Sleep during COVID-19 lockdown: a cross-cultural pilot study

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1 Summary

2 Our study aimed to assess the change in the sleep patterns during the Coronavirus
3 lockdown in five regions (Austria/Germany, Ukraine, Greece, Cuba and Brazil), using
4 online surveys, translated in each language. Part of the cohort was collected directly
5 during lockdown, to which retrospective cross-sectional data from and after lockdown
6 (retrospective) questionnaires were added. We investigated sleep times and sleep
7 quality changes from before to during lockdown and found that, during lockdown,
8 participants had (i) worse perceived sleep quality for those who reported to be worried
9 by COVID-19, (ii) a shift of bedtimes to later hours during workdays, and (iii) a sleep
10 loss on free days (resulting from more overall sleep during workdays), leading to (iv) a
11 marked reduction of social jetlag across all cultures.

12 For further analyses we then split the participants by job (system relevant or not)
13 because it was assumed that the nature of the lockdown's consequences is dependent
14 upon system relevance. System relevant jobs were found to have earlier wake-up
15 times as well as shorter total sleep times on workdays, leading to a higher social jetlag
16 for people in system relevant jobs.

17 Cultural differences revealed a general effect that participants from Greece and
18 Ukraine had later bedtimes (on both work and free days) and wake-up times (on
19 workdays) than Cuba, Brazil and Austria, irrespective of COVID-19 lockdown
20 restrictions.

21

22 Keywords:

23 COVID-19, pandemic, sleep habits, sleep problems, cross-cultural, social jetlag

24

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Introduction

In December 2019 a cluster of pneumonia cases developed in the Wuhan province of China, generated by the subsequently identified SARS-CoV2 (severe acute respiratory syndrome - coronavirus 2)¹. The high contagiousity of the virus drove to a rapid worldwide spread of the coronavirus-disease (COVID-19), leading to the declaration of a pandemic by the World Health Organization (WHO) on 11th of March 2020². This prompted countries to impose strict social distancing measures, including the recommendation to stay at home, the ban on group meetings, and the shutdown of schools and non-essential commercial activities³. The effects of 'grounding' a nation reduced the spread of the virus⁴, but also forced people to drastically change their social behaviour and everyday habits, such as fixed waking up and going to work times, having regular mealtimes, having scheduled sports and leisure activities, as well as social events. These timekeepers, which kept one's habitual activity/rest rhythm, were suddenly disturbed due to the lockdown measures, leading to changes in one's circadian rhythm⁵. For example, the social pressure to wake up early during workdays was partially removed during the lockdown for people who could work from home and/or on a more flexible time schedule. This was found to reduce the difference between sleep times on workdays and sleep times on free days, commonly referred as social jetlag⁶. In addition, the concern about the disease itself, the worry about personal health and about one's family's health, as well as the anxiety about the future of one's workplace and financial situation had a strong impact upon the psychological state of the general population. Numerous reports show a decline in mental health, quality of

life and quality of sleep in populations affected by the pandemic⁶⁻¹⁶, with healthcare workers under the most pressure^{17,18}.

The current study aims to investigate how sleep patterns and sleep quality changed during the lockdown, and if this varies from one country to another. First, we hypothesized that sleep quality negatively correlates to the amount of worrying about the ongoing pandemic. Furthermore, based on the study by Blume et al.⁶, we hypothesized that, during lockdown, there will be a shift of sleep times to later hours during workdays and consequently an attenuation of the social jetlag, as well as lower sleep quality⁶⁻¹⁶ given the collateral damage of the lockdown measures.

Importantly, we hypothesized that participants having system relevant jobs (workers in health care and public service, as well as IT workers maintaining the IT systems in offices and institutions) may display different effects, with such jobs showing earlier wake-up times, less overall sleep and less reduction of social jetlag.

We also distributed our survey in various countries including Austria, Cuba, Germany, Greece, Ukraine and Brazil to examine whether cultural effects may alter the observed changes in sleep during the pandemic.

Methods

Data collection: Data was collected in two phases: (i) during and (ii) after lockdown. During lockdown, a cohort was gathered through a set of two questionnaires: an entry questionnaire and a morning protocol. The entry questionnaire was a one-time survey containing questions about demographics and habitual sleep times before the COVID-19 situation, as well as about the quality of sleep, and the changes in work patterns and environment. The morning protocol was a survey that had to be completed daily, for about seven days, containing questions about the previous night's sleep and about

73 the amount of worry for the ongoing COVID-19 pandemic. An average of 4.94
74 workdays and 3.46 free days were collected from each participant.

75 Since the acquired cohort was too small when the lockdowns were lifted for the first
76 time, a second roll-out of the survey followed immediately after lockdown. This was a
77 one-time survey where we pooled the questions of the two above-mentioned
78 questionnaires, asking about sleep habits before and sleep habits during lockdown, on
79 workdays and on free days separately. These cross-sectional data were then added,
80 and averages for each sleep value were computed.

81 Considering the novelty of the COVID-19 situation, standardized sleep questionnaires
82 did not appear sufficient and were extended by questions concerning working from
83 home, being worried about the epidemic, or changes in sleep behaviour during as
84 compared to before lockdown. All questions were reviewed and approved by the Ethics
85 Committee of the University of Salzburg.

86 All questionnaires were generated in LimeSurvey and had versions in 6 languages:
87 German, English, Greek, Ukrainian, Spanish and Portuguese. The link to the
88 questionnaires was distributed through social media platforms (e.g., Facebook, Twitter)
89 and with the help of collaboration partners from other universities. The data from the
90 first set of questionnaires (the cohort) was acquired for each country depending on the
91 lockdown dates: Austria: 15.03.2020 - 29.05.2020, Germany: 22.03.2020 - 11.05.2020,
92 Ukraine: 12.03.2020 - 02.06.2020, Greece: 12.03.2020 - 11.05.2020, and Cuba:
93 20.03.2020 - 10.07.2020. Data from Brazil were only collected in the second phase in a
94 cross-sectional, one-time retrospective questionnaire. The start dates were set to the
95 start of nationwide restrictions of mobility and to schools and shops closing, and the
96 end dates correspond to the reopening of schools and shops (and mostly return of the
97 workers to their normal offices). The cross-sectional data, collected with the single
98 questionnaire, were acquired from 23.06.2020 until 16.09.2020 and the questions
99 referred specifically to sleep habits “before lockdown” and “during lockdown”. For most

countries (except for Cuba, where the lockdown was still in place until 30.09.2020), this data was retrospective. We are aware that the survey answers might be influenced by a response bias¹⁹, as we had no other objective measures of sleep in the current study, however, we tried to sample data during or as close as possible to the lockdowns. Since this was an ad hoc study, triggered by the COVID-19 pandemic and the sudden social distancing restrictions, the choice of these five countries was also motivated by pre-existing collaborations that would speed up data collection in this novel situation.

Participants: Inclusion criteria for the participants were: age 25-65 and living in one of the countries mentioned above. In total, 381 participants fulfilled these criteria. After a preliminary analysis, we found that 11 participants working in the food industry had a very different pattern of sleep/wake hours compared to the other job categories. As the group was too small to be considered separately, we had to exclude them, which left us with 370 participants, from which 71 were living in Austria and Germany, 62 in Greece, 78 in Ukraine, 95 in Cuba and 64 in Brazil. Out of the 370 participants, 12.7% (47) were from the cohort data and the rest of 87.3% (323) were from the cross-sectional, retrospective data. For analysis of each sleep variable, we excluded outliers (3 standard deviations from the group mean) and missing values.

We defined system relevant jobs as activity in areas that could not be shut down but and rather expected increases in the amount of work during lockdown. Because of the expected strain on the healthcare system, health care professionals were included. In addition, we included public service employees such as postal office workers, bus drivers, or workers in administration, as well as people working in IT, because of the increased workload for those managing the IT systems for institutions and companies that moved their activity online. In total, 108 participants had system relevant jobs (health care, public service, IT) and 262 system irrelevant jobs (any other job, retired or unemployed, domestic occupation or no answer). People in system-relevant jobs were

less susceptible to be sent on home office, forced holiday or unpaid leave of absence (Supp. Fig. 1 - How the COVID-19 lockdown affected job routines for participants in different job groups). The mean age was 39.2 years ($SD = 11.2$) (see Suppl. Table 1 for an overview of sociodemographic data).

Measurement: For each participant, the data was collected separately for workdays and free days. Sleep values collected included bedtime, wake-up-time and subjective total-sleep-time. From data we derived time-in-bed and social jetlag, with time-in-bed, a more objective measure of sleep duration (and validation of the subjective total-sleep-time), calculated as the simple difference between *wake-up-time* and *bedtime* (e.g. 07:15_(02Apr) to 23:45_(01Apr) = 07:30). Social jetlag was computed as $mid-sleep\ point_{(free\ days)} - mid-sleep\ point_{(workdays)}$. The mid-sleep point was thereby calculated as $bedtime + (wake-up-time - bedtime)/2$ (e.g. $23:45_{(01Apr)} + (07:15_{(02Apr)} - 23:45_{(01Apr)})/2 = 23:45_{(01Apr)} + 07:30/2 = 23:45_{(01Apr)} + 03:45 = 03:30_{(02Apr)}$).

Data processing: Data analysis was performed in Matlab version 2019b²⁰. Averages for each sleep value described above were computed for each country and for each job. The total number of participants was too low to be able to divide them further by job within each country, so in this pilot study we only ran statistical analyses on job groups and on countries separately.

Statistical Analysis: Statistical analysis was performed in R, version 3.6²¹. Due to a significant country effect on age ($F(4, 365) = 5.88, p < .001, \eta^2 = 0.06$), as well as job effect on age ($F(1, 368) = 14.52, p < .001, \eta^2 = 0.04$), main effects and interactions were analysed while controlling for age. Thus, a two way mixed ANCOVA with within-subjects factor "COVID-19" (before vs. after), between-subjects factor "country" (Greece vs. Ukraine vs. Cuba vs. Austria vs. Brazil) and "age" as a covariate was

performed to examine country and COVID-19 lockdown effects separately for free and workdays, while controlling for age. Similarly, a two way mixed ANCOVA with within-subjects factor “COVID-19” (before vs. during), between-subjects factor “job” (system relevant vs. system irrelevant), and “age” as covariate, was performed in order to explore job x COVID-19 effects, separately for free and workdays. Post-hoc analysis of significant main effects was performed using Bonferroni-corrected pairwise marginal mean comparisons, using the “rstatix” package²². Similar analysis was used on social jetlag scores. The “age x COVID-19” interaction on social jetlag scores was explored by statistically comparing Fisher-transformed correlation coefficients using a paired t-test. The effects of COVID-19-related worry on sleep quality was examined using both a chi-square and Spearman's correlation. Note that for the chi-square analysis the “I don't worry at all” and “I barely worry” responses were merged to achieve a comparable number of observations.

Results

Effects of COVID-19 pandemic on sleep time variables

Total-sleep-time

Analysis of total-sleep-time on free days, revealed a significant COVID-19 effect ($F(1, 317) = 5.155, p = .024, \eta^2 = .016$), suggesting that participants slept more before (mean (M) = 08:23, SD = 01:07) than during COVID-19 lockdown on free days (M = 08:13, SD = 01:13) as they seemed to make up for their sleep already during workdays (cf. Table 1; $M_{\text{before}} = 07:19, SD = 01:07; M_{\text{during}} = 07:30, SD = 01:11$). Latter effect however, was not significant across all subjects ($F(1, 317) = .006, p = .941, \eta^2 < 0.01$).

In addition, there was a general and significant country effect on both free ($F(4, 314) = 3.72, p = .006, \eta^2 < 0.045$) and workdays ($F(4, 314) = 5.01, p < .001, \eta^2 < 0.06$). On free days, Cuba (M = 08:33, SD = 01:01) slept significantly more than Greece (M = 08:03,

SD = 01:10), Ukraine ($M = 08:24$, $SD = 01:18$), Austria ($M = 08:09$, $SD = 00:59$) and Brazil ($M = 08:09$, $SD = 01:16$), and on workdays, Cuba ($M = 07:34$, $SD = 01:03$) and Ukraine ($M = 07:43$, $SD = 01:12$) slept significantly more than Greece ($M = 07:11$, $SD = 01:08$), Austria ($M = 07:04$, $SD = 01:01$) and Brazil ($M = 07:14$, $SD = 01:14$).

In addition, there was a significant effect of job on workdays ($F(1, 317) = 6.74$, $p = .01$, $\eta^2 = .021$) revealing that participants with system relevant jobs slept significantly less ($M = 07:09$, $SD = 01:04$) than participants with system irrelevant jobs ($M = 07:31$, $SD = 01:10$). This was not the case on free days ($F(1, 317) = 0.269$, $p = .604$, $\eta^2 < 0.01$; cf. Figure 1A).

Figure 1: (A) Differences in total-sleep-times during minus before COVID-19 lockdown, for system relevant and system irrelevant jobs. On workdays (red) participants with system irrelevant jobs sleep more during lockdown than before, but participants with system relevant jobs do not. On free days (green), all participants sleep less during the lockdown than before. (B) Differences in bedtimes and wake up times during minus before COVID-19 lockdown, for system relevant and system irrelevant jobs. On workdays (red), both job groups go to bed and wake up later during lockdown than before. On free days (green), participants from both job groups go to bed a little later during than before the lockdown, but wake up at almost the same time as before the lockdown. Negative values describe a loss of sleep during lockdown; positive values describe a gain in sleep during lockdown.

Time-in-bed

Time-in-bed data confirms these results. For detailed results, see Supp. Table 2.

Bedtimes

Analysis of bedtimes revealed a significant COVID-19 effect on workdays ($F(1, 318) = 17.019, p < .001, \eta^2 = .051$), with earlier bedtimes before COVID-19 lockdown ($M = 23:21, SD = 01:06$) than during lockdown ($M = 23:44, SD = 01:23$), but this was not the case for free days ($F(1,318) = 2.081, p = .15, \eta^2 = .007$).

Furthermore, there was a significant country effect for both work ($F(4, 315) = 11.25, p < .001, \eta^2 = .125$) and free days ($F(4,315) = 10.10, p < .001, \eta^2 = .114$). On free days Greece had later bedtimes ($M = 01:06, SD = 01:17$) than every other country: Brazil ($M = 00:12, SD = 01:37$), Cuba ($M = 00:01, SD = 01:10$), Austria ($M = 23:58, SD = 01:09$), Ukraine ($M = 00:09, SD = 01:17$). On workdays, Ukraine ($M = 23:43, SD = 01:20$) had significantly later bedtimes than Austria ($M = 23:16, SD = 00:55$) and Cuba ($M = 23:06, SD = 00:55$) but not Brazil ($M = 23:00, SD = 01:28$), while Greece had later bedtimes ($M = 00:17, SD = 01:17$) than every other country.

215 The effect of job as well as the job x COVID-19 interactions did not reach statistical
216 significance.

217

218 **Wake-up-time**

219 Analysis of the wake-up-times on workdays revealed a significant COVID-19 effect
220 ($F(1, 312) = 26.75, p < .001, \eta^2 = .079$) with later wake-up-times during COVID-19
221 lockdown ($M = 07:23, SD = 01:30$) as compared to before lockdown ($M = 06:48, SD =$
222 $01:09$). But this was not the case for free days ($F(4, 312) = 2.284, p = .132, \eta^2 = .004$).
223 In addition, there was a country effect for both free ($F(4, 312) = 4.723, p = .001, \eta^2 =$
224 $.057$) and workdays ($F(4, 312) = 7.902, p < .001, \eta^2 = .092$). On free days, Greece ($M =$
225 $09:08, SD = 01:39$) had later wake-up-times than Brazil ($M = 08:27, SD = 01:41$),
226 Austria ($M = 08:25, SD = 01:41$) and Ukraine ($M = 08:44, SD = 01:38$), but not Cuba ($M =$
227 $0:35, SD = 01:09$). On workdays, Greece ($M = 07:27, SD = 01:31$) and Ukraine ($M =$
228 $07:39, SD = 01:28$) had later wake-up-times than Cuba ($M = 06:42, SD = 00:58$),
229 Austria ($M = 06:47, SD = 01:04$), and Brazil ($M = 06:55, SD = 01:31$) - see Table 1 for
230 raw sleep values per country.

231

A. Sleep before and during lockdown on workdays									
		Total Sleep		Time in Bed		Going to Bed		Wake Up	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Country									
Austria *	Before	07:03	00:59	07:32	01:08	23:02	00:55	06:30	00:55
	During	07:05	01:04	07:40	01:08	23:29	00:52	07:04	01:09
Greece	Before	07:01	01:07	07:06	01:01	24:01	01:03	07:01	01:12

	During	07:20	01:08	07:25	01:11	24:32	01:28	07:53	01:41
Ukraine	Before	07:33	01:08	07:50	00:58	23:35	01:10	07:23	01:20
	During	07:52	01:15	08:06	01:17	23:51	01:29	07:54	01:33
Cuba	Before	07:33	01:03	07:36	00:56	22:56	00:50	06:30	00:48
	During	07:34	01:04	07:43	01:02	23:15	00:59	06:54	01:04
Brazil	Before	07:08	01:09	07:21	00:57	23:17	01:12	06:35	01:10
	During	07:21	01:18	07:33	01:17	23:43	01:41	07:15	01:45
Job									
System Relevant	Before	07:09	01:02	07:16	00:58	23:09	00:56	06:27	00:52
	During	07:10	01:07	07:20	01:05	23:32	01:10	06:53	01:18
System Irrelevant	Before	07:23	01:08	07:36	01:01	23:26	01:09	06:57	01:13
	During	07:38	01:11	07:52	01:13	23:49	01:28	07:36	01:32
B.Sleep before and during lockdown on free days									
		Total Sleep		Time in Bed		Going to Bed		Wake Up	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Country									
Austria *	Before	08:21	00:55	08:41	00:57	23:55	01:11	08:31	01:17

	During	07:58	01:02	08:29	01:01	24:00	01:08	08:19	01:18
Greece	Before	08:07	01:02	08:07	00:58	24:59	01:16	09:04	01:38
	During	07:59	01:18	08:01	01:15	25:12	01:29	09:12	01:42
Ukraine	Before	08:27	01:18	08:38	01:05	24:03	01:08	08:42	01:34
	During	08:20	01:20	08:30	01:12	24:15	01:25	08:46	01:42
Cuba	Before	08:38	01:00	08:41	00:59	23:58	01:14	08:37	01:08
	During	08:29	01:02	08:34	01:01	24:03	01:05	08:32	01:09
Brazil	Before	08:15	01:12	08:28	00:55	24:02	01:17	08:22	01:26
	During	08:04	01:21	08:14	01:19	24:22	00:15	08:31	01:55
Job									
System Relevant	Before	08:27	00:58	08:28	01:03	23:59	01:10	08:30	01:09
	During	08:10	01:09	08:20	01:07	24:16	01:22	08:34	01:25
System Irrelevant	Before	08:22	01:10	08:33	00:59	24:15	01:19	08:43	01:47
	During	08:15	01:15	08:24	01:12	24:23	01:30	08:43	01:51

Table 1. Sleep values before and during lockdown, on workdays (A) and on free days

(B). All values are in HH:MM format and represent the average from all participants in that group (job or country). *Includes values from Austria (55 participants) and Germany (16 participants).

Analysis of wake-up-times showed also a significant difference between system relevant and system irrelevant jobs on workdays ($F(1, 315) = 27.32, p < .001, \eta^2 =$

.037), with participants in system relevant jobs waking up earlier ($M = 06:40$, $SD = 01:08$) as compared to participants in system irrelevant jobs ($M = 07:17$, $SD = 01:25$). However, this was not the case for free days ($F(1,315) = 0.007$, $p = .933$, $\eta^2 < .001$; cf. Figure 1B).

Effects of COVID-19 pandemic on social jetlag

Analysis of social jetlag revealed a robust COVID-19 effect ($F(1, 325) = 22.24$, $p < .001$, $\eta^2 = .064$) with higher social jetlag scores before COVID-19 lockdown ($M = 01:20$, $SD = 00:59$) than during lockdown ($M = 00:57$, $SD = 00:56$). In addition, there was a significant job effect ($F(1, 325) = 10.294$, $p < .001$, $\eta^2 = .031$) with participants in system relevant jobs showing higher social jetlag scores ($M = 01:20$, $SD = 00:52$) compared to participants in system irrelevant jobs ($M = 01:04$, $SD = 01:01$) - see Figure 2.

Figure 2: Social Jetlag in hours (difference of sleep midpoint of working minus sleep midpoint of free days) for system relevant ($n = 108$) and system irrelevant ($n = 262$) jobs before and during COVID-19. Note that during COVID-19 there is reduced social jetlag for both groups. Participants with system relevant jobs reported higher social jetlag than participants with system irrelevant jobs, independent of the COVID-19 situation. (* $p < .05$, ** $p < .01$, *** $p < .001$).

In addition, there was a significant age x COVID-19 interaction ($F(1,325) = 9.46$, $p = .002$, $\eta^2 = .028$) indicating less social jetlag with increasing age ($r_s = -0.21$, $p < .001$), but no such relation during COVID-19 lockdown ($r_s = -0.01$, $p = .72$) (cf. Supp. Figure 2). For more details, see Supplemental Table 2.

Effects of worrying about the COVID-19 pandemic on subjective sleep quality

The majority of the participants (53%, $N = 174$) reported that they were somewhat worried, while 22% ($N = 71$) barely worried and 25% ($N = 81$) worried a lot. Sleep quality did not change during lockdown for most 65% of the participants ($N = 207$), while 26% ($N = 84$) reported a deterioration and only 12% ($N = 35$) an improvement.

Analysis of the relationship between sleep quality and worry about COVID-19 pandemic revealed a significant association ($\chi^2(4) = 20$, $p < .001$), indicating that participants who do not (or barely) worry are less likely to sleep worse, whereas participants who worry a lot about the pandemic are overrepresented in the group, indicating that they are much more likely to sleep worse during lockdown (cf. Figure 3). Follow-up correlational analysis between sleep quality change and worry about COVID-19 showed that sleep quality change and worry about COVID-19 were negatively

278 correlated ($r_s = -0.19$, $p < .001$). This negative correlation indicates that sleep quality
 279 worsens as worry about COVID-19 increases.

280

281 For an extensive report on the results, please see Suppl. Table 2.

282

283 **Figure 3:** Effects of worry about the COVID-19 pandemic on subjective sleep quality
 284 visualised as χ^2 residuals. Note that people who do not (or barely) worry are less likely
 285 (than expected) to sleep worse (in red), whereas the participants who worry a lot about
 286 the pandemic are much more likely to sleep worse (in blue).

287

288 Discussion

289 COVID-19 lockdown effects

290 Results reveal that the lockdown had strong effects on all of the measured sleep variables.

291 On workdays, participants started to go to bed and wake up later during lockdown than
 292 before (by an average of 23 minutes and, respectively, 35 minutes), meaning that
 293 participants on average won 12 minutes of sleep every day over the work days. On free
 294 days, participants then went to bed and woke up at similar times to those before COVID-
 295 19, and even slept 10 minutes less than before lockdown, likely due to the prolonged
 296 sleeping times during the work week.

297 This shift of sleep to later wake-up-times on workdays confirms our hypothesis and is
 298 reflected in the reduction of the social jetlag, which reduced for all participants with an
 299 average of 23 minutes. Similar effects are reported by Blume et al⁶ who show a median
 300 social jetlag decrease of 13 minutes. This suggests that without the workweek constraint,
 301 sleep during workdays shifts towards participants' more natural rhythm, with later bedtimes
 302 and especially awakening times, thereby resembling sleep patterns during free days. The
 303 loss of sleep on free days was unexpected, but given the data, it is most likely related to
 304 the decrease of sleep debt during the workweek in lockdown. Alternatively, one could
 305 speculate that worrying about COVID-19 could have a negative impact on falling asleep
 306 and staying asleep on free days, as worry and rumination are known to increase sleep
 307 disturbances^{23,24}.

308

309 **Cultural effects**

310 The cultural differences we see for total-sleep-time and time-in-bed indicate that, on
 311 workdays, participants from Cuba and Ukraine sleep more than the other countries,
 312 independently of the lockdown. The country effects for bedtimes and wake-up-times point
 313 out Greece and Ukraine as those who go to bed and wake up the latest on workdays,
 314 irrespective of the lockdown. These results confirm our hypothesis that sleeping habits
 315 differ from country to country.

316 Two aspects may explain these differences: sociocultural factors and the geographical
 317 location, which determines the amount of daily sunlight at time of data sampling. During

318 spring and summer (the time when the data was collected), in Ukraine, Germany and
 319 Austria the sun rises earlier and sets later than in Greece and Cuba, while Brazil is in
 320 between²⁵. This gives the former countries more hours of daylight than the latter. However,
 321 in our analyses, Ukraine and Greece had the latest bedtimes and wake-up-times from all
 322 the countries analysed, even though they got very different amounts of sunlight during the
 323 day. This leaves sociocultural factors (i.e. customs, lifestyle) as the main influence on the
 324 intercultural sleep differences. Interestingly, the results indicate that COVID-19 affected
 325 sleep in all countries in the same way with no specific cross-cultural effects.

326

327 **Job effects**

328 Participants with system relevant jobs woke up, on average, 37 minutes earlier and slept
 329 22 minutes less on workdays than participants with system irrelevant jobs, while no
 330 differences were found on free days. This also results in a bigger social jetlag for
 331 individuals with system relevant jobs than for those with system irrelevant jobs irrespective
 332 of the lockdown.

333 Data show a trend that social jetlag decreased during lockdown more strongly for
 334 participants with system irrelevant jobs (on average 26 minutes) than for those with system
 335 relevant jobs (on average 14 minutes). These results support our hypothesis that
 336 participants with system relevant jobs would have earlier wake-up-times and less overall
 337 sleep, whereas participants with system irrelevant jobs managed to catch up on sleep with
 338 later wake-up-times on workdays (cf. Figure 1B). In this respect, the current study is an
 339 important extension of existing literature⁶, endorsing the theory that system relevant and
 340 system irrelevant jobs have very different situations and environmental constraints when it
 341 comes to sleeping times.

342

343 **Age effects**

344 We refrain from formulating hypotheses regarding the influence of age, but one age effect
 345 attracted our attention: there was a negative correlation between age and social jetlag
 346 before, but not during lockdown (cf. Supp. Figure 2). That is, under normal social
 347 circumstances, young people have a higher social jetlag than older people, but during
 348 lockdown, this effect disappears. This suggests that the permission to work from home
 349 office and the ban on social events during the COVID-19 lockdown reduced this work/free
 350 difference for young people more than it did for the older ones. As an implication of these
 351 results, young people may feel the pressure of the lockdown more strongly than older
 352 people, which might make them less inclined to comply with the distancing measures,
 353 especially since they are at a lower risk for serious complications of the disease. On the
 354 other hand, a reduction in social jetlag may indicate that younger people returned, during
 355 lockdown, to their inherent activity/rest rhythm, which may also have positive effects on
 356 their overall health during lockdown.

357

358 **Subjective sleep quality**

359 Almost two thirds of our participants reported no change in sleep quality during lockdown,
 360 which contradicts our hypothesis and is also in disagreement with observed (yet mild)
 361 overall decrease in sleep quality in the study of Blume and colleagues⁶. However, in our
 362 study, subjective sleep quality is highly correlated with the individual subjective concern
 363 regarding COVID-19, and gets worse the more concern is reported (cf. Figure 3). The
 364 reduction in subjective sleep quality for this segment of the population has major
 365 implications, since low sleep quality is associated with higher risk for depression, suicide²⁵,
 366 and even immune system dysfunctions²⁶, and therefore can aggravate the risk of serious
 367 long-term costs on health and well-being.

368

369 Conclusion

370 Altogether, the results indicate (i) worse perceived sleep quality in participants worrying
371 about COVID-19, (ii) a shift of bedtimes to later hours on workdays, and (iii) a marked
372 reduction of the social jetlag during the COVID-19 lockdown due to a normalization or
373 harmonization of sleeping times between workdays and free days.

374 Although the study sample is not huge, we would like to point to the fact that we actually
375 find very coherent effects across 5 different countries/regions when it comes to changes
376 due to the COVID-19 lockdown measures.

377 When it comes to cross-cultural sleep habits, we see that these vary substantially between
378 culture, and we do find the expected variation^{27,28} in bedtimes and wake-up times with later
379 times for the Greek and Ukrainian samples as compared to Austrian, Brazilian and Cuban
380 samples. Upcoming studies such as the “International COVID-19 Sleep Study (ICOSS)”,
381 initiated by Prof. Markku Partinen from Helsinki, will be covering 15 countries from Europe,
382 Asia and North America, and will substantially contribute to our current knowledge on
383 intercultural differences in sleep during COVID-19²⁹. We are looking forward to seeing how
384 such results will extend recent findings.

385

386 Ethics approval and informed consent

387 The study received approval from the Ethics Committee of the Paris Lodron University of
388 Salzburg, Austria. Informed consent was obtained from each participant. The study was
389 conducted according to the guidelines of the Declaration of Helsinki.
390

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Figure Legends

Figure 1: (A) Differences in total-sleep-times during lockdown minus before COVID-19 lockdown, for system relevant and system irrelevant jobs. On workdays (red) participants with system irrelevant jobs sleep more during lockdown than before, but participants with system relevant jobs do not. On free days (green), all participants sleep less during the lockdown than before. (B) Differences in bedtimes and wake up times during lockdown minus before COVID-19 lockdown, for system relevant and system irrelevant jobs. On workdays (red), both job groups go to bed and wake up later during lockdown than before. On free days (green), participants from both job groups go to bed a little later during lockdown than before the lockdown, but wake up at almost the same time as before the lockdown. Negative values describe a loss of sleep during lockdown; positive values describe a gain in sleep during lockdown.

Figure 2: Social Jetlag in hours (difference of sleep midpoint of working days minus sleep midpoint of free days) for system relevant ($n = 108$) and system irrelevant ($n = 262$) jobs before and during COVID-19. Note that during COVID-19 there is reduced social jetlag for both groups. Participants with system relevant jobs reported higher social jetlag than participants with system irrelevant jobs, independent of the COVID-19 situation. (* $p < .05$, ** $p < .001$).

Figure 3: Effects of worry about the COVID-19 pandemic on subjective sleep quality visualised as χ^2 residuals. Note that people who do not (or barely) worry are less likely (than expected) to sleep worse (in red), whereas the participants who worry a lot about the pandemic are more likely to sleep worse (in blue).

498 **Tables**

A. Sleep before and during lockdown on workdays									
		Total Sleep		Time in Bed		Going to Bed		Wake Up	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Country									
Austria *	Before	07:03	00:59	07:32	01:08	23:02	00:55	06:30	00:55
	During	07:05	01:04	07:40	01:08	23:29	00:52	07:04	01:09
Greece	Before	07:01	01:07	07:06	01:01	24:01	01:03	07:01	01:12
	During	07:20	01:08	07:25	01:11	24:32	01:28	07:53	01:41
Ukraine	Before	07:33	01:08	07:50	00:58	23:35	01:10	07:23	01:20
	During	07:52	01:15	08:06	01:17	23:51	01:29	07:54	01:33
Cuba	Before	07:33	01:03	07:36	00:56	22:56	00:50	06:30	00:48
	During	07:34	01:04	07:43	01:02	23:15	00:59	06:54	01:04
Brazil	Before	07:08	01:09	07:21	00:57	23:17	01:12	06:35	01:10
	During	07:21	01:18	07:33	01:17	23:43	01:41	07:15	01:45
Job									
System Relevant	Before	07:09	01:02	07:16	00:58	23:09	00:56	06:27	00:52
	During	07:10	01:07	07:20	01:05	23:32	01:10	06:53	01:18

System Irrelevant	Before	07:23	01:08	07:36	01:01	23:26	01:09	06:57	01:13
	During	07:38	01:11	07:52	01:13	23:49	01:28	07:36	01:32

499

B. Sleep before and during lockdown on free days									
		Total Sleep		Time in Bed		Going to Bed		Wake Up	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
<i>Country</i>									
Austria *	Before	08:21	00:55	08:41	00:57	23:55	01:11	08:31	01:17
	During	07:58	01:02	08:29	01:01	24:00	01:08	08:19	01:18
Greece	Before	08:07	01:02	08:07	00:58	24:59	01:16	09:04	01:38
	During	07:59	01:18	08:01	01:15	25:12	01:29	09:12	01:42
Ukraine	Before	08:27	01:18	08:38	01:05	24:03	01:08	08:42	01:34
	During	08:20	01:20	08:30	01:12	24:15	01:25	08:46	01:42
Cuba	Before	08:38	01:00	08:41	00:59	23:58	01:14	08:37	01:08
	During	08:29	01:02	08:34	01:01	24:03	01:05	08:32	01:09
Brazil	Before	08:15	01:12	08:28	00:55	24:02	01:17	08:22	01:26
	During	08:04	01:21	08:14	01:19	24:22	00:15	08:31	01:55
<i>Job</i>									

System Relevant	Before	08:27	00:58	08:28	01:03	23:59	01:10	08:30	01:09
	During	08:10	01:09	08:20	01:07	24:16	01:22	08:34	01:25
System Irrelevant	Before	08:22	01:10	08:33	00:59	24:15	01:19	08:43	01:47
	During	08:15	01:15	08:24	01:12	24:23	01:30	08:43	01:51

500 **Table 1.** Sleep values before and during lockdown, on workdays (A) and on free days
501 (B). All values are in HH:MM format and represent the average from all participants in
502 that group (job or country). *Includes values from Austria (55 participants) and
503 Germany (16 participants).

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