 (0.533)
SD	0.038	−1,338.484 (0.079)	−38.868 (0.557)	1,241.530 (0.065)	288.971 (0.786)	−368.375 (0.663)
SE	0.034	−1.677 (0.352)	0.261 (0.097)	2.584 (0.105)	0.874 (0.729)	1.108 (0.580)
MST	0.033	1,114.065 (0.067)	−44.230 (0.402)	104.807 (0.844)	82.696 (0.922)	1,094.169 (0.105)
SOff	0.023	503.566 (0.464)	−90.732 (0.130)	460.248 (0.447)	296.168 (0.759)	787.866 (0.303)
SOL	0.064	**232.512 (0.010)**	**−21.591 (0.006)**	−135.011 (0.087)	−89.364 (0.476)	−0.013 (1.000)
NWAKE	0.006	0.034 (0.903)	−0.018 (0.449)	0.020 (0.936)	0.025 (0.948)	−0.203 (0.511)
WASO	0.022	113.689 (0.806)	−54.920 (0.173)	−500.093 (0.220)	64.263 (0.921)	−228.895 (0.656)
Total RD	0.056	166.473 (0.836)	**−240.199 (0.001)**	−549.998 (0.439)	−61.742 (0.956)	−993.634 (0.268)
Total SD	0.016	−526.992 (0.512)	−96.084 (0.171)	−503.819 (0.477)	38.834 (0.973)	−593.098 (0.507)

The differences between the two groups as identified through *t*-tests, Welch-tests and Mann–Whitney *U*-tests stay significant when taking into account the covariates age, gender and educational level, except for the parameter SOL on week days. Values are bold where the *p*-value is less than the significance level cut-off of 0.05.

MST, average between sleep onset and offset; NWAKE, number of awakenings lasting at least 5 min after sleep onset between sleep onset and sleep offset; RD, rest duration (time lying down during NSI); SD, sleep duration (between sleep onset and offset, regardless of awakenings); SE, sleep efficiency, SD/RD; SOff, sleep offset (end of time classified as sleep during NSI); SOL, sleep-onset latency (time period between start of NSI and sleep onset); WASO, sum of minutes classified as wake between sleep onset and sleep offset.

more than 9 hr (week days: 32.0% versus 12.2%) and a larger proportion of Employed subjects lying down for less than 7 hr (29.1% versus 8.0%). No significant differences were observed on weekends.

Concerning SD, significant group differences were only present when considering the complete night–day cycle on week days: long SD (> 8 hr) was more frequent in Unemployed subjects than in Employed subjects (12.0% versus 0.7%), while short SD (< 6 hr) was

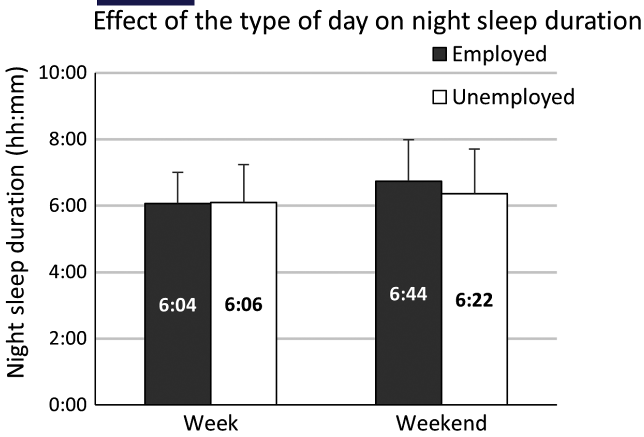

FIGURE 1 The difference between employed subjects and unemployed subjects in average night sleep duration was stronger on the weekend ($p = 0.085$) as on week days ($p = 0.798$). The type of day of the week has a modulating effect ($p = 0.020$). The antennae represent standard deviations

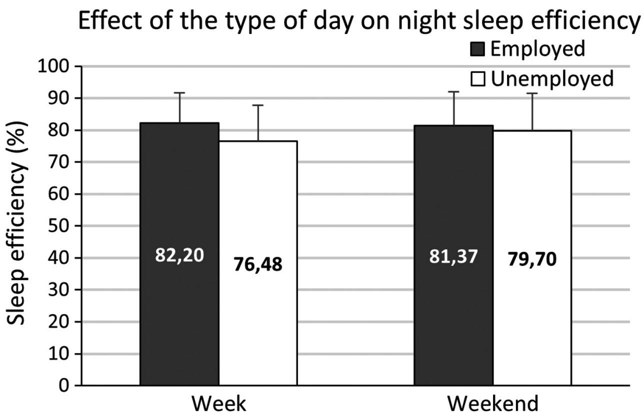

FIGURE 2 The difference between employed subjects and unemployed subjects in sleep efficiency (SE) was significant during the week ($p = 0.002$) but not on the weekend ($p = 0.355$). The type of day of the week has a modulating effect ($p < 0.001$). The antennae represent standard deviations

more frequent in the sample of Employed subjects (39.2% versus 24.0%).

Low SE (< 80%) was significantly more prevalent in Unemployed subjects than in Employed ones on week days (52.0% versus 28.9%) but not on weekends. Late MST (after 03:30 hours) was significantly more frequent in Unemployed subjects on week days (32.0% versus 13.5%), but only on trend level on weekends (70.0% versus 54.7%). Similarly, significant group differences regarding NWAKE and WASO were only present on week days: high NWAKE (> 5) were significantly more frequent in Unemployed subjects than in Employed ones (24.0% versus 8.1%), and a long time classified as WASO (> 60 min) was significantly more frequent in Unemployed subjects than in Employed individuals (64.0% versus 35.8%).

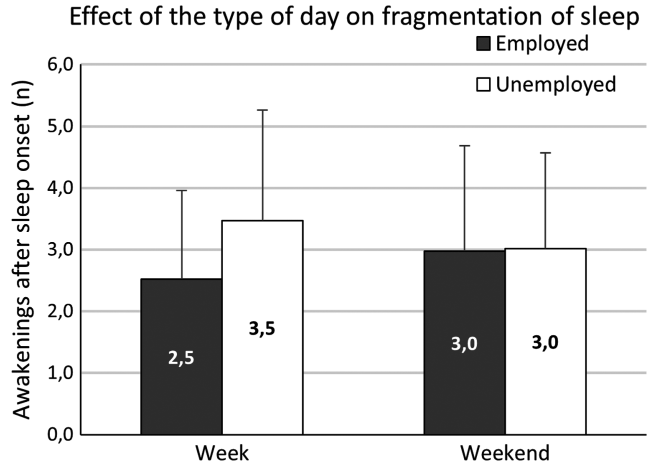

FIGURE 3 The difference between employed subjects and unemployed subjects in average number of awakenings after sleep onset (NWAKE) was significant during the week ($p = 0.001$) but not on the weekend ($p = 0.646$). The type of day of the week has a modulating effect ($p < 0.001$). The antennae represent standard deviations

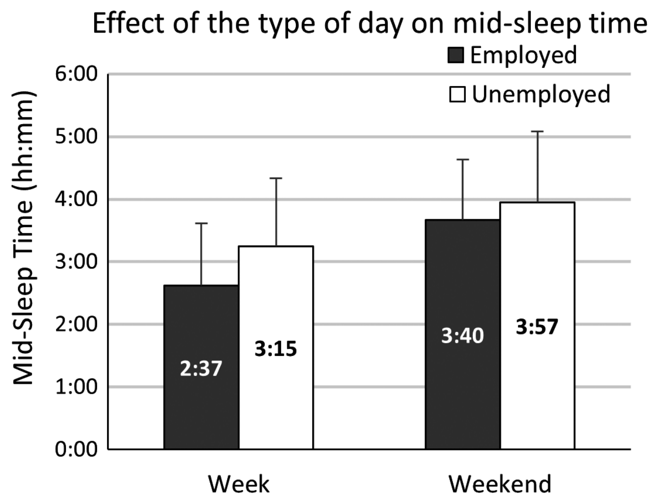

FIGURE 4 The difference between employed subjects and unemployed subjects in average mid-sleep time (MST) was significant during the week ($p < 0.001$) but not on the weekend ($p = 0.089$). The type of day of the week has a modulating effect ($p = 0.025$). The antennae represent standard deviations

4 | DISCUSSION

The aim of this study was to explore whether objectively measured sleep differs between employed and unemployed people, and whether possible differences persist on weekend nights. Group comparisons did not reveal significantly prolonged sleep in unemployed subjects as shown by previous questionnaire-based research (Basner et al., 2014; Patel et al., 2015). However, it can be discussed whether such questionnaires assess time-in-bed rather than actual

TABLE 4 Distribution of subjects having values below or above cut-off scores in sleep parameters

	Employed (N = 148)			Unemployed (N = 50)			X^2-test
RD (NSI)	**< 7 hr**	**7–9 hr**	**> 9 hr**	**< 7 hr**	**7–9 hr**	**> 9 hr**	***p***
Week	40.5%	56.1%	3.4%	24.0%	62.0%	14.0%	**0.007**
WE	16.2%	64.9%	18.9%	30.0%	64.0&	6.0%	**0.022**
SD (NSI)	**< 6 hr**	**6–8 hr**	**> 8 hr**	**< 6 hr**	**6–8 hr**	**> 8 hr**	***p***
Week	46.6%	53.4%	0.0%	40.0%	58.0%	2.0%	0.176
WE	20.9%	68.2%	10.8%	38.0%	54.0%	8.0%	0.056
SE	**< 80%**	**80%–90%**	**> 90%**	**< 80%**	**80%–90%**	**> 90%**	***p***
Week	28.9%	50.0%	21.1%	52.0%	36.0%	12.0%	**0.012**
WE	31.4%	47.9%	20.7%	37.8%	35.6%	26.7%	0.348
SOL	**< 5 min**	**5–15 min**	**> 15 min**	**< 5 min**	**5–15 min**	**> 15 min**	***p***
Week	27.7%	56.8%	15.5%	16.0%	56.0%	28.0%	0.075
WE	29.1%	54.7%	16.2%	30.0%	36.0%	34.0%	**0.015**
MST	**< 02:30 hours**	**02:30–03:30 hours**	**> 03:30 hours**	**< 02:30 hours**	**02:30–03:30 hours**	**> 03:30 hours**	***p***
Week	41.9%	44.6%	13.5%	18.0%	50.0%	32.0%	**0.001**
WE	7.4%	37.8%	54.7%	10.0%	20.0%	70.0%	0.069
NWAKE	**< 1**	**1–5**	**> 5**	**< 1**	**1–5**	**> 5**	***p***
Week	10.1%	81.8%	8.1%	6.0%	70.0%	24.0%	**0.010**
WE	5.4%	85.1%	9.5%	4.0%	88.0%	8.0%	0.874
WASO	**< 15 min**	**15–60 min**	**> 60 min**	**< 15 min**	**15–60 min**	**> 60 min**	***p***
Week	5.4%	58.8%	35.8%	0.0%	36.0%	64.0%	**0.001**
WE	4.1%	50.0%	45.9%	4.0%	42.0%	54.0%	0.605
Total RD (NSI + DTI)	**< 7 hr**	**7–9 hr**	**> 9 hr**	**< 7 hr**	**7–9 hr**	**> 9 hr**	***p***
Week	29.1%	58.8%	12.2%	8.0%	60.0%	32.0%	**< 0.001**
WE	12.2%	52.7%	35.1%	10.0%	58.0%	32.0%	0.798
Total SD (NSI + DTI)	**< 6 hr**	**6–8 hr**	**> 8 hr**	**< 6 hr**	**6–8 hr**	**> 8 hr**	***p***
Week	39.2%	60.1%	0.7%	24.0%	64.0%	12.0%	**< 0.001**
WE	15.5%	66.2%	18.2%	26.0%	50.0%	24.0%	0.108

DTI, daytime interval; MST, mid-sleep time (average between sleep onset and sleep offset during NSI); NSI, night sleep interval; NWAKE, number of awakenings lasting at least 5 min after sleep onset between sleep onset and sleep offset; RD, rest duration (time lying down, sleeping or not, as classified by the actigraph during NSI); SD, sleep duration (between sleep onset and offset, regardless of awakenings); SE, sleep efficiency, SD/RD; SOL, sleep-onset latency (time period between start of NSI and sleep onset); WASO, sum of minutes classified as wake between sleep onset and sleep offset.

sleep duration. Accordingly, in our sample, unemployed people do lie down longer during the night (on average 29 min) and during the complete night–day cycle (59 min). Difference in SD also reached significance when considering the whole night–day cycle, but accounted for only 25 min on average. SE is on average 5% points lower in unemployed subjects. They need slightly more time to fall asleep, sleep during a later period of the night (38 min later MST) and have a more fragmented sleep with more and in sum longer awakenings during the night. These results confirm previous findings showing lower sleep quality in unemployed people (Grandner et al., 2010; Maeda et al., 2019; Wu et al., 2018).

To explore whether unusually high or low values in sleep parameters were more frequent in unemployed subjects, we divided subjects into three groups based on predefined cut-off values (low, middle, high). Frequency analysis showed that the distributions of employed and unemployed subjects is indeed uneven. The proportion of subjects with long SD is larger in the group of unemployed people. During the working week, a larger proportion of unemployed compared with employed people display low SE and long periods of WASO.

As expected, almost all differences in sleep parameters between employed and unemployed subjects were not present on weekends. One obvious explanation for this is the pace of life becoming similar for both groups on weekends. Both groups sleep at a later period of the night on weekends, which is most likely linked to social activities frequently happening on Friday and Saturday evenings. Additionally, on the weekend, employed people might compensate for short sleep durations imposed by work constraints during the week. Therefore, it could also be discussed that the sleep of employed people is negatively impacted by their working activities during the week rather than unemployed people sleeping too much. Accordingly, increases in nightly lying down and SD were seen in the employed sample during weekend nights. Nonetheless, lower SE, longer SOL and more fragmented sleep attest to the lower sleep quality of unemployed subjects.

To sum up, unemployed subjects do not sleep significantly longer than employed subjects, but they display longer time lying down. Their night sleep is less efficient, more fragmented and shifted to a later point of the night. Accordingly, unemployed individuals could benefit from intervention programmes aiming at promoting healthy sleep habits, ranging from simple sleep hygiene instructions to cognitive behavioural therapy for insomnia (Cunningham & Shapiro, 2018). Considering the well-researched link between sleep problems and depression, such interventions could also aim at detecting depression at early stages, as is the case in the German pilot project “Psychosocial Coaching” (Pfeil et al., 2013).

4.1 | Strengths and limitations

To our knowledge, no previous study has compared sleep parameters of employed and unemployed people using objective measurement methods. Sleep was objectively assessed over the course of several nights (on average 6.7 days per participant) with a differentiation between week and weekend nights. The exclusion of participants likely to have distorted sleep patterns due to a variety of somatic and/or mental illnesses (including depression), shift-work or self-reported abnormal sleep is a major strength of this study. Another strength is the use of nearest-neighbour matching between groups, taking into account the covariates gender, age, educational level and family status.

The study presents some weaknesses, the most important one being a relatively small sample with 198 subjects. Although we selected subjects of a broad age range (41–64 years), the average age of 56.4 years is high, making it difficult to generalise results to the whole working-age population. Educational levels were unevenly distributed, with an overrepresentation of vocational education, again putting into question the generalisability of our results. Information on some important physical and psychological conditions such as sleep apnea, myoclonus, restless legs syndrome, insomnia, dementia and mental disorders other than depression was not available for this project. Considering the age structure of the sample, however, we assume that dementia-related illnesses had no influence on sleep parameters. Furthermore, while a 7-day actigraphy measurement was performed within LIFE, in some cases no full set of 7 night–day cycles could be analysed due to off-body periods. Our minimum requirement of 4 night–day cycles during the working week plus 1 night–day cycle during the weekend does not meet the requirements of ICSD-3 diagnostic criteria for most sleep disturbances. However, most participants clearly exceeded the minimum requirements. It was impossible to take marital status into account as a confounding factor. Instead of working week and weekend days, it would have been more pertinent to differentiate between "working days" and "days off work", taking into account for example public holidays.

4.2 | Conclusion and practical implications

This study reveals differences in sleep behaviour between employed and unemployed subjects aged between 41 and 64 years of the LIFE cohort. It supports previous findings, according to which unemployment influences subjects' sleep quality, mainly by revealing less efficient and more fragmented sleep patterns. Considering the strong association between sleep and physical as well as mental health (Bertisch et al., 2018; Hensch et al., 2019; Hillman et al., 2018), it could be important to help unemployed people manage their sleep hygiene. This could help prevent a vicious circle in which unhealthy behaviours and unemployment maintain each other. Intervention programmes for the improvement of sleep hygiene could, for example, be offered by unemployment agencies as a way of supporting reintegration into the labour market.

Further research should be carried out using a larger and younger sample, also taking into account family status as well as circadian preferences.

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CONFLICT OF INTERESTS

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AUTHOR CONTRIBUTIONS

SG, RM and UH conceived the study design and questions; CS, CE and TH commented on them. CE, CS, TH and UH participated in the conception of the LIFE Adult Study (Loeffler et al., 2015). CS edited data of the study. SG, RM and CS performed the statistical analyses. All authors performed interpretation of statistical tests and corresponding results. SG wrote the first complete version of the manuscript. All authors critically edited the manuscript and agreed to its submission.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon request.

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