# Remote work and social jetlag: Systematic review and empirical investigation of the healthy adult working force in Finland

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This study aimed to investigate the association between remote work and sleep parameters (social jetlag, self-reported sleep quality, and sleep duration) among healthy adult working force in Finland. The hypothesis was that remote work would reduce social obligations, which are the main cause of social jetlag, and therefore associate with smaller amount of social jetlag and with other sleep parameters, especially among evening chronotypes. This hypothesis was based on a systematic review of effects of COVID-19 restrictions on social jetlag, which was conducted.

This thesis utilizes data from a survey conducted in Climate Nudge Project and included 830 participants who worked or studied full-time after excluding those with sleep, health, or work ability issues.

Remote work was operationalized as work modality and as frequency of work at the workplace. Statistical analyses were conducted using *t*-tests for work modality and simple linear regression and general linear models to assess the association between remote work and sleep parameters after inclusion of covariates.

Remote work was associated with longer sleep duration and smaller amount of social jetlag. Those with any amount of remote work (work modality) compared with full week of work at the workplace had 17 minutes longer sleep duration during weekdays and 21 minutes shorter social jetlag. Predictions from general linear model produced similar results and these associations were strongest among evening types.

Overall, these findings suggest that remote work may have a beneficial impact on sleep duration and social jetlag. Future studies should examine whether remote work increases productivity, which could increase the opportunities for remote work within companies and therefore utilize the beneficial association between remote work and sleep.

**Key words**: Adult, Chronotype, COVID-19, Distance work, Systematic review, Sleep deprivation, Sleep duration, Sleep quality, Sleep-wake timing

Pro gradu -tutkielma

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Tämä tutkimus tutki etätyön ja uniparametrien (sosiaalinen aikaerorasitus, itsearvioitu unen laatu ja unen kesto) välistä yhteyttä suomalaisessa terveessä aikuisväestössä. Tutkimuksen hypoteesi oli, että etätyö vähentäisi sosiaalisten velvollisuuksien määrää, jotka ovat sosiaalisen aikaerorasituksen pääaiheuttajia, mikä olisi yhteydessä alhaisempaan sosiaaliseen aikaerorasitukseen sekä muihin uniparametreihin, erityisesti iltatyypeillä. Tutkimuksen hypoteesi perustui tehtyyn systemaattiseen katsaukseen COVID-19 rajoitusten vaikutuksista sosiaaliseen aikaerorasitukseen.

Tämä pro gradu -tutkielma hyödyntää kyselydataa Ilmastotuuppaus-projektista. Tutkimus sisälsi 830 vastaajaa, jotka työskentelivät tai opiskelivat täysipäiväisesti ilman unen, terveyden tai työkyvyn ongelmia

Etätyö operationalisoitiin työmuotona sekä työpaikalla tehdyn työn frekvenssinä. Tilastolliset analyysit suoritettiin käyttämällä *t*-testejä työmuodolle sekä yksinkertaisia lineaarisia regressio- ja yleisiä lineaarisia malleja arvioimaan etätyön ja uniparametrien välistä yhteyttä kovariaattien huomioimisen jälkeen.

Etätyö oli yhteydessä pidempään unen kestoon sekä vähäisempään sosiaaliseen aikaerorasitukseen. Mikä tahansa määrä etätyötä (työmuoto) verrattuna koko viikon työhön työpaikalla, oli yhteydessä 17 minuuttia pidempään unen kestoon ja 21 minuuttia lyhyempään sosiaaliseen aikaerorasitukseen. Yleisen lineaarisen mallin mallinnukset antoivat vastaavanlaiset tulokset ja nämä yhteydet olivat suurimpia iltatyypeillä.

Kaikkiaan, nämä tulokset antavat viitteitä, että etätyöllä voi olla positiivisen yhteys unen kestoon ja sosiaaliseen aikaerorasitukseen. Jatkotutkimusten tulisi tutkia lisääkö etätyö työn tuottavuutta, mikä voisi olla tapa lisätä etätyön mahdollisuutta yrityksissä ja sitä kautta hyödyntää etätyön hyödyllistä vaikutusta uneen.

**Avainsanat:** Kronotyyppi. COVID-19, Etätyö, Systemaattinen katsaus, Univaje, Unen kesto,

Unen laatu, Univalve ajoitus

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# 1 Introduction

Need for sleep is fundamental for humans and disruption of sleep has adverse health outcomes. There are variety of biological and social reasons which might cause disrupted sleep. Sleep problems (troubles falling or staying asleep), early work schedules, social life, or biological preference for sleep timing can result as shortened sleep or sleep deprivation. Recommended amount of sleep for adults ranges between seven to nine hours, according to National Sleep Foundation guidelines (Hirshkowitz et al., 2015) and in a sleep duration study of Finnish general population in 2006 (Kronholm et al., 2006), participants reported average sleep duration of 7hr 30min. Too short sleep duration (under six hours) has many adverse health outcomes such as increased risk for diabetes, cardiovascular diseases, obesity, and overall increased mortality (Itani et al., 2017; Liu et al., 2017; Patel et al., 2008). Short sleep duration is also associated with decreased academic performance (Curcio et al., 2006). Sleep deprivation and short sleep duration are common around the world, for example a population study done in U.S.A in 2012 observed that third of US adults reported sleeping six hours or less (Ford et al., 2015) and earlier mentioned Finnish population study (Kronholm et al., 2006) included 14.5% of short sleepers. High prevalence of sleep deprivation and short sleep combined with their association with many adverse health outcomes have caused insufficient sleep to be considered a public health epidemic (Chattu et al., 2018).

Whilst factors affecting sleep and adverse effects of short sleep are well documented, social jetlag is quite recent concept coined by Wittman and his colleagues in 2006 (Wittman et al., 2006). Social jetlag (SJL) is a form of circadian misalignment, which causes chronic sleep deprivation which originates from a discrepancy between the biological (circadian rhythm) and social (work, school) clock (Wittmann et al., 2006). This discrepancy between the biological and social clocks is mainly due to social obligations (work or school), which force the majority of people to wake up too early for their biological sleep schedule, thus creating sleep deprivation (Wittman et al, 2006). SJL is very common and approximately 46-70% of participants from The Munich ChronoType Questionnaire database are experiencing at least one hour of SJL (Roenneberg et al., 2012; Roenneberg et al., 2019), and only 12.4% do not experience SJL at all (Roenneberg et al., 2019). The Munich ChronoType Questionnaire is an internet-based questionnaire, where everyone can ask permission to participate, with over 65 000 eligible entries mainly from central Europe (Roennenberg et al., 2012).

SJL causes a severe form of sleep deprivation due to its chronic nature. Therefore, SJL causes the same adverse effects of sleep deprivation mentioned above and in addition, it causes adverse effects associated with more severe sleep deprivation such as cancer among shift workers (Knutsson, 2003; Papantoniou et al., 2018; Schernhammer et al., 2003). SJL is also linked to decreased working ability and performance as well as early disability pension in Japanese and Finnish populations (Okajima et al., 2021; Räihä et al., 2021). Due to the high prevalence of SJL (40-70%) and the negative effects of chronic form of sleep deprivation, SJL has all the qualities to be recognized as a public health epidemic.

SJL is caused by social obligations, therefore improving SJL requires relaxing social obligations. Whilst the globally anxiety-inducing COVID-19 pandemic has had various negative consequences, it has also provided a unique opportunity to research the effects of reduced social obligations and how remote work is associated with SJL. Before the pandemic, only 5.4% in the EU-27 countries usually worked from home and in Finland 30% of people sometimes or usually worked from home (The European Commission's science and knowledge service, 2020). However, the COVID-19 pandemic and its increased impact in 2020 (World Health Organization, n.d.) caused global action and most countries imposed restrictions or mandates which were an attempt to prevent the virus from spreading. These restrictions changed the way people worked or studied since many schools and workplaces were closed, which increased remote work. Remote work became a new norm for many since over a third (34%) of Europeans reported working from home during the pandemic (Eurofound, 2020).

The adverse effects of SJL are well documented, but research on the association between SJL and remote work is lacking. The initial hypothesis of this study is that remote work could alleviate social obligations, the main cause of SJL, by removing the need to commute and possibly offering more flexible working hours. This would lessen the friction between the biological and the social clocks and thus decreasing SJL. For example, 80% or more of working individuals use an alarm clock on their workdays, which indicates waking up before they would wake up naturally (Korman et al., 2020; Roenneberg et al., 2012). Remote work removes the need to commute, which gives individuals more time in the morning. More time in the morning together with the possibility of having more flexible working hours could allow people to sleep according to their natural sleep timing and thus relieve the discrepancy between the social and internal clocks.

In addition to social obligations, a person's internal clock affects SJL. Every person has an individual preference for the timing of sleep and activity, which is called chronotype (Roenneberg & Merrow, 2016). Chronotype ranges from early morning types to late evening types, where the former goes to sleep earlier, and the latter goes to sleep later than other chronotypes. This results in evening types usually having more SJL (Wittman et al, 2006) since they cannot go to sleep as early as morning types but are still forced to wake up at the same time due to social obligations. In addition to the initial hypothesis of this study, it is presumed that evening chronotypes would benefit more from remote work than other chronotypes since they have typically more SJL than other chronotypes.

## 1.1 Chronotype

A chronotype is an individual's preferred time for sleep and activity (Roenneberg & Merrow, 2016) and it affects when people feel the need to go to sleep and wake up. Individuals have little control over their chronotype since chronotype is based on biology, but other factors such as developmental and external factors influence how chronotype interacts with external factors to produce the sleep-wake rhythm. Chronotypes can vary from extreme morning types to extreme evening types while most of the population lies somewhere in between (Roenneberg, Daan & Merrow, 2003). There can be up to a 12hr difference in sleep timing between an extreme morning type and an extreme evening type (Roenneberg, Wirz-Justice & Merrow, 2003), meaning they do not sleep at the same time at all. A population study made by Räihä and his colleagues (2021) of Finnish adults showed that of the Finnish population 44.8% are morning types, 44.1% intermediate types, and 11.1% evening types.

Biological factors such as the internal clock and circadian system affect our chronotype. The internal clock is an evolutionary adaptation to our planet's 24-hour dark-light cycle. Our internal clock in isolation (free-running period) is not exactly 24 hours so it needs to be regularly entrained to external time. The "free-running period", which is the daily repeating cyclic behaviour of human's bodily functions (sleep and wake, body temperature, hunger, and digestion), was first studied by Aschoff and his colleagues (1965). They found it to be 25hr (Aschoff et al., 1965), but later studies showed it to be closer to 24 hours (Czeisler et al., 1999). This free-running period is genetic, where 80 to 90% of adults had longer than 24hr long free-running periods (Crowley & Eastman, 2018; Czeisler et al, 1999).

Since the free-running period is not exactly 24hr long it needs to be entrained. Entrainment happens when zeitgebers (German, time givers) synchronize the free-running period to match the dark-light rotation of the earth (Roenneberg et al., 2019). Zeitgebers are signals such as light, temperature, and nutrition, from which sunlight is the main entrainer (Roenneberg et al., 2019). Roenneberg, Daan, and Merrow (2003) illustrate the internal clock as an oscillator (pendulum or swing) that zeitgebers entrain to match external time by pushing the pendulum on different phases. Different free-running periods entrain to sunlight differently and free-running periods under 24 hours need to have their entrained phase earlier (lengthening their internal day to 24hr) than those with over 24 hours (shortening their internal day to 24hr) free-running period (Roenneberg & Merrow, 2016). Morningness associates with shorter free-running period than eveningness (Duffy et al., 2001).

## 1.2 Social Jetlag (SJL)

SJL is a form of circadian misalignment that resembles jetlag, from which the name originates (Wittman et al., 2006). In jetlag, our internal time is not aligned with the new light-dark cycle because we travel across several time zones too quickly. Because our entrainment mechanism takes one day per time zone to catch up, it takes several days before the internal and new external time are synchronized (Roenneberg et al., 2019). Symptoms of jetlag include daytime tiredness, sleep problems (inability to go to sleep, early awakenings, or disturbed night-time sleep), impaired alertness and performance, disorientation, and digestive problems (Kryger et al., 2005, Chapter 55, pp. 659-660).

Social obligations are the main cause of SJL. They cause shortened sleep during the workweek, which is compensated during the weekend by sleeping more. This combination of shortened sleep during the week and longer compensatory sleep during the weekend causes a shift of sleep timing and duration between weekdays and weekends. This shift can be quantified by calculating the absolute difference between mid-sleep (MS) on workdays (MSW) and mid-sleep on free days (MSF): $\Delta MS = |MSF - MSW|$, as proposed by Wittman and his colleagues (2006).

Shift work is an example of SJL and circadian misalignment due to the nature of rotating work schedules. Shift workers experience several hours, even up to six hours, of SJL during night shifts (Juda et al., 2013; Vetter et al., 2015). While evening types experience more SJL during normal working schedules (Wittman et al., 2006), in shift work morning and evening types both suffer from considerable SJL. SJL was observed to be highest for morning types in night shifts and highest for evening types in morning shifts (Juda et al., 2013).

SJL is associated with many adverse effects such as chronic sleep deprivation (Roenneberg, Kuehnle, et al., 2007; Wittmann et al., 2006), worse sleep quality (Wittmann et al., 2006 Roenneberg et al., 2012; Sűdy et al., 2019), smoking (Wittman et al., 2006), obesity (Roenneberg et al., 2012), and lower grades in university (Haraszti et al., 2014) and in high school (Díaz-Morales & Escribano, 2015). SJL is also associated with increased cortisol levels (Rutters et al., 2014), unhealthier habits, for example, less healthy diets (Mota et al., 2019; Zerón-Rugerio et al., 2019) and less physical activity (Alves et al., 2016). SJL is also associated with increased depressive symptoms (Islam et al., 2019; Levandovski et al., 2011) and decreased work performance in the Japanese population (Okajima et al., 2021). In the Finnish population SJL and eveningness were associated with decreased working ability and being on disability pensions during midlife (Räihä et al., 2021). The most adverse effect of extreme SJL, in shift workers, is its association with cancer (Knutsson, 2003; Papantoniou et al., 2018; Schernhammer et al., 2003).

### 1.3 Other factors affecting SJL, sleep, or chronotype

The study interest in this study are the possible association between remote work and SJL and whether evening chronotypes would benefit more from this association. However, to study this association, other factors affecting SJL, sleep, or chronotype must be taken into consideration since they might mediate the association between remote work and SJL. Such factors covaried in this study are age, sex, place of residence (urban-rural classification), self-reported health, household size, and stress.

Sex and age affect peoples’ chronotypes. On average females are earlier chronotypes than males, and chronotype peaks at its latest in females at 19.5 years of age and in males at 21 years of age, and this difference will gradually decline until it disappears around the age of 50 (Roenneberg et al., 2004). Similarly, SJL peaks during young adulthood (18-21 years) and starts to decline afterwards as we age (Gottlieb et al., 2022; Roenneberg et al., 2012).

Chronotype has a latitudinal cline and being farther away from the equator the later the chronotype is (Leocadio-Miguel et al., 2017). Place of residence (urban-rural classification) affects chronotype and sleep timing. Comparison of rural populations and urban populations has shown that in urban settings people go to sleep later (Carvalho et al., 2014), have 30 minutes later chronotype on average (Roenneberg & Merrow, 2007), and had two hours later circadian clock timing (Wright et al., 2013).

Self-reported health was covaried to be certain that the possible effect of remote work on SJL would not be due to self-reported health. Household size was also covaried since a higher number of children in the households has been associated with insufficient sleep in a previous study (Chapman et al., 2012). Stress was covaried since it often leads to anxiety and insomnia (Sleep Foundation, 2022, June 24). The COVID-19 pandemic has increased anxiety and depression prevalence worldwide by 25% according to World Health Organization (2022, March 2). In addition, the Russian invasion of Ukraine has incited a lot of public discourse in Finland, and together with Finland's shared border and war history with Russia (Winter and Continuation war) is expected to cause stress and anxiety. Therefore, stress related to the COVID-19 pandemic and the Russian invasion of Ukraine was covaried.

### 1.4 Systematic review of the effects of COVID-19 restrictions on SJL

The initial hypothesis of this study is that remote work could alleviate social obligations, the main cause of SJL, by removing the need to commute and possibly offering more flexible working hours and that evening chronotypes would benefit more from remote work than other chronotypes since they have typically more SJL than other chronotypes. However, the initial hypothesis should be supported by previous research, and thus a systematic review of the effects of COVID-19 restrictions on SJL and whether there were any studies associating remote work or chronotype with SJL, was conducted. Research questions for systematic review were 1) are COVID-19 restrictions associated with SJL and 2) are there studies associating remote work or chronotype with SJL. These results are presented in Table 1. Database search, quality assessment of included articles, description of material and results, and study limitations are presented in Appendix 1.

**Table 1**

Studies included in the systematic review of the effects of COVID-19 restrictions on social jetlag (SJL) that have studied SJL change from no restrictions (before or after COVID-19) to during restrictions

| **Study**<br>Authors<br>Data countries | **Sample**<br>*n* (females %)<br>Age ($M \pm SD$) | **Design**<br>Data inquiry method<br>How data were collected | **Results**<br>Baseline SJL<br>SJL change | **Associations with remote work (RW) and chronotype (C)** |
|---|---|---|---|---|
| Benedict et al., 2021<br>Sweden | *n* = 191 (77.5%)<br>Age = 47.2 ± 13.1 | Survey<br>Retroactive data collection | Baseline = 64 min<br>SJL = dec. 17 min *** | RW = -<br>C = - |
| Blume et al, 2020<br>Three countries[1] | *n* = 435 (75.2%)<br>Age = 26-35 (*Mdn*) | Survey<br>Retroactive data collection | Baseline = -<br>SJL = dec. 13 min (*Mdn*) *** | RW = linked to SJL reduction<br>$p$ =.014, $d$ =0.27<br>C = SJL reduced especially in later C<br>$p$ =.037, $d$ = 0.22 |
| Bottary et al., 2022<br>USA | *n* = 610 (82.9%)<br>Age = 39.24 ± 17.45 | Survey<br>Before and during restrictions | Baseline = -<br>SJL = dec. 19.3 min *** | RW = -<br>C = evening chronotype associated with SJL ($p$ =.011) until age was considered ($\tau$ = .36, SE = .33, 95% *CI* [−.20;1.16], $p$ = .20 |
| Brandão et al, 2021<br>14 countries | *n* = 14 968 (68.0%)<br>Age = 40 | Survey<br>Retroactive data collection | Baseline = 59 min<br>SJL = 46% dec by 58 min and 20% inc by 44 min *** | RW = -<br>C = later C was associated with both dec and inc SJL groups[2] |
| Florea et al., 2021<br>Six countries[3] | *n* = 370 (-)<br>Age = 39.2 ± 11 | Survey<br>During and after restrictions | Baseline = 80 min<br>SJL = dec 23 min *** | RW = system relevant job had higher SJL than system irrelevant job[4]<br>$F(1, 325) = 10.29$, $p$ < .001, $\eta^2$ = 0.031)<br>C = - |
| Korman et al., 2020<br>40 countries | *n* = 7517 (68.2%)<br>Age = 32.7 ± 9.1 | Survey[5]<br>Retroactive data collection | Baseline = -<br>SJL = dec 29 min *** | RW = decreased more SJL than work at workplace***<br>C = indirect indication that later C had more SJL red. $\rho = -0.593$, $p < .001$[6] |
| Leone et al., 2020<br>Argentina | *n* = 1021 (69.6%)<br>Age (first survey) = 37.43 ± 13.21<br>Age (second survey) = 38.67 ± 13.247 | Survey<br>Before and during restrictions | Basellline = 107 min<br>SJL = dec 54 min ***<br>$d$ = .682 | RW = decreased more SJL than work at workplace<br>$F(3, 951) = 13.73$,<br>$p$ < .001, $n^2_p$ = .041<br>C = - |
| Massar et al., 2022<br>Singapore | *n* = 198 (69.2%)<br>Age = 26.15 ± 5.83 | Wearable technology<br>Longitudinal | Baseline = 31 min<br>SJL dec 7.9 min ***<br>$r$ = - 0.23[7] | RW = not associated with SJL red. $p$ > .50[8]<br>C = - |
| Ong et al., 2021<br>Singapore | *n* = 1824 (51.6%)<br>Age = 30.94 ± 4.62 | Wearable technology<br>Longitudinal | Baseline = 58 min<br>[9]SJL= dec 8 min and 15 min *** | RW = -<br>C = - |
| Raman & Coogan, 2022<br>Ireland | *n* = 797 (62.4 %)<br>Age = 40.2 ± 12.7 | Survey<br>Retroactive data collection | Baseline = 66 min<br>SJL = dec 29 min *** | RW = decreased more SJL than work in workplace ***<br>$\eta^2_p$ = 0.028<br>C = - |
| Ramírez-Contreras et al., 2022<br>Spain | *n* = 139 (85%)<br>Age = 20 – 30 (range) | Questionnaire<br>Case control study[10] | Baseline = -<br>SJL = dec 42 min *** | RW = -<br>C = - |
| Staller & Randler, 2021<br>Germany | *n* = 681 (71.1%)<br>Age = 28.63 ± 10.49 | Survey<br>Retroactive data collection | Baseline = 99 min<br>SJL = dec 50 min -[11] | RW = -<br>C = - |
| Tahara et al., 2021<br>Japan | *n* = 30 275 (73.7%)<br>Age = 36.3 (M) | Survey<br>Retroactive data collection | Baseline = 48 min<br>SJL = dec 13 min[12] | RW = -<br>C = - |
| Tanioka et al., 2022<br>Japan | *n* = 2222 (75.5%)<br>Age = 21.9 ± 4.4 | Survey<br>Before and during restrictions | Baseline = 84 min<br>SJL dec 18 min *** | RW = -<br>C = - |
| Wright et al., 2020<br>North America | *n* = 139 (70.5%)<br>Age 22.2 ± 1.7 | Sleep log data<br>Before and during restrictions | Baseline = 54 min<br>SJL dec 18 min ** | RW = -<br>C = - |

*Note.* Number of studies = 15, total $N$ = 61 387. In **design,** retroactive data collection means that participants were asked retroactive information of their sleep before restrictions. **Results** report average baseline during no restrictions and average SJL change from no restrictions to during restrictions and **Associations** report the association between SJL and remote work (RW) or Chronotype (C).

dec = decreased; inc = increased; *Mdn* = median; red = reduction; SJL = social jetlag.

[1] Sample was a convenience sample. The data were gathered from Austria, Germany, and Switzerland.

[2] Midsleep was later in increased and reduced SJL groups than in unchanged SJL groups both before and during pandemic *** which indicates later chronotype in those groups.

[3] Austria, Brazil, Cuba, Germany, Greece, and Ukraine.

[4] System relevant jobs (increased workload due to pandemic for example health care) had to work at workplaces while irrelevant jobs could work from home.

[5] The survey is called Global Chrono Corona Survey (GCCS).

[6] Later chronotypes suffered more pre- COVID-19 SJL (***) and it had negative correlations with SJL change. In essence, later chronotype correlated with larger SJL change.

[7] $r$ is an effect size for nonparametric tests such as Wilcoxon signed-rank tests used here.

[8] There were 24 participants excluded from these analyses since they did not report any working days, so the sample size for these analyses is, $n$ = 174.

[9] SJL decreased from baseline by 8 min during increased restrictions and 15 min during lockdown on average.

[10] The study was case control study in which they compared pre-pandemic and during pandemic groups.

[11] This study did not directly report data on SJL change, but they reported midsleep changes during weekdays and weekends before and during restrictions, which are used to calculate SJL. Midsleep change was statistically significant both during weekdays ($t$ = 17.30, $p$ < .001) and during weekends ($t$ = -3.48, $p$ = .001), which resulted SJL to decrease on average 50 minutes (before restrictions: $M$ = 1:39, $SD$ = 1:00 vs. during restrictions $M$ = 0:49, $SD$ = 0:42).

[12] This study reported significant interaction effects between age and restrictions in two-way repeated ANOVA ($p$ < .001). Post hoc analyses observed that participants aged 10 – 60 years had lower SJL during restrictions than before restrictions ($p$ < .001). In the table average SJL baseline and SJL change are reported from the whole sample from this study ($n$ = 30 275).

***$p$ < .001, **$p$ < .01, *$p$ < .05, - no data.

This systematic review strongly implies that during reduced social obligations (COVID-19 restrictions) SJL decreases. All studies, except one (14/15) found SJL to be lower during COVID-19 restrictions compared to without restrictions (either before or after restrictions). This one study (Brandão et al, 2021) found that some participants (20%) increased, and nearly half of the participants (46%) decreased SJL from before restrictions to during restrictions. Few studies also associated later chronotype and remote work with decreased SJL. However, the effect sizes of these associations were inadequately reported, so more precise conclusions are hard to draw. These results are documented in more detail in Appendix 1. Nevertheless, any amount of SJL reduction is beneficial because SJL is linked to many adverse health outcomes. Korman and her colleagues (2020) propose that about 20 minutes is tolerable amount of SJL. In their study participants with over 20 minutes of SJL before restrictions tend to reduce SJL, and participants with under 20 minutes of SJL before restrictions tend to have small or no changes at all.

### 1.5 Aims of the study

The purpose of this study was to 1) examine the association between remote work and SJL, sleep duration, and self-reported sleep quality as well as 2) find out if these associations differed among chronotypes. Initially, the hypothesis was that remote work could alleviate social obligations, the main cause of SJL, by removing the need to commute and possibly offering more flexible working hours and that evening chronotypes could benefit most from remote work since they have typically more SJL than other chronotypes. However, the initial hypothesis should be supported by previous research and thus a systematic review was conducted.

The result of the systematic review makes the initial hypothesis plausible by showing associations between reduced social obligations and SJL and by showing a few associations between later chronotype and remote work with reduced SJL. Since remote work associated with reduced SJL, this study hypothesizes that other sleep parameters, such as sleep duration and self-reported sleep quality, would positively associate with remote work. Therefore, the study hypotheses are as follows. Remote work is associated with 1a.) longer sleep duration, 1b.) better self-reported sleep quality, and 1c.) smaller amount of SJL. In addition, the study hypotheses include that 2) these associations are expected to be strongest among evening chronotypes.

The study included only people who work or study full-time and do not have serious sleep problems. This was done for the results of this study to reflect only the association between remote work and sleep parameters, and not poor sleep for a variety of reasons. Therefore, all other work modes (shift work, part-time), people with very short or long sleep duration, people suffering from insomnia, people with low ability to work, and people with self-reported mental health issues were excluded.

# 2 Methods

## 2.1 CLIMATE NUDGE survey

This study utilizes data from the survey conducted in The Climate Nudge Project (https://ilmastotuuppaus.fi/). The data for the project was collected by the market research company Kantar TNS. Kantar TNS collected the data between 19 April 2022 to 16 May 2022. The study sample consists of 3,600 participants aged 18-79 and is representative of the Finnish general population regarding age, gender, and place of residence. Kantar recruited participants from their participant register, and the participants answered the survey online while receiving small monetary compensation. A more detailed explanation of the data collection procedures can be found in the data collection registration: https://osf.io/3s8uc. The Climate Nudge survey (CNS) was approved by the Ethics Committee for Human Sciences at the University of Turku.

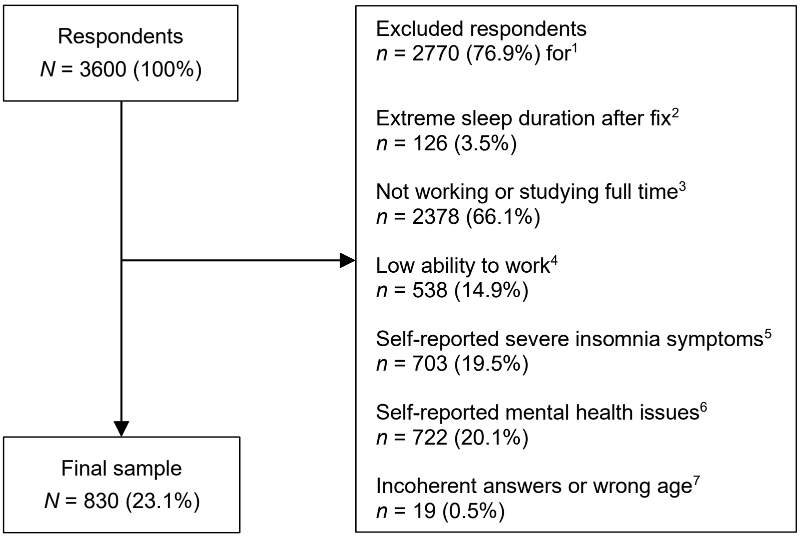
The Climate Nudge survey (CNS; 2022) survey was divided into five sections (Background; Climate change; Acceptability and politics; Car use and commuting; and Well-being) and this study utilizes only a small portion of it. A more elaborate explanation of the survey sections and questions can be found in the data collection registration (https://osf.io/3s8uc). Participants could answer in Finnish, Swedish, or English. In addition, participants were asked for their demographic information (postal code, age, gender, employment, level of education, and children in the household).

## 2.2 Study participants

The total number of respondents was 3,600 ($M$ = 53.7, $SD$ = 16.9 years, range 19-90, 55.8% females). Exclusion criteria for this study were extreme sleep duration (3hr or less and 14hr or more), not working or studying full time, self-reported insomnia symptoms almost every night, self-reported mental health issues, and low ability to work. After these exclusions, there were 18 incoherent answers regarding work status and one reported age outside of the 18-79 age range. Thus, the final sample consisted of 830 respondents (Age: $M$ = 45.5, $SD$ = 11.4, range 19-69, 46.9% females), of which 750 (90.4%) were workers and 80 (9.6%) were students. These strict exclusion criteria resulted in the final sample to represent healthy adult working force, rather than the general Finnish population, which the original study sample of 3600 participants did. A more detailed explanation of exclusion criteria and a flowchart of included respondents are presented in Figure 1.

**Figure 1**

Flowchart of included respondents in this study




*Notes.* Reported percentages are from the entire sample ($N$ = 3600).

[1]The total number of respondents excluded was 2770 (76.9%). There were multiple exclusion criteria, and a participant could belong to one or more exclusion categories. Therefore, adding frequencies and percentages in exclusion categories does not result in 2770 (76.9%).

[2]The proportion of participants reporting extreme sleep duration was abnormally high ($n$ = 501*,* 13.9%). A previous study (Korman et al., 2020) used similar cut-off points and reported a lot smaller proportion of participants with extreme sleep (< 3hr and >14hr; 3.1%). It was assumed that participants confused 12hr and 24hr time formats when answering questions related to bed and wake up times which resulted in reported extreme sleep duration being so high (13.9%). Therefore, the frequency of participants was examined who reported bedtime between 6.00 and 12.00 during weekdays (10.0%) and during weekends (9.0%) which is unrealistic in comparison with sleep times in Munich Chronotype Questionnaire (MCTQ) database, where during weekdays 1.5% and during weekends 8.9% participants go to sleep after 3.00 (Roenneberg, Kuehnle, et al., 2007). To fix this 12hr were added to participants' bedtimes between 6.00 and 12.00 ($n$ = 451, 12.9%). This fix lowered extreme sleep duration from 13.9% ($n$ = 501) to 3.5% ($n$ = 126) which is similar in size to a previous study (Korman et al., 2020).

[3]Unemployment or pension ($n$ = 1499, 41.6%); shift work, part-time work, laid off or other work status ($n$ = 817, 22.7%); and home with children ($n$ = 62, 1.7%) were assessed with one question which asked the current working status of the participants. These were excluded, for the data to be limited strictly to full-time workers and students with normal sleep schedules.

[4] Low ability to work was assessed in the Climate Nudge survey (CNS) with a self-assessment from zero (could not work at all) to ten (work ability at its best). People who assessed their work ability between zero and three were considered having a low work ability.

[5] Self-reported severe insomnia symptoms were assessed in CNS with adapted four items from Jenkins Sleep Scale-4 (JSS-4), that assess sleep problems from the previous 4 weeks. These adapted four items were difficulties to fall asleep, difficulties maintaining sleep (waking up several times during night), you have had to wake up too early in the morning, and nonrestorative sleep (you have felt excessively sleepy after waking up after normal night of sleep). These are scaled as a Likert-type scale in this data (1 = not at all, 2 = few times a month, 3 = about once a week, 4 = several time a week, 5= almost every night). In a previous study (Juhola et al., 2021) of internal consistency of JSS, participants were considered having sleep difficulties, if they answered yes (over 15 nights in previous 4 weeks) to any of these four items. This study's adapted version of JSS-4 would characterize frequent insomnia if participants reported sleep problems multiple times per week (4) or almost

every night (5). With this criterion, 48.2% of participants reported having frequent insomnia. In a study measuring JSS-4's psychometric properties, 33% of participants reported having zero sleep problems, that is they answered "not at all" to all questions (Tibubos et al., 2020). In this study, this proportion was 7%. This study data shows a large proportion of frequent insomnia symptoms and a small proportion of having no sleep symptoms at all. It is not meaningful to exclude half of the study data due to frequent insomnia, so participants who reported having sleep problems almost every night, were only excluded. In this study 19.5% participants reported having sleep problems almost every night (self-reported severe insomnia symptoms), which is still a large proportion. One reason for this could be a huge proportion of people without a job or they were on pension (41.6%) which in a previous study (Tibudos et al., 2020) was linked to increased sleep problems.

[6]Self-reported mental health issues were assessed in CNS with the following questions. Have you had one or more of the following health problems during the last 12 months; depression, anxiety disorder, panic disorder, or some other mental health problem? If participant reported having any of these, they were considered to have self-reported mental health issues.

[7]Those participants who reported incoherent answers reported working or being a student in one question and in another question, they did not report working or being a student. One person reported an age outside of 18-79.

## 2.3 Measures

Dependent variables in this study were sleep duration, self-reported sleep quality, and SJL. Sleep duration was divided into sleep duration during weekdays and weekends. The independent variable in this study was remote work and covariates were age, gender, self-reported health, stress related to the COVID-19 pandemic and the Russian invasion of Ukraine, and chronotype.

**Sleep duration, self-reported sleep quality, and SJL**. Because the study data came from a population level survey, actual sleep duration could not be measured. Therefore, sleep duration was estimated with self-reported average bed- and wake up times, assessed in the survey, which were used to calculate sleep duration. Participants were asked separately in the survey about their sleep duration during weekdays, which was defined as "those nights when you have to study, work…the following morning", and weekends which was defined as "those nights when you do not need to do anything in particular the following morning". In this study, the terms weekday and weekend refer to workdays and free days, which for many are the same as weekdays and weekends. Self-reported sleep quality was assessed with the question, "How would you rate your sleep quality overall?", in a Likert-scale (1 = Good, 2 = Fairly good, 3 = not bad nor good, 4 = Fairly bad, 5 = Bad). Original quantification by Wittman and his colleagues (2006) was used to define SJL in this study, where SJL is an absolute difference between midsleep (MS) during free days (weekend = MSF) and workdays (weekday =MSW; SJL = ΔMS =MSF−MSW). The Midpoint of sleep was calculated with the following formula (bedtime + 0.5(sleep duration)) for weekdays and weekends. Positive SJL means that sleep timing (midpoint of sleep) is later during weekends and negative SJL means that sleep timing is earlier during weekends.

**Remote work**. Remote work was operationalized from the question, “How many days a week do you currently spend at your place of work or study?” with response options from zero to seven times per week. This question was dichotomized into work modality, which was divided into remote work and work at the workplace. Participants belonged to remote work group if they reported any amount of remote work (0-4 days at the workplace) and into the work at workplace group when they reported working a full week at the workplace (5-7 days at the workplace). This was done so that sleep variables (bedtime and wake up time, sleep duration, self-reported sleep quality, and SJL) could be compared between work modalities. Another reason to dichotomize groups was because division into three categories (no remote work, hybrid work, and a lot of remote work) would have resulted in unequal groups. This division is arbitrary, and it compares participants who reported any amount of remote work with people working full time at their place of work or study, which is five to seven days. This process is presented in Table 2. The same question was operationalized as the frequency of work at the workplace, where a higher score indicates a higher frequency of work at workplace and a lower score indicates lower frequency of work at workplace, which was interpreted as an indication of remote work. In combination with the study’s exclusion criteria for participants, this guarantees that reported values represent remote work or work at the workplace since all the study participants are working or studying full time, and for example, two reported workdays at the workplace means at least three workdays done remotely. This duality of operationalization was made to simplify study results (work modality) and to perform linear regression and general linear models (GLM) with remote work as a continuous independent variable.

**Table 2**

Frequency of work at the workplace distribution dichotomized into work modality

| Frequency of work at the workplace | | | Work modality | |
|---|---|---|---|---|
| | Frequency | % | Remote work | Work at workplace |
| 0 | 97 | 11.7 | 395 (47.6%) | |
| 1 | 92 | 11.1 | | |
| 2 | 71 | 8.6 | | |
| 3 | 66 | 8.0 | | |
| 4 | 69 | 8.3 | | |
| 5 | 412 | 49.6 | | 435 (52.4%) |
| 6 | 10 | 1.2 | | |
| 7 | 13 | 1.6 | | |

*Note*. Work modality was dichotomized as remote work when 0-4 days of workdays were done remotely and as work at the workplace when 5-7 workdays were done at the place of work. This resulted in two groups where one does any amount of remote work (1 to 5 workdays done remotely which is 0-4 days of work at the workplace) with a full week of work at the workplace (5 to 7 workdays done at the workplace).

**Chronotype**. Chronotype was assessed with the Morningness-Eveningness questionnaire (MEQ). MEQ correlates with circadian rhythms measured by body temperature (Horne & Ostberg, 1976), and dim light melatonin onset (DLMO), which is regarded as the most reliable measure of circadian timing (Kantermann et al., 2015). This study used shortened Finnish version of MEQ (MEQs), which had 6 items. This shortened MEQ uses 6 items which explain 83% of the total variation from the original full MEQ (Hätönen et al., 2008) These items asses 1) easiness to wake up in the first half an hour, 2) tiredness in the first half an hour, 3) anticipated performance in the morning (7.00-8.00), 4) preferred timing of 2hr physical labour, 5) desired timing of 5h long period of work which pays according to results, and 6) self-assessment of being a morning or evening type. From these questions, total sum score is calculated, and this study used cut-off points previously determined by Merikanto et al (2012), which were validated for the Finnish population (5-12 = evening type, 13-18 = intermediate type, and 19-27 = morning type). The internal consistency of MEQs in this study was measured with Cronbach alpha and McDonald Omega. The internal consistency was acceptable for the whole population ($N = 3600$, $\alpha = .729$, $\omega = .775$) and for the final study sample ($n = 830$, $\alpha = .697$, $\omega = .766$). McDonald Omega is nearing a good level of internal consistency.

**Covariates**. Age, gender, place of residency (urban-rural classification), self-reported health, household size, and stress were covaried in GLM analyses due to their associations with sleep or SJL. They were measured as follows: gender (female, male, other), age (numeric), self-reported health (1 = good, 2 = fairly good, 3 = mediocre, 4 = fairly bad, 5 = bad), and stress related to COVID-19 pandemic and the Russian invasion of Ukraine (1 = has significantly increased stress I experience, 2 = has slightly increased stress I experience, 3 = has not affected stress I experience, 4 = has decreased stress I experience). Because self-reported health and stress items were inverted, low scores on these items indicate higher levels of health (better health) and stress. Place of residency (urban-rural classification) was categorized in the survey with the same categories used by the Finnish environment institute (SYKE, 2021; 1 = sparsely populated rural areas, 2 = rural heartland areas, 3 = rural areas close to urban areas, 4 = local centres in rural areas, 5 = peri-urban area, 6 = outer urban area, 7 = inner urban area. However, for this study's purposes, these categories were combined into four categories, which would even out the group sizes (1 = sparsely populated rural areas [sparsely populated rural areas and rural heartland areas], 2 = densely populated rural areas [rural areas close to urban areas and local centres in rural areas], 3 = sparsely populated urban areas [peri-urban area], and 4 = densely populated urban areas [outer urban area and inner urban area]).

## 2.4 Statistical analyses

Preliminary analyses included a normality test for dependent variables, correlations for continuous variables, *t*-tests for dichotomic variables, and analysis of variance (ANOVA) for categoric variables to see if the independent variable (remote work as a continuous variable) or covariates explained variation in the dependent variables. These preliminary analyses were performed to check the assumptions of linear models. All variables showed a significant association at least with some or all dependent variables, except household size and place of residence (urban-rural classification) which were dropped from GLM's. The results of these preliminary analyses are presented in Appendix 2.

Primary analyses consisted of three parts. The First part consisted of comparing work modalities (remote work and work at the workplace) to see the association between remote work and dependent sleep variables (sleep duration, self-reported sleep quality, and SJL), as well as bed- and wake up times. These analyses were done with independent samples *t*-tests. The Second part was to model the association between remote work and the dependent sleep variables. In these analyses, continuous variable of remote work (frequency of work at the workplace) was used. Correlations and simple linear regression models were used to model the association between remote work and the dependent sleep variables. After this, GLM's were constructed to see if associations from correlations and simple linear models stayed significant after covariates, which were gender, age, self-reported health, stress related to the COVID-19 pandemic and the Russian invasion of Ukraine, and chronotype, were considered. The Third part of the analyses was to compare whether different chronotypes showed different magnitude of effect on these associations from previous analyses (correlations, simple and general linear models), where the evening chronotype was expected to have the largest associations. This was done by dividing participant into groups based on chronotype and then performing same correlations, linear regression models, and GLM's that were used when examining hypotheses 1a, 1b, and 1c.

Throughout the study, an alpha level of .01 will be used to decrease the possibility of type I error, to combat the effect of high sample sizes on *p*-value, and to alleviate the multiple comparison problem. All statistical analyses were conducted with SPSS Statistics Version 27.

# 3 Results

The final sample consisted of 830 respondents (Age: *M* = 45.5, *SD* = 11.4, range 19-69, 46.9% females). The final sample had 289 (34.8%) morning types, 409 (49.3%) intermediate types, and 132 (15.9%) evening types. Chronotype distribution as well as other covariates and frequency of work at the workplace are presented in Table 3

**Table 3**

Descriptives of frequency of remote work and covariates

| | | Total ($n$ = 830) | | Men ($n$ = 441) | | Women ($n$ = 389) | |
|---|---|---|---|---|---|---|---|
| | | $n$ / $M$ | % / $SD$ | $n$ / $M$ | % / $SD$ | $n$ / $M$ | % / $SD$ |
| Age | | 45.51 | 11.40 SD | 46.55 | 10.67 SD | 44.32 | 12.09 SD |
| Chronotype | Morning | 289 | 34.8% | 150 | 34.0% | 139 | 35.7% |
| | Intermediate | 409 | 49.3% | 215 | 48.8% | 194 | 49.9% |
| | Evening | 132 | 15.9% | 76 | 17.2% | 56 | 14.4% |
| Work modality | Work at the workplace | 435 | 52.4% | 231 | 52.4% | 204 | 52.4% |
| | Remote work | 395 | 47.6% | 210 | 47.6% | 185 | 47.6% |
| Frequency of work at the workplace | | 3.52 | 1.94 SD | 3.50 | 1.99 SD | 3.53 | 1.87 SD |
| Work status | Full time work | 750 | 90.4% | 409 | 54.5% | 341 | 45.5% |
| | Student[1] | 80 | 9.6% | 32 | 40.0% | 48 | 60.0% |
| Household size[2] | | 2.11 | 1.19 SD | 2.10 | 1.14 SD | 2.14 | 1.24 SD |
| Self-reported health | | 1.91 | 0.77 SD | 1.95 | 0.78 SD | 1.85 | 0.77 SD |
| Stress related to COVID-19 | | 2.51 | 0.71 SD | 2.63 | 0.67 SD | 2.37 | 0.73 SD |
| Stress related to Russian invasion of Ukraine | | 2.12 | 0.69 SD | 2.22 | 0.70 SD | 2.00 | 0.65 SD |

*Note*. *n* = 830, Age: 45.51 ± 11.40, range 19-69, 46.9% females).

[1] Students (*n* = 80) are grouped together, but they are divided into university students (*n* = 42, 52.5%), university of applied science students (*n* = 21, 26.25%), vocational school students (*n* = 9, 11.25%), and high school students (*n* = 8, 10.0%).

[2] Household size of one means a person lives alone.

## 3.1 Preliminary analyses: assumptions of linear models

Assumptions of linear models were met, and these preliminary analyses are presented in the Appendix 2. The results of these preliminary analyses were that household size and place of residence (urban-rural classification) were dropped from covariates since they did not associate with any of the dependent sleep variables. Other covariates showed associations with at least some of the dependent sleep variables, so they were included in the analyses. In addition, chronotype associated with SJL and self-reported sleep quality. Morning types had lower SJL than intermediate or evening types and morning types had better self-reported sleep quality than evening types.

## 3.2 Comparing sleep duration, self-reported sleep quality, and SJL between work modalities

Sleep variables were compared between work modalities with independent samples *t*-tests and these results are presented in Table 4. On weekdays remote work group went to bed later than those participants working at the workplace. This effect was small. On weekdays remote work group woke up later than those participants working at the workplace. This effect was medium to large-sized. Figures 2 and 3 present differences between work modalities in sleep duration, during weekdays and weekends, and in SJL. On weekdays remote work group had longer sleep duration than those participants working at the workplace. This effect was small. Remotely working participants had lower SJL than those participants working at the workplace. This effect was medium sized. On weekends, there were no differences in bedtimes, wake up times, sleep duration, and self-reported sleep quality between work modalities.

**Table 4**

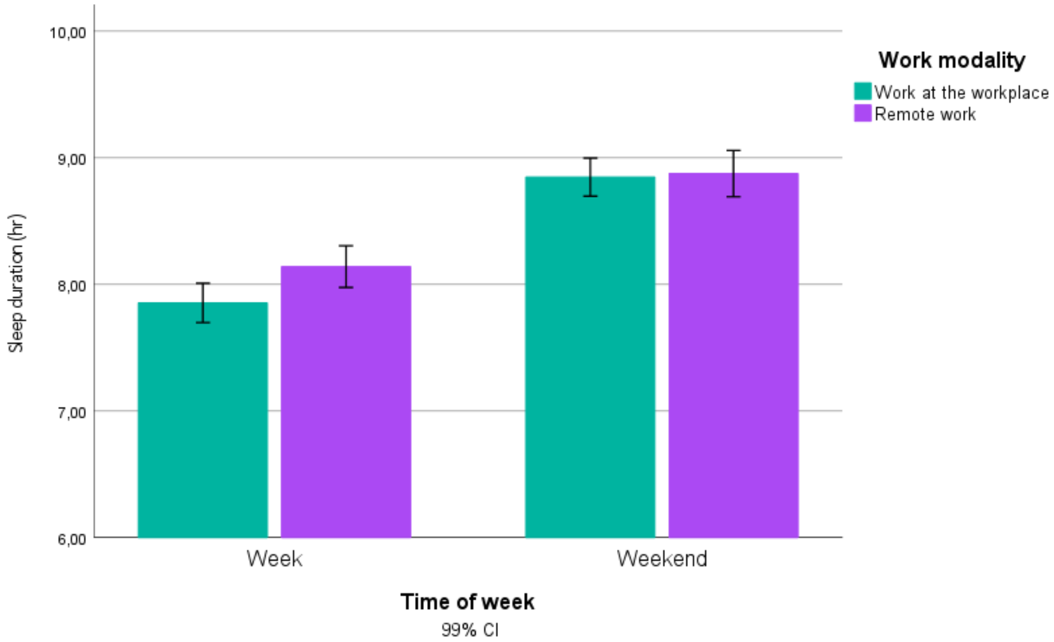
Comparison of sleep variables between work modalities

| | Work modality | | | | |
|---|---|---|---|---|---|
| | Remote work ($n$ = 395) | Work at the workplace ($n$ = 435) | | | |
| | $M \pm SD$ | $M \pm SD$ | $t(df)$ | $p$ | $d$ |
| Bedtime weekday | 22:52 ± 1:23 | 22:30 ± 1:18 | 3.90(828) | **< .001** | .271 |
| Bedtime weekend | 23:26 ± 1:35 | 23:17 ± 1:23 | 1.37(828) | .172 | .095 |
| Wake up time weekday | 7:01 ± 1:01 | 6:22 ± 0:59 | 9.35(828) | **< .001** | .649 |
| Wake up time weekend | 8:19 ± 1:21 | 8:08 ± 1:19 | 1.84(828) | .067 | .128 |
| Sleep duration weekday | 8:08 ± 1:16 | 7:51 ± 1:15 | 3.28(828) | **.001** | .228 |
| Sleep duration weekend | 8:52 ± 1:24 | 8:51 ± 1:13 | 0.31(828) | .758 | .021 |
| SJL | 0:56 ± 0:50 | 1:17 ± 0:56 | -5.70(827.72) | **< .001** | -.394 |
| Self-reported sleep quality | 2:15 ± 0:83 | 2:12 ± 0:87 | 0.43(828) | .668 | .030 |

*Note*. Comparisons between work modalities were made with independent samples *t*-tests. Welch *t*-test was used for SJL due to unequal variances between work modalities. Times are presented as hh:mm. Statistically significant differences are bolded in the table.

**Figure 2**

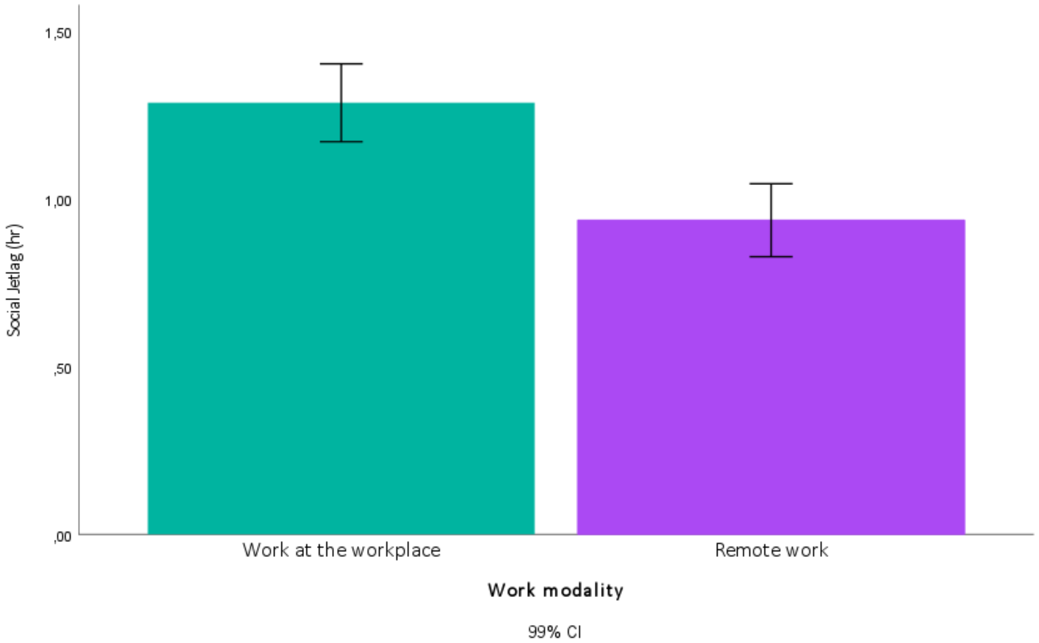
Comparison of sleep duration between work modalities during weekdays and weekends




*Note*. Independent samples *t*-tests were used to compare sleep duration between work modalities. Sleep duration is presented in hours.

**Figure 3**

Comparison of SJL between work modalities




*Note*. Welch *t*-test was used to compare SJL between work modalities. Welch *t*-test was used due to unequal variances between work modalities. SJL is presented in hours.

## 3.3 The association of work at the workplace with sleep duration, self-reported sleep quality, and SJL

The association between work at the workplace and dependent sleep variables was analysed with correlations, simple linear regression models, and GLM's. Correlations between work at the workplace and dependent sleep variables are presented in Table 5 and the association of work at the workplace with dependent sleep parameters, in the total sample, and among chronotypes, were analysed with simple linear regression and GLM and these results are presented in Tables 6 to 9. The associations between other covariates and dependent sleep parameters, in the GLM analyses, are presented in the supplementary data Tables 2 to 5 (Appendix 3).

**Table 5**

Correlations between work at the workplace and dependent sleep variables in total sample and among chronotypes

| | Pearson correlation | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Total sample** (*n* = 830) | | **Morning type** (*n* = 289) | | **Intermediate type** (*n* = 409) | | **Evening type** (*n* = 132) | |
| | ***r*** | ***p*** | ***r*** | ***p*** | ***r*** | ***p*** | ***r*** | ***p*** |
| | Frequency of work at the workplace | | | | | | | |
| Sleep duration during weekdays | -.109 | **.002** | -.028 | .641 | -.129 | **.009** | -.177 | .042 |
| Sleep duration during weekends | .014 | .693 | .023 | .698 | .024 | .624 | .013 | .885 |
| Self-reported sleep quality | .007 | .832 | .008 | .888 | .005 | .920 | .067 | .444 |
| SJL | .167 | **< .001** | .182 | **.002** | .183 | **< .001** | .211 | .015 |

*Note*. Pearson correlation coefficient was used to analyse the association between work at the workplace and dependent sleep variables. Statistical significance level is set at alpha level .01 and are bolded in the table. Near statistical significance .01-.025 is highlighted with grey colour.

Associations between the frequency of work at the workplace and sleep duration during weekdays are presented in Tables 5 and 6. On weekdays frequency of work at the workplace correlated negatively with sleep duration. Frequency of work at the workplace was a statistically significant predictor of sleep duration and stayed as a statistically significant predictor after the inclusion of covariates. More workdays at the workplace associated with shorter sleep duration during weekdays. This effect was small.

Among chronotypes, a statistically significant association between work at the workplace and sleep duration on weekdays was observed in intermediate types and not in evening types and morning types. These associations stayed similar after the inclusion of covariates. In intermediate types, work at the workplace associated with shorter sleep duration during weekdays with a small effect. In evening types, the association between work at the workplace and shorter sleep duration during weekdays was not statistically significant, but the effect size was small.

## Table 6

The association between work at the workplace and sleep duration during weekdays in total sample and among chronotypes was analysed with simple linear regression in model 1 and further analysed with GLM, which included covariates in model 2

| | Sleep duration on weekdays | | | | | |
|---|---|---|---|---|---|---|
| **Frequency of work at the workplace** | ***B*** | ***SE*** | **99% *CI*** | ***t*** | ***p*** | ***$R^2$ / $\omega^2_p$*** |
| **Total sample (*n* = 830)** | | | | | | |
| Model 1 | -0.07 | 0.02 | [-0.13, -0.01] | -3.15 | **.002** | .012 |
| Model 2 | -0.07 | 0.02 | [-0.13, -0.01] | -3.05 | **.002** | .010 |
| **Morning type (*n* = 289)** | | | | | | |
| Model 1 | -0.02 | 0.03 | [-0.10, 0.07] | -0.47 | .641 | .001 |
| Model 2 | -0.02 | 0.03 | [-0.10, 0.07] | -0.55 | .580 | .000 |
| **Intermediate type (*n* = 409)** | | | | | | |
| Model 1 | -0.09 | 0.03 | [-0.18, -0.001] | -2.62 | **.009** | .017 |
| Model 2 | -0.09 | 0.03 | [-0.18, 0.00] | -2.58 | **.010** | .014 |
| **Evening type (*n* = 132)** | | | | | | |
| Model 1 | -0.12 | 0.06 | [-0.28, 0.03] | -2.05 | .042 | .031 |
| Model 2 | -0.12 | 0.06 | [-0.28, -0.04] | -1.93 | .056 | .020 |

*Note*. The association between work at the workplace and sleep duration during weekdays in the total sample and among chronotypes was analysed with simple linear regression in model 1 and further analysed with GLM, which included covariates (gender, age, self-reported health, stress related to COVID-19 and Russian invasion of Ukraine, and chronotype) in model 2. Statistical significance level is set at alpha level .01 and is bolded in the table. Near statistical significance .01-.025 is highlighted with grey colour. For simple linear regression $R^2$ and for GLM partial Omega squared ($\omega^2_p$) was used as an effect size estimator.

Sleep duration is measured in hours, which affects the interpretation of Beta coefficient (*B*).

CI = confidence interval, LL = lower limit, UL = upper limit.

The associations between the frequency of work at the workplace and sleep duration during weekends are presented in Tables 5 and 7. On weekends, the frequency of work at the workplace did not associate with sleep duration. Among any of the chronotypes, no association was observed between the frequency of work at the workplace and sleep duration during weekend.

Associations between frequency of work at the workplace and self-reported sleep quality are presented in Tables 5 and 8. The frequency of work at the workplace did not associate with self-reported sleep quality. Among the chronotypes, no association was observed between the frequency of work at the workplace and self-reported sleep quality.

## Table 7

The association between work at the workplace and sleep duration during weekends in total sample and among chronotypes was analysed with simple linear regression in model 1 and further analysed with GLM, which included covariates in model 2

| | | | Sleep duration on weekends | | | |
|---|---|---|---|---|---|---|
| **Frequency of work at the workplace** | ***B*** | ***SE*** | **99% *CI*** | ***t*** | ***p*** | $R^2$ / $\omega^2_p$ |
| **Total sample (*n* = 830)** | | | | | | |
| Model 1 | 0.01 | 0.02 | [-0.05, 0.07] | 0.39 | .693 | .000 |
| Model 2 | 0.02 | 0.02 | [-0.05, 0.08] | 0.63 | .532 | .000 |
| **Morning type (*n* = 289)** | | | | | | |
| Model 1 | 0.02 | 0.04 | [-0.09,0.12] | 0.39 | .698 | .001 |
| Model 2 | 0.01 | 0.04 | [-0.09, 0.12] | 0.28 | .782 | .000 |
| **Intermediate type (*n* = 409)** | | | | | | |
| Model 1 | 0.02 | 0.03 | [-0.07, 0.10] | 0.49 | .624 | .001 |
| Model 2 | 0.02 | 0.03 | [-0.07, 0.10] | 0.46 | .643 | .000 |
| **Evening type (*n* = 132)** | | | | | | |
| Model 1 | 0.01 | 0.06 | [-0.15, 0.16] | 0.15 | .885 | .000 |
| Model 2 | 0.02 | 0.06 | [-0.14, 0.18] | 0.32 | .753 | .000 |

*Note*. The association between work at the workplace and sleep duration during weekends in the total sample and among chronotypes was analysed with simple linear regression in model 1 and further analysed with GLM, which included covariates (gender, age, self-reported health, stress related to COVID-19 and Russian invasion of Ukraine, and chronotype) in model 2. Statistical significance level is set at alpha level .01 and is bolded in the table. Near statistical significance .01-.025 is highlighted with grey colour. For simple linear regression $R^2$ and for GLM partial Omega squared ($\omega^2_p$) was used as an effect size estimator.

Sleep duration is measured in hours, which affects the interpretation of Beta coefficient (*B*).

CI = confidence interval, LL = lower limit, UL = upper limit.

Associations between the frequency of work at the workplace and SJL are presented in Tables 5 and 9. The frequency of work at the workplace correlated positively with SJL. Frequency of work at the workplace was a statistically significant predictor of SJL and stayed as a statistically significant predictor after the inclusion of covariates. More workdays at the workplace associated with greater amount of SJL. This effect was small.

A statistically significant association between frequency of work at the workplace and SJL was observed in intermediate and morning types. In evening types, this association was nearly significant. These associations stayed similar after the inclusion of covariates and the size of these associations was small. More workdays at the workplace associated with greater amount of SJL in all chronotypes.

## Table 8

The association between work at the workplace and self-reported sleep quality in total sample and among chronotypes was analysed with simple linear regression in model 1 and further analysed with GLM, which included covariates in model 2

| | Self-reported sleep quality | | | | | |
|---|---|---|---|---|---|---|
| **Frequency of work at the workplace** | ***B*** | ***SE*** | **99% *CI*** | ***t*** | ***p*** | **$R^2$ / $\omega^2_p$** |
| **Total sample (*n* = 830)** | | | | | | |
| Model 1 | 0.003 | 0.02 | [-0.04, 0.04] | 0.21 | .832 | .000 |
| Model 2 | 0.004 | 0.02 | [-0.03, 0.04] | 0.25 | .801 | .000 |
| **Morning type (*n* = 289)** | | | | | | |
| Model 1 | 0.004 | 0.03 | [-0.07, 0.07] | 0.14 | .888 | .000 |
| Model 2 | 0.002 | 0.03 | [-0.07, 0.07] | 0.08 | .940 | .000 |
| **Intermediate type (*n* = 409)** | | | | | | |
| Model 1 | 0.002 | 0.02 | [-0.05, 0.06] | 0.10 | .920 | .000 |
| Model 2 | -0.002 | 0.02 | [-0.05, 0.05] | -0.09 | .932 | .000 |
| **Evening type (*n* = 132)** | | | | | | |
| Model 1 | 0.03 | 0.04 | [-0.07, 0.14] | 0.77 | .444 | .005 |
| Model 2 | 0.04 | 0.04 | [-0.06, 0.13] | 0.97 | .336 | .000 |

*Note*. The association between work at the workplace and self-reported sleep quality in the total sample and among chronotypes was analysed with simple linear regression in model 1 and further analysed with GLM, which included covariates (gender, age, self-reported health, stress related to COVID-19 and Russian invasion of Ukraine, and chronotype) in model 2. Statistical significance level is set at alpha level .01 and is bolded in the table. Near statistical significance .01-.025 is highlighted with grey colour. For simple linear regression $R^2$ and for GLM partial Omega squared ($\omega^2_p$) was used as an effect size estimator.

CI = confidence interval, LL = lower limit, UL = upper limit.

Associations between other covariates and dependent sleep parameters are presented briefly here and in full detail in the supplementary data Tables 2 to 5 (Appendix 3). During weekdays, older age associated with shorter and female gender nearly associated with increased sleep duration. During weekends, evening and intermediate chronotype associated with longer sleep duration compared with morning types. Older age, lower self-reported health, and evening chronotype associated with, and greater amount of stress related to COVID-19 nearly associated with lower self-reported sleep quality. Evening and intermediate chronotype associated with greater amount of SJL compared with morning types.

# Table 9

The association between work at the workplace and SJL in total sample and among chronotypes was analysed with simple linear regression in model 1 and further analysed with GLM, which included covariates in model 2

| | SJL | | | | | |
|---|---|---|---|---|---|---|
| **Frequency of work at the workplace** | ***B*** | ***SE*** | **99% *CI*** | ***t*** | ***p*** | $R^2 / \omega^2_p$ |
| **Total sample (*n* = 830)** | | | | | | |
| Model 1 | 0.08 | 0.02 | [0.04, 0.12] | 4.86 | **< .001** | .028 |
| Model 2 | 0.09 | 0.02 | [0.04, 0.13] | 5.37 | **< .001** | .032 |
| **Morning type (*n* = 289)** | | | | | | |
| Model 1 | 0.08 | 0.03 | [0.01, 0.15] | 3.14 | **.002** | .033 |
| Model 2 | 0.08 | 0.03 | [0.01, 0.15] | 3.03 | **.003** | .028 |
| **Intermediate type (*n* = 409)** | | | | | | |
| Model 1 | 0.08 | 0.02 | [0.03, 0.14] | 3.76 | **< .001** | .034 |
| Model 2 | 0.08 | 0.02 | [0.02, 0.14] | 3.67 | **< .001** | .030 |
| **Evening type (*n* = 132)** | | | | | | |
| Model 1 | 0.11 | 0.04 | [-0.01, 0.22] | 2.46 | .015 | .044 |
| Model 2 | 0.10 | 0.04 | [-0.01, 0.22] | 2.34 | .021 | .033 |

*Note*. The association between work at the workplace and SJL in the total sample and among chronotypes was analysed with simple linear regression in model 1 and further analysed with GLM, which included covariates (gender, age, self-reported health, stress related to COVID-19 and Russian invasion of Ukraine, and chronotype) in model 2. Statistical significance level is set at alpha level .01 and is bolded in the table. Near statistical significance .01-.025 is highlighted with grey colour. For simple linear regression $R^2$ and for GLM partial Omega squared ($\omega^2_p$) was used as an effect size estimator.

CI = confidence interval, LL = lower limit, UL = upper limit.

SJL is measured in hours, which affects the interpretation of Beta coefficient (*B*).

# 4 Discussion

The aim of this study was to examine 1) the association between remote work and dependent sleep variables and 2) to find out if these associations differed among chronotypes. The study hypotheses were that remote work associates with 1a) longer sleep duration, 1b.) better self-reported sleep quality, and 1c.) smaller amount of SJL. In addition, these study hypotheses include that 2) these associations are expected to be strongest among evening chronotypes. From these associations between remote work and sleep, the results support hypothesis 1a (longer sleep duration), do not support 1b (better self-reported sleep quality), support 1c (smaller amount of SJL), and partially support 2 (strongest associations among evening types).

The data supported the hypothesis (1a) that during weekdays remote work was associated with longer sleep duration. Those participants who worked remotely (work modality) went to bed on average 22 minutes later, woke up 39 minutes later, and had 17 minutes longer sleep duration during weekdays than those who worked at the workplace. There were no differences between work modalities in bedtime, wake up time, and sleep duration during weekends. Statistical model (GLM) predicted that, when several covariates were adjusted, those working five days remotely had 21 minutes shorter sleep duration during weekdays than those working five days at the workplace. The frequency of work at the workplace did not have an association with sleep duration during weekends.

The data did not support hypothesis (1b) that the frequency of work at the workplace was associated with better self-reported sleep quality, which was not expected. However, other covariates such as older age, lower self-reported health, greater amount of stress, and evening chronotype associated with lower self-reported sleep quality. These results suggest that other self-reported quality of life measures, such as self-reported health and stress related to COVID-19, associate with self-reported sleep quality rather than the frequency of work at the workplace.

The data supported hypothesis (1c) that remote work was associated with smaller amount of SJL. Those participants who worked remotely (work modality) had on average 21 minutes lower SJL than those working at the workplace. Statistical model (GLM) predicted that, when several covariates were adjusted, those working five days remotely had 25 minutes lower SJL than those working five days at the workplace.

The data partially supported the hypothesis (2) that the strength of the association between remote work and dependent sleep parameters is strongest among evening types. There was no association between remote work and sleep duration during weekends or self-reported sleep quality. However, there was association between remote work and sleep duration during weekdays and between remote work and SJL. Intermediate and evening types had an association between remote work and sleep duration during weekdays, but morning types did not. Statistical model (GLM) predicted, when several covariates were adjusted, that working five days remotely had 5 minutes, 26 minutes, and 36 minutes longer sleep duration during weekdays than working five days at the workplace in morning, intermediate, and evening types respectively. SJL showed similar associations among chronotypes. Statistical model (GLM) predicted, when several covariates were adjusted, that working five days remotely had 23 minutes, 25 minutes, and 31 minutes shorter SJL than working five days at the workplace in morning, intermediate, and evening types respectively.

These study results are in line with the result from the systematic review showing that remote work associates with lower amount of SJL than work at the workplace. Five studies (Blume et al, 2020; Florea et al., 2021; Leone et al., 2020; Raman & Coogan, 2022) explored this and due to many similarities and despite some differences with this study, the results from this study reflect more or less the results from the systematic review.

The key similarity was that this study and the five studies most similar to this (Blume et al, 2020; Florea et al., 2021; Leone et al., 2020; Raman & Coogan, 2022) examined whether remote work when compared to work at the workplace associated with lower amount of SJL. The key difference was the time period from which they collected data. This study collected data during a time period after the lockdown, specifically a time period when working remotely was not forced upon due to COVID-19 restrictions or lockdowns. All the five studies (Blume et al, 2020; Florea et al., 2021; Leone et al., 2020; Raman & Coogan, 2022) collected data during restrictions and before or after restrictions. At the start of restrictions, remote work became mandatory, and it was a novel thing during the lockdown, and after the lockdown people were used to it and for many it became a voluntary way to work.

Regarding data-acquisition, there were some similarities and differences. Four of the studies (Blume et al, 2020; Florea et al., 2021; Leone et al., 2020; Raman & Coogan, 2022) in the systematic review acquired data with surveys, which was similar to this study. Surveys acquire data with subjective measures and therefore are not as reliable as objective data measurements. In those four studies, some data were gathered retroactively (from before restriction and during restrictions or from during restriction and after restrictions). This made it possible to study how SJL has changed (causative data), but in this study only associative (correlative) data could be studied. Retroactive data has the benefit of causative data, but it comes with the risk of recall bias, which decreases the reliability of the results. Only one study (Massar et al., 2022) used objective measurement (wearable technology) and longitudinal study design, which is more reliable than subjective measurement and retroactive data collection methods. This one study (Massar et al., 2022) was the only one where remote work did not decrease SJL more than work at the workplace. This study, however, has problems with generalization since all the participants were either from the same university (student or staff) or work in the same hospital.

Regarding measurements, these five studies (Blume et al, 2020; Florea et al., 2021; Leone et al., 2020; Massar et al., 2022; Raman & Coogan, 2022) and the current study defined remote work differently. The definitions in these five studies could be categorized into the proportion of remote work (proportion of remote work hours or days) and relevant or irrelevant jobs where relevant jobs were essential (healthcare) that could only be done at the workplace and irrelevant jobs were done at home. The final category was working status which compared different versions of working/not working and working from home/at the workplace. However, all these five studies (Blume et al, 2020; Florea et al., 2021; Leone et al., 2020; Massar et al., 2022; Raman & Coogan, 2022) and this study gathered data separately from workdays and free days or weekdays and weekends, which was used to determine SJL.

The current study differs from these five studies (Blume et al, 2020; Florea et al., 2021; Leone et al., 2020; Massar et al., 2022; Raman & Coogan, 2022), with its strict exclusion criteria, which resulted in different study population than in the other studies. In this study, only full-time adult students or workers, without serious sleep problems, low ability to work, or self-reported mental health issues were excluded. In four studies (Florea et al., 2021; Leone et al., 2020; Massar et al., 2022; Raman & Coogan, 2022) there were nearly no exclusion criteria (adult population, non-shift workers, no extreme sleep). One study (Blume et al., 2020) had quite similar exclusion criteria, as in the current study, which were non-full-time workers (no retired, unemployed or, shift workers), participants with sleep medication or volunteers with sleep disorders.

The one study most similar to this study was Blume and colleaques (2020) study. They had similar age range (18–65 vs. 18-79 in this study), exclusion criteria, and they collected data separately from weekdays and weekends to determine SJL. There were three differences between Blume's and her colleague's (2020) study and this study which were the time period during data-acquisition (during lockdown vs. after lockdown in this study), the definition of remote work, and data collection method. Blume and her colleagues (2020) determined remote work as the proportion of work hours done at home and in this study remote work was operationalized indirectly from the frequency of work at the workplace and dichotomized as remote work or work at the workplace. Blume and her colleagues (2020) collected data with surveys, which was similar to this study, but they also collected retroactive data from before the pandemic. Compared with this study, Blume and her colleagues (2020) have a more objective measurement of remote work and they have the benefits and downfalls of retroactive data, which are causal interferences and risk of recall bias. More strict exclusion criteria in this study and different time period (after and during lockdown) makes direct comparison difficult. However, in both studies remote work associates with lower amount of SJL.

Covariates in this study were controlled for due to their known association with dependent variables. These known associations which were replicated in this study were that older age associated with shorter sleep duration, which is normative (Li et al., 2018), evening chronotype associated with lower self-reported sleep quality (Roeser et al., 2012), and greater amount of SJL (Wittman et al., 2006), and women nearly associated with longer sleep duration (Mong & Cusmano, 2016).

Chronotype distribution in this study (collected in 2022) was different from Räihä's and his colleagues' study (2021), which also utilized MEQs in 2012. The proportion of chronotypes in this data compared with Räihä's and his colleaques study data (2021) were: morning types (34.8% vs. 44.8%), intermediate types (49.3% vs. 44.1%), and evening types (15.9% vs. 11.1%). Both samples are from Finnish adult populations from ten years apart, which indicates that chronotype distribution has become later since the proportion of morning types has decreased, and intermediate and evening types have slightly increased. This has been observed in other studies, which have directly compared chronotype distribution before and during COVID-19 (Genta et al., 2021; Leone et al, 2020). Chronotype distribution was not part of the research questions, so this remains just as an observation.

## 4.1 Strengths and limitations of this study

Robust methodology is one of the strengths of this study. Performing GLM analysis with covariates after linear regression models gives quite robust evidence for the association of independent variables with the dependent variable. Large sample size and multiple comparison problem were taken into account by lowering alpha level to 0.01 and using partial Omega squared as the effect size estimator for GLM, which is less biased than partial eta squared (Okada, 2013).

The original study sample consisted of 3,600 participants aged 18-79 and was representative of the Finnish general population regarding age, gender, and place of residence. The study sample was collected at interesting times when people were more used to COVID-19 pandemic conditions, and remote work was mostly voluntary and not heavily encouraged by the Finnish government, as it was during early pandemic in 2020 when restrictions were imposed in (Finnish Government, 2020). This study implemented rigorous exclusion criteria which led to a suboptimal but still adequate sample size of 830 (23.1%). This was mostly due to the high proportion of people not working or studying full time 2378 (66.1%) from which unemployment or pension ($n$ = 1499, 41.6%), contributed to the largest proportion. Additionally, other health, sleep, or work ability related issues added the proportion of excluded participants up to 76.9% ($n$ = 2770). The upside of these rigorous exclusion criteria is that the results reflect the association between remote work and sleep parameters in people working or studying full time, and not due to poor sleep for a variety of reasons. The downside of these exclusion criteria is that the results of this study are not generalizable to the whole adult population, but only to those adults who are healthy, are working or studying full time, and do not have work ability issues.

One of the major sleep-related issues and the performed fix for it in this study was about extreme sleep duration. The study sample ($N$ = 3600) had an abnormally large proportion of participants with extreme sleep duration (13.9%) compared with a previous study by Korman and her colleagues (2020) with similar cut-off points (< 3hr and >14hr; 3.1%). This was addressed by assuming that some participants confused 12hr and 24hr time formats, which was not specified in the survey, and this was fixed by adding 12 hours to bedtimes between 6.00 and 12.00. This was not optimal, but it lowered the proportion of extreme sleep to 3.5% which seemed to fix the high proportion of extreme sleep. This skewed data systematically towards overestimating the amount of extreme sleep. However, the sleep duration had to be between three and fourteen hours, which limited that only reasonable sleep durations were included. Some data before the fix that was reasonably eligible was not included, but also some data before the fix was not eligible, because of clear confusion of time formats, became eligible. This fix seemed to work out since the proportion of extreme sleep did decrease by a large margin, whereas there was the possibility of the exact opposite.

The study's subgroups, especially the evening chronotype group ($n$ = 132), were not large enough for GLM with six variables. A small sample size lowers statistical power, but in contrast, larger sample size increases statistical power and with a large enough sample size, the $p$-value will always be significant (Demidenko, 2016). This is shown for example in the association between frequency of work at the workplace and sleep duration during weekdays among chronotypes. Evening types did have three times smaller sample size ($n$ = 132) than intermediate types ($n$ = 409). This resulted in that intermediate types had a more statistically significant association ($p$ = .010) than evening types ($p$ = .056), despite the effect size suggesting a larger effect in favour for evening types ($\omega^2_p$ = .020 vs. .014). The association between frequency of work at the workplace and SJL among chronotypes produced similar results.

Remote work was operationalized in two different ways. The frequency of work in the workplace was dichotomized into work modality and also used as a continuous variable where a low score represents remote work and a high score represents work at the workplace. This was desirable, since comparing two groups (remote work and work at the workplace) is intuitive and easy to interpret and allows the use of a continuous variable in linear model analyses. However, the biggest limitation of this study concerns the operationalization of remote work. Remote work was operationalized indirectly from the frequency of work at the workplace. Remote work was interpreted as not working at the workplace but not working at the workplace does not necessarily indicate remote work, since a participant could have for example a shortened workweek. However, this study included only participants, who reported working or studying full-time. Therefore, the interpretation was that a higher frequency of work at the workplace indicates a lower frequency of remote work and vice versa. This operationalization would have improved if there were another question regarding the total number of workdays in the week, which would have made it possible to calculate the proportion of frequency of work at the workplace. After that, the proportion of remote work would have been 100% - (frequency of work at the workplace), if the assumption is that work is either done at the workplace or remotely. This would have been a more direct operationalization of remote work. Similar operationalization has been used in other studies, which have directly calculated the proportion of remote work in hours or workdays (Blume et al., 2020; Massar et al., 2022).

There were also problems with dichotomizing frequency of work at the workplace into work modalities (remote work and work at the workplace). Participants belonged to remote work group when they reported zero to four workdays at the workplace. The problem with dichotomizing variables is that forcing participants into two distinct groups might not necessarily reflect real-life phenomena. For example, dividing the frequency of work at the workplace into three categories (no remote work, hybrid work, and a lot of remote work) reflects real life better. A participant working three days at the workplace might better represent hybrid work than remote work. Another problem with dichotomizing concerns participants who reported working four days a week at the workplace. They would have been grouped into remote work group, but it is unknown if a participant has a day off or is working remotely. According to the study hypothesis, this should not have significant importance, since both, a day off and remote work, would mean reduced social obligations which were hypothesized to be associated with better sleep. Therefore, working only four days at the workplace might better represent belonging to remote work group rather than into work at the workplace group. This operationalization was done so that any amount of remote work or reduced social obligations, is compared with work at the workplace.

Another limitation of this study was the subjective nature of the data. All the sleep data came from self-estimates which are subjective and thus are not the most reliable. However, population-level studies mostly use subjective measurements, since they are cost-efficient, but their limitations should be acknowledged.

## 4.2 Future studies

Since studying the association between remote work and SJL is in its early stages, in the future terminology and definitions of remote work and SJL should be unified. In study limitations discussing operationalizing remote work, there were in total six different studies which all defined remote work differently, which were also different from how this study defined remote work. Out of these definitions, there are some which are continuous (proportion of remote work) and some which are dichotomized (either remote work or work at the workplace), but none included three categories of work (no remote work, hybrid work, and a lot of remote work) which might better represent the real-life phenomena than strictly dichotomizing participants into remote work or work at the workplace category. Another study, not included in the systematic review (Salfi et al., 2022) dodged this problem by comparing participants who work full-time remotely or at the workplace. This, however, comes with a similar problem as dichotomizing since participants who do not fit into these categories are not properly represented in these kinds of analyses.

There could be one solution to both problems (unifying remote work definition and the problem with dichotomizing work into remote work and work at the workplace), which is to use the proportion of remote work as definition of remote work, which has been used before. Blume and her colleagues (2020) used the proportion of remote work hours and Massar and his colleagues (2022) used the proportion of remote workdays. The proportion of remote work hours has the benefit of larger deviation, and the proportion of remote workdays has the benefit of simplicity. The proportion of remote work could also be categorized which would be devoid of the problem with the length of the workweek since remote work is presented in percentages. Then the percentages could be divided, for example, into three categories discussed in this study, which are no remote work, hybrid work, and a lot of remote work. However, the problem with dividing into categories is in deciding how the categorizations should be done.

In future studies, the association of remote work with sleep variables among chronotypes should be assessed with more elegant analyses with large enough subgroups to directly compare the effect of remote work on sleep variables between chronotypes.

In addition, future studies should examine associations between remote work and productivity. Poor sleep and SJL have widely documented adverse effects, but it might not be a selling point for companies, that ultimately decide if an employee can work remotely. If remote work would increase productivity, through improved sleep or some other factors, it would be a great incentive for companies and organizations to allow people to work remotely. For example, SJL is associated with decreased working ability and performance (Okajima et al., 2021; Räihä et al., 2021), which could indicate that SJL could also be associated with poorer productivity. Future studies could also compare different fields of work and if certain fields would benefit more from reduced social obligations (remote work).

Additionally in this study, the proportion of chronotypes was different from another Finnish population study (Räihä et al., 2021), which would indicate that chronotype distribution has become later since proportion of morning types has decreased, and intermediate and evening types have slightly increased. However, chronotype distribution was not part of the research questions, so this remains just as an observation, which should be tested in further studies.

### 4.3 Conclusion

The adverse effects of sleep deprivation and SJL are well documented. The COVID-19 pandemic brought changes to the ways people work by increasing remote work. This study's systematic review gathered existing research on the effects of reduced social obligations on SJL. The systematic review associated reduced social obligations with reduced SJL. In addition, there were a few studies in systematic review showing an association between chronotype or remote work with reduced SJL.

This study found beneficial associations, similar to the systematic review, between remote work and sleep duration during weekdays and SJL, which was expected. Evening types benefitted most from remote work regarding sleep duration and all chronotypes seemed to benefit from remote work in regarding SJL. Self-reported sleep quality did not associate with remote work, which was not expected, but rather with other self-reports of health and stress.

The research on remote work, at least in the area of SJL, suffers from varying definitions of remote work. Varying definitions make comparing results from different studies difficult. A unified definition of remote work would improve this and the proportion of remote work either in hours or workdays could be one way to solve this problem. The proportion of remote work could also be categorized based on the percentage, which should be defined in the future.

Recent studies, which were included in the systematic review, and this study indicates the beneficial effect of remote work with SJL. Therefore, future studies should examine whether remote work increases productivity. This could be a selling point to companies to begin offering the possibility for remote work and open the possibility of the beneficial effect of remote work for more people.

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# 6 Appendices

## 6.1 Appendix 1: Supplementary data: Systematic review

The following databases were searched for relevant studies in the systematic review, PsycINFO-, PubMed-, ProQuest all -, ScienceDirect-, and Medline databases. These databases were chosen, because sleep, SJL, and COVID-19 can be viewed from medical and psychological perspectives. The database searches included the own keywords of each database, for example, mesh terms in Pubmed. The following search phrases were used as a baseline for all the databases 1.) “(Covid* AND (mandate* OR restrict* OR lockdo* OR Quarantine* (Stay* AND home))) AND (Chronotyp* OR "circadian rhythm" OR "social jet*" OR "social time press*" OR "internal clock" OR "Biological clock" OR "body clock" OR "social clock") AND sleep* NOT (patient OR psychiatric)” and 2.) “("Social jet*") AND covid*”. The exact database search phrases for different databases in the systematic review were as follows:

Medline: (COVID-19/ OR Covid* OR SARS-CoV-2/) AND (mandate* OR restrict* OR lockdo* OR Quarantine/ OR (Stay* AND home)) AND (Chronotyp* OR Biological Clocks/ OR Circadian Rhythm/ OR "circadian rhythm" OR "social jet*" OR "social time press*" OR "internal clock" OR Circadian Clocks/ OR "Circadian Clocks" OR "body clock" OR "social clock") AND (Sleep/ OR Sleep*) NOT (Patient OR Patients/ OR Psychiatric) **AND** ("Social jet*") AND (COVID-19/ OR Covid* OR SARS-CoV-2/)

PsycINFO: ((Covid* OR DE "COVID-19") AND (mandate* OR restrict* OR lockdo* OR DE "Quarantine" OR (Stay* AND home))) AND (Chronotyp* OR DE "Chronotype" OR “circadian rhythm” OR “social jet*” OR “social time press*” OR ”internal clock” OR “Biological clock” OR “body clock” OR “social clock”) AND (sleep* OR DE "Sleep" OR DE "Sleep Quality" OR DE "Sleep Wake Cycle") NOT (psychiatric or Patient) **AND** ("Social jet*") AND (covid* OR DE "COVID-19" OR DE "Coronavirus" OR pandemic OR DE "Pandemics") NOT (patient or Psychiatric)

PubMed: (("COVID-19"[Mesh] OR  "SARS-CoV-2"[Mesh] OR Covid*) AND (mandate* OR restrict* OR lockdo* OR "Quarantine"[Mesh] OR (Stay* AND home))) AND (Chronotyp* OR "circadian rhythm" OR "Circadian Rhythm"[Mesh] OR "social jet*" OR "social time press*" OR "internal clock" OR "Biological clock" OR "Circadian Clocks"[Mesh] OR "body clock" OR "social clock") AND sleep* NOT (patient OR psychiatric) **AND** ("Social jet*") AND (covid* OR "COVID-19"[Mesh] OR "SARS-CoV-2"[Mesh])

ProQuest all: database search was limited to scholarly journals, dissertations, and theses. The database search searched anywhere except full text (NOFT). The first search phrase was (MAINSUBJECT.EXACT("COVID-19") OR Covid* OR MAINSUBJECT.EXACT("Severe acute respiratory syndrome coronavirus 2")) AND (MAINSUBJECT.EXACT("Quarantine") OR MAINSUBJECT.EXACT("Government mandates") OR mandate* MAINSUBJECT.EXACT("Regulation") OR MAINSUBJECT.EXACT("Restrictions") OR restrict* OR MAINSUBJECT.EXACT("Shelter in place") OR lockdo* OR (Stay* AND home)) AND (Chronotyp* OR MAINSUBJECT.EXACT("Circadian rhythm") OR "circadian rhythm" OR MAINSUBJECT.EXACT("Biological clocks") OR "Biological clock" OR "social jet*" OR "social time press*" OR "internal clock" OR "body clock" OR "social clock") AND (sleep* OR MAINSUBJECT.EXACT("Sleep")) NOT (patient OR psychiatric). The second search phrase was ("Social jet*") AND (covid* OR MAINSUBJECT.EXACT("COVID-19") OR MAINSUBJECT.EXACT("Severe acute respiratory syndrome coronavirus 2"))

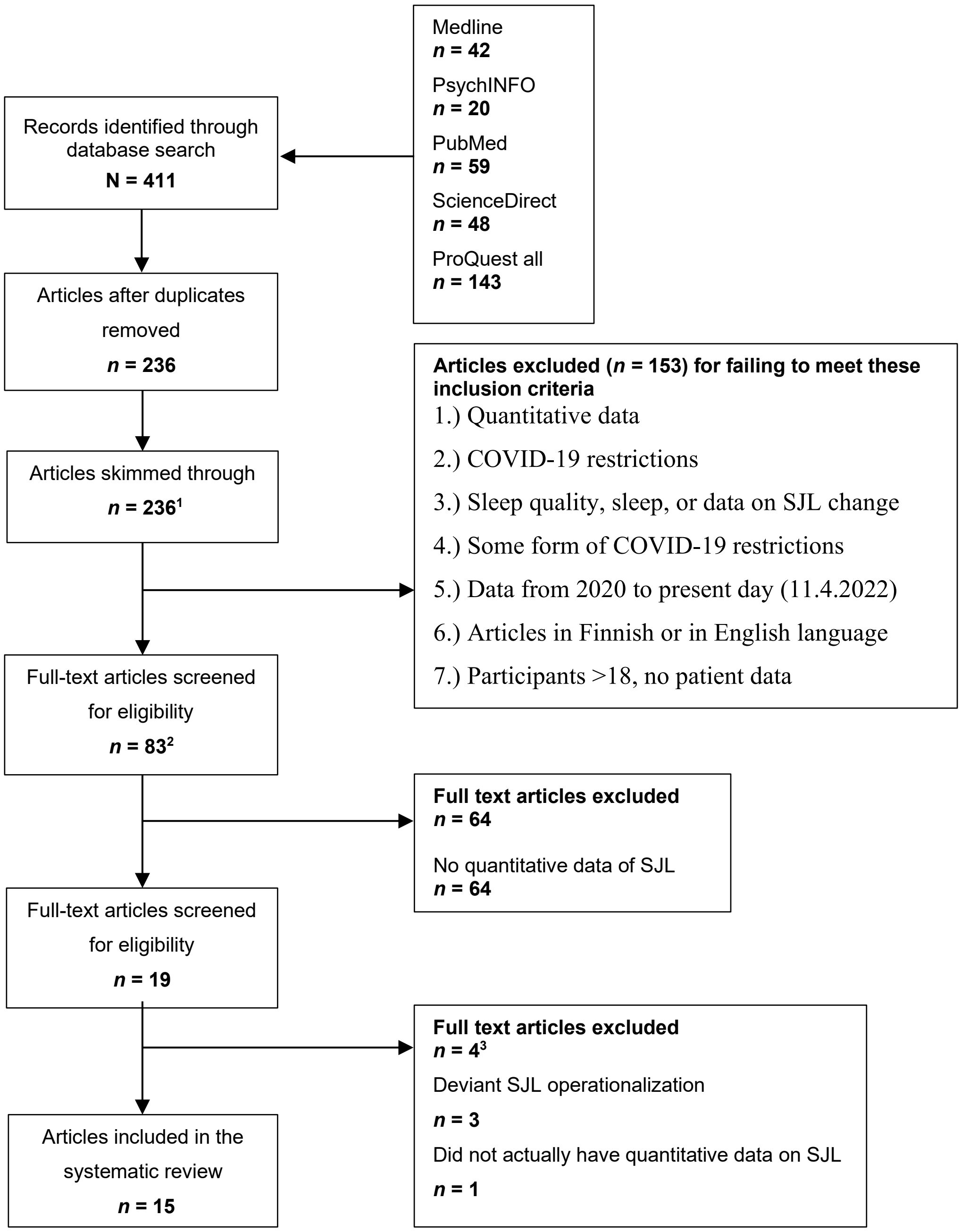
ScienceDirect: ScienceDirect limits database search to eight Boolean operators and it does not support wildcards (* -symbol). Therefore, ScienceDirect database search is more crude compared to others. The search phrases were. Covid AND (Chronotype OR "social jetjag OR "social jet lag") AND sleep - (patient OR psychiatric) **AND** ("Social jet") AND covid

*Note.* A spelling mistake was discovered 1.6.2022 on the ScienceDirect database search phrase ("social jetjag). After the spelling mistake was fixed a new database search was made, which had 19 additional sources. There was one article (Florea et al., 2021) that was not in the initial ScienceDirect database search, but it was included in the systematic review from other databases.

The database search was conducted 4.4 – 11.4.2022. The database search yielded 411 results. The initial exclusion and inclusion criteria were 1.) the studies in the articles must include quantitative data, 2.) the studies included in the systematic review must have data during COVID-19 restrictions, 3.) the studies must include data on sleep quality, sleep change, or must include data on SJL change, 4.) the studies must include some form of COVID-19 restrictions, for example, lockdown or quarantine), 5.) the studies must date from 2020 to present day (11.4.2022), because COVID-19 was identified on 7$^{th}$ of January 2020 (World Health Organization, n.d.), 6.) the articles must be in Finnish or in English, and 7.) the participants need to be over 18 and they must be healthy meaning no patient or psychiatric patient data. Article titles and abstracts were skimmed through for mentions of sleep quality changes, sleep changes, or SJL changes and if such mentions were found, the articles were further examined for the other criteria. These exclusion criteria resulted in a total of 83 articles, which resulted in the use of tightened exclusion criteria. The initial criteria were not strict, because it was assumed that the database search would not find that many studies. However, the existence of this many studies allowed the use of stricter criteria, which were applied directly to this study's point of interest. This new criterion was that there needed to be quantitative data on SJL reduction during the COVID-19 pandemic. The new criteria for the full-text article screening were that the studies must have quantitative data of SJL. This screening resulted 19 studies. These articles were properly read, and three articles had to be dropped due to improper SJL operationalization. The original operationalization of SJL, by Wittmann and his colleagues (2006), was used ($\Delta MS = |MSF - MSW|$) and three articles that deviated from this were excluded. In addition, one article had to be excluded, because it was mistakenly observed to have quantitative data, which it did not have. Excluding these four articles resulted in 15 articles being included in the systematic review. This process is presented in Supplementary data Figure 1.

## Supplementary data Figure 1

Flowchart of included articles in the systematic review




*Note.* The database search was done 4.4 – 11.4.2022.

[1] The headlines and the abstracts of these articles were skimmed through with the following criteria 1.) the studies in the articles must include quantitative data, 2.) the studies must be during COVID-19 restrictions, 3.) the studies must include data on sleep quality, sleep change, or must include data on SJL change, 4.) the studies must include some form of COVID-19 restrictions (for example lockdown or quarantine), 5.) the studies must date from 2020 to present day (11.4.2022), because COVID-19 was identified on 7th of January 2020 (World Health Organization, n.d.), 6.) the articles must be in Finnish or in English, and 7.) the participants need to be over 18 and they must be healthy meaning no patient or psychiatric patient data.

[2] Due to high number of results, screening inclusion criteria were tightened. In addition to original criteria, articles must have quantitative data of SJL.

[3] Three articles were excluded due to deviant SJL operationalization. The original operationalization of SJL, by Wittmann and his colleagues (2006), were used ($\Delta MS = |MSF - MSW|$). One article had to be excluded because it was mistakenly observed to have quantitative data, which it did not have.

All the articles included in the systematic review were from peer-reviewed journals. The quality of journals was assessed with JCI (Journal Citation Indicator), JIF (Journal Impact Factor), and Article influence factor which are presented in the Supplementary data Table 1. The data were taken from 2020 Journal citation reports (JCR) (Clarivate Analytics, n.d.). No data were available from two journals Clocks & Sleep and Somnology in the JCR 2020, so data were gathered from Exaly (n.d.) and Resurcify (n.d.) respectively.

The average JIF-score was 4.89 (range: 1.59 – 10.83) and the average JIF-score from the last five years was 5.95 (range: 3.44 – 11.71). A rule of thumb for JIF-scores is that the average JIF-score is less than one, a good JIF-score is three, and excellent JIF-score is ten or greater (SCI Journal, 2022, February 9). However, JIF values vary greatly between fields, and in some fields two is considered excellent, and therefore comparisons should be made in the respective fields of the journals (SCI Journal, 2022, February 9). JIF percentile is a journal's standing in their respective field and in this systematic review, the average JIF percentile is 74.46 (range: 55.05 – 91.69). JCI value provides a normalized measure of citation impact in their fields (Clarivate analytics, 2021, May 20). The average JCI percentile is 78.36 (range: 59.92 – 94.19).

Journals that had data in JCR 2020 had good JCI and JIF values which indicates good journal quality. All articles were peer-reviewed which further indicate good quality. Journals "Clocks & Sleep" and "Somnology – Current Sleep Research and Concepts" had the lowest and fourth lowest JIF-score, which were still above average (> 1). These journals had only JIF-scores, which were the lowest among journals included in the systematic review, which were still above average JIF-score. This also indicates good quality of journals included in the systematic review.

## Supplementary data Table 1

Quality assessment of Journals included in the systematic review with JIF, JCI and Article influence factor values

| Journal | N | JIF (2020) | JIF percentile (AVG) | 5-year JIF* | JCI percentile (AVG) |
|---|---|---|---|---|---|
| Biochemical Pharmacology | 1 | 5.86 | 86.05 | 5.68 | 93.98 |
| Clocks & Sleep[1] | 1 | 3.7[1] (2021) | - | - | - |
| Chronobiology International | 1 | 2.88 | 58.22 | 3.44 | 66.15 |
| Current biology | 3 | 10.83 | 91.69 | 11.71 | 94.19 |
| International Journal of Obesity | 1 | 5.10 | 74.38 | 5.80 | 84.78 |
| Journal of Sleep Research | 1 | 3.98 | 60.86 | 4.71 | 71.20 |
| Nature and Science of Sleep | 1 | 5.35 | 77.96 | 5.32 | 59.62 |
| Nutrients | 1 | 5.72 | 81.25 | 6.35 | 76.89 |
| Scientific Reports | 1 | 4.38 | 77.08 | 5.13 | 85.55 |
| Sleep | 2 | 5.85 | 82.02 | 6.79 | 79.25 |
| Sleep Medicine | 1 | 3.49 | 55.05 | 4.61 | 71.96 |
| Somnology – Current Sleep Research and Concepts | 1 | 1.59[2] (2021) | - | - | - |
| **Average** | | 4.89 | 74.46 | 5.95 | 78.36 |
| **Range** | | 1.59 – 10.83 | 55.05 – 91.69 | 3.44 – 11.71 | 59.92 – 94.19 |

*Note*. Statistics are reported in the 2020 JCR published by Clarivate Analytics (Clarivate Analytics, n.d.). AVG = average, JIF = Journal impact factor; JCI = Journal citation indicator; JCR = Journal citation reports.

[1]Data were not available in JCR 2020. JIF was acquired from Exaly.

[2]Data were not available in JCR 2020. JIF was acquired from Resurcify.

The total number of studies was 15 and the total study population was 61 387 in which most of which were females (70.9%). Participants' mean age varied from 21.9 – 47.2. Eleven studies were surveys or questionnaires, two studies used wearable technology, one study used sleep log data, and one study was a case-control study.

Studies were multinational. In four studies data were collected from multiple countries (Austria, Germany, and Switzerland, Blume et al, 2020; 14 countries, Brandão et al, 2021; 6 countries, Florea et al., 2021; 40 countries Korman et al., 2020). Other studies gathered data from Sweden, USA, Argentina, Singapore (*n* = 2), Ireland, Spain, Germany, Japan (*n* = 2), and North America. In all studies, data during restrictions were gathered from February 2020 to November 2020, which was during partial or full lockdown. This meant that in every study, their respective countries limited working at the workplace in some ways where most people were forced to work remotely depending on the profession.

Average baseline SJL (no restrictions) was reported in eleven articles, and it varied from 31-107 minutes. The average SJL change (reduction) varied from 7.9 – 58 minutes. The effect size for SJL reduction was reported in two articles. Leone and her colleague's study (2020) reported a large effect ($d$ = .682) and Massar and his colleagues' study (2022) reported a small effect size ($r$ = -.23).

The main result of the systematic review was that SJL decreased during COVID-19 restrictions. All studies reported decreased SJL, but in one study (Staller & Randler, 2021) data on SJL change was not reported (Staller & Randler, 2021) and another study (Brandão et al, 2021) reported both a reduction and an increase of SJL (46% study participants decreased SJL and 20% study participants increased SJL, *p's* < .001). The remaining studies ($n$ = 13) reported statistically significant (*p's* < .001) SJL reduction.

The association between remote work and SJL was reported in six articles. Five studies reported that remote work associated with decreased SJL (*p's* < .014) and one study (Massar et al., 2022) found no association ($p$ > .50). Four of these five articles reported an association between remote work and decreased SJL, reported effect sizes. Blume and his colleagues (2020) study reported a small effect size ($d$ = .27), and other three studies (Florea et al., 2021; Leone et al., 2020; Raman & Coogan, 2021) reported large effect sizes ($\eta^2_p$*'s* > .028).

The association between chronotype and SJL was reported in four articles. In three articles later chronotype associated with decreased SJL (*p's* < .037) and the effect size was reported only in one study (Blume et al., 2020). The effect size observed in their study was small ($d$ = .22). In the fourth article evening chronotype associated with SJL reduction, until age was covaried ($p$ = .20).

There were a few limitations in the systematic review. Most studies reported only $p$-values and only a few studies reported effect size estimates. Study populations were large (range: 139 – 30 275), which in turn makes minor changes very easily statistically significant. Therefore, robust conclusions about the effect sizes are hard to make. In addition, most participants (70.9%) were female, but the large sample size ($n$ = 61 387) resulted in a large sample size for men as well. Only one person performed database searches, which could result in individual errors.

## 6.2 Appendix 2: Supplementary data: Preliminary analyses

*Tests of normality for dependent variables.* Normality was assessed with the Kolmogorov-Smirnov test of normality. None of the dependent variables (sleep length, subjective sleep quality, and SJL) were normally distributed, $p$*'s* < .001, but since the sample size is large ($n$ = 830), normality can be assumed according to the central limit theorem.

*Correlations for continuous variables.* Linear regression assumes associations between independent variables (IV) and dependent variables (DV). **Remote work** (IV) correlated with sleep length week ($r$ = -.109, $p$ = .002) and SJL ($r$ = .167, $p$ < .001). Originally the covariates in this study were age, subjective health, household size, stress related to the COVID-19 pandemic and the Russian invasion of Ukraine, and place of residence (urban-rural classification), but since household size didn't correlate with any of the DV's ($r$*'s* < .029, $p$*'s* > .179) it was dropped from the analyses.

*T-test for dichotomic variables.* There was nearly a **gender** difference in sleep duration during weekdays, $t(828) = 2.41$, $p = .015$, and in self-reported sleep quality, $t(828) = -2.42$, $p = .016$. Between genders there were no differences in sleep duration during weekends, $t(828) = 1.60$, $p = .110$, and in SJL, $t(828) = -1.76$, $p = .079$.

*ANOVA for categoric variables.* **Chronotype** associated with SJL with nearly intermediate-sized effect $F(2, 827) = 18.89$, $p < .001$, $\omega^2 = .041$. Tukey HSD post-hoc test revealed that morning types (0.52 ± 0.48; hh:mm) had lower SJL than intermediate (1.13 ± 0.54) or evening types (1.23 ± 1.01), $p$*'s* < .001. Chronotype had a statistically significant small effect on self-reported sleep quality $F(2, 827) = 5.95$, $p = .003$, $\omega^2 = .012$. Tukey HSD post-hoc revealed that morning types (2.02 ± 0.85) had better self-reported sleep quality than evening types (2.32 ± 0.89, $p = .002$), but did not differ from intermediate types (2.16 ± 0.83, $p = .078$). Chronotype almost had a statistically significant small effect on sleep duration during weekends $F(2, 827) = 4.51$, $p = .011$, $\omega^2 = .008$. **Place of residence (urban-rural classification)** did not associate with any of the DV's, $p$*'s* > .174, $\omega^2$*'s* < .002, so it was dropped from the analyses as a covariate.

## 6.3 Appendix 3: Supplementary data: The associations between other covariates and dependent sleep parameters, in the GLM analyses

## Supplementary data Table 2

The association between covariates and sleep duration during weekdays in the total sample and among chronotypes analysed with GLM

| Covariates | *B* | *SE* | Sleep duration weekday 99% *CI* | *t* | *p* | $\omega^2_p$ |
|---|---|---|---|---|---|---|
| **Total sample (*n* = 830)** | | | | | | |
| Female[1] | 0.22 | 0.09 | [-0.02, 0.45] | 2.42 | .016 | .006 |
| Age | -0.01 | 0.004 | [-0.02, -0,002] | -3.04 | **.002** | .100 |
| Self-reported health | 0.04 | 0.06 | [-0.10, 0.19] | 0.77 | .441 | .000 |
| Stress COVID-19 | 0.14 | 0.07 | [-0.04, 0.31] | 1.96 | .050 | .003 |
| Stress Russian invasion of Ukraine | -0.03 | 0.07 | [-0.21, 0.16] | -0.37 | .712 | .000 |
| Chronotype | | | | | .236 | .001 |
| Evening type[2] | -0.17 | 0.13 | [-0.51, 0.17] | -1.29 | .198 | |
| Intermediate type[3] | 0.04 | 0.10 | [-0.21, 0.29] | 0.44 | .659 | |
| **Morning type (*n* = 289)** | | | | | | |
| Female[1] | 0.21 | 0.12 | [-0.11, 0.52] | 1.69 | .093 | .006 |
| Age | -0.01 | 0.01 | [-0.02, 0.01] | -1.27 | .205 | .002 |
| Self-reported health | -0.05 | 0.08 | [-0.25, 0.15] | -0.64 | .525 | .000 |
| Stress COVID-19 | 0.02 | 0.10 | [-0.25, 0.29] | 0.17 | .868 | .000 |
| Stress Russian invasion of Ukraine | 0.03 | 0.10 | [-0.22, 0.28] | 0.30 | .764 | .000 |
| **Intermediate type (*n* = 409)** | | | | | | |
| Female[1] | 0.17 | 0.14 | [-0.19, 0.53] | 1.22 | .224 | .001 |
| Age | -0.02 | 0.01 | [-0.03, -0.001] | -2.75 | **.006** | .016 |
| Self-reported health | 0.11 | 0.09 | [-0.12, 0.34] | 1.23 | .220 | .001 |
| Stress COVID-19 | 0.24 | 0.10 | [-0.02, 0.51] | 2.39 | .017 | .011 |
| Stress Russian invasion of Ukraine | 0.01 | 0.11 | [-0.28, 0.29] | 0.07 | .947 | .000 |
| **Evening type (*n* = 132)** | | | | | | |
| Female[1] | 0.38 | 0.26 | [-0.29, 1.05] | 1.49 | .138 | .009 |
| Age | -0.01 | 0.01 | [-0.04, 0.02] | -0.55 | .586 | .000 |
| Self-reported health | 0.02 | 0.16 | [-0.40, 0.44] | 0.12 | .905 | .000 |
| Stress COVID-19 | 0.01 | 0.19 | [-0.49, 0.51] | 0.05 | .963 | .000 |
| Stress Russian invasion of Ukraine | -0.15 | 0.20 | [-0.68, 0.37] | -0.77 | .447 | .000 |

*Note*. The association between covariates and sleep duration during weekdays in the total sample and among chronotypes was analysed with GLM. A statistical significance level is set at alpha level .01 and is bolded in the table. Near statistical significance .01-.025 is highlighted with grey colour. Partial Omega squared ($\omega^2 p$) was used as an effect size estimator.

CI = confidence interval, LL = lower limit, UL = upper limit.

[1] Gender is the covariate variable in which male is a redundant parameter, which means that the female gender is compared to the male gender.

[2,3] Chronotype is the covariate variable, only in the total sample, in which morning chronotype is a redundant parameter, which means that evening types and intermediate types are compared with morning types.

## Supplementary data Table 3

The association between covariates and sleep duration during weekends in the total sample and among chronotypes analysed with GLM

| | | | Sleep duration weekends | | | |
|---|---|---|---|---|---|---|
| **Covariates** | ***B*** | ***SE*** | **99% *CI*** | ***t*** | ***p*** | **$\omega^2_p$** |
| **Total sample (*n* = 830)** | | | | | | |
| Female[1] | 0.15 | 0.09 | [-0.09, 0.39] | 1.62 | .105 | .002 |
| Age | -0.01 | 0.004 | [-0.02, 0.006] | -1.11 | .265 | < .001 |
| Self-reported health | -0.10 | 0.06 | [-0.25, 0.05] | -1.67 | .095 | .002 |
| Stress COVID-19 | 0.03 | 0.07 | [-0.16, 0.21] | 0.35 | .725 | .000 |
| Stress Russian invasion of Ukraine | 0.06 | 0.07 | [-0.13, 0.25] | 0.78 | .436 | .000 |
| Chronotype | | | | | **.010** | .009 |
| Evening type[2] | 0.35 | 0.14 | [-0.004, 0.71] | 2.55 | .011 | |
| Intermediate type[3] | 0.26 | 0.10 | [0.003, 0.53] | 2.61 | **.009** | |
| **Morning type (*n* = 289)** | | | | | | |
| Female[1] | 0.12 | 0.15 | [-0.28, 0.51] | 0.78 | .435 | .000 |
| Age | -0.01 | 0.01 | [-0.02, 0.01] | -0.81 | .420 | .000 |
| Self-reported health | -0.18 | 0.10 | [-0.43, 0.07] | -1.84 | .067 | .008 |
| Stress COVID-19 | -0.23 | 0.13 | [-0.56, 0.11] | -1.76 | .079 | .007 |
| Stress Russian invasion of Ukraine | 0.10 | 0.12 | [-0.21, 0.41] | 0.82 | .412 | .000 |
| **Intermediate type (*n* = 409)** | | | | | | |
| Female[1] | 0.16 | 0.14 | [-0.20, 0.51] | 1.14 | .257 | < .001 |
| Age | -0.004 | 0.01 | [-0.02, 0.01] | -0.72 | .470 | .000 |
| Self-reported health | -0.07 | 0.09 | [-0.30, 0.15] | -0.82 | .415 | .000 |
| Stress COVID-19 | 0.11 | 0.10 | [-0.15, 0.36] | 1.06 | .288 | < .001 |
| Stress Russian invasion of Ukraine | 0.04 | 0.11 | [-0.24, 0.32] | 0.37 | .713 | .000 |
| **Evening type (*n* = 132)** | | | | | | |
| Female[1] | 0.28 | 0.25 | [-0.38, 0.94] | 1.11 | .268 | < .001 |
| Age | -0.003 | 0.01 | [-0.03, 0.03] | -0.25 | .801 | .000 |
| Self-reported health | -0.03 | 0.16 | [-0.44, 0.38] | -0.20 | .845 | .000 |
| Stress COVID-19 | 0.19 | 0.19 | [-0.30, 0.69] | 1.03 | .304 | < .001 |
| Stress Russian invasion of Ukraine | 0.06 | 0.20 | [-0.46, 0.58] | 0.29 | .770 | .000 |

*Note*. The association between covariates and sleep duration during weekends in the total sample and among chronotypes was analysed with GLM. A statistical significance level is set at alpha level .01 and is bolded in the table. Near statistical significance .01-.025 is highlighted with grey colour. Partial Omega squared ($\omega^2$p) was used as an effect size estimator.

CI = confidence interval, LL = lower limit, UL = upper limit.

[1] Gender is the covariate variable in which male is a redundant parameter, which means that the female gender is compared to the male gender.

[2,3] Chronotype is the covariate variable, only in the total sample, in which morning chronotype is a redundant parameter, which means that evening types and intermediate types are compared with morning types.

## Supplementary data Table 4

The association between covariates and self-reported sleep quality in the total sample and among chronotypes analysed with GLM

| | | | Self-reported sleep quality | | | |
|---|---|---|---|---|---|---|
| **Covariates** | ***B*** | ***SE*** | **99% *CI*** | ***t*** | ***p*** | **$\omega^2_p$** |
| **Total sample (*n* = 830)** | | | | | | |
| Female[1] | -0.12 | 0.06 | [-0.27, 0.03] | -2.02 | .044 | .004 |
| Age | 0.01 | 0.003 | [0.002, 0.02] | 3.46 | **.001** | .013 |
| Self-reported health | 0.26 | 0.04 | [0.17, 0.37] | 7.11 | **< .001** | .056 |
| Stress COVID-19 | -0.11 | 0.05 | [-0.22, 0.01] | -2.33 | .020 | .005 |
| Stress Russian invasion of Ukraine | 0.01 | 0.05 | [-0.11, 0.13] | 0.15 | .883 | .000 |
| Chronotype | | | | | **.004** | .011 |
| Evening type[2] | 0.27 | 0.09 | [0.05, 0.49] | 3.12 | **.002** | |
| Intermediate type[3] | 0.15 | 0.06 | [-0.02, 0.31] | 2.33 | .020 | |
| **Morning type (*n* = 289)** | | | | | | |
| Female[1] | -0.17 | 0.01 | [-0.42, 0.08] | -1.76 | .080 | .007 |
| Age | 0.01 | 0.004 | [0.00, 0.023] | 2.53 | .012 | .018 |
| Self-reported health | 0.24 | 0.06 | [0.08, 0.40 | 3.93 | **< .001** | .048 |
| Stress COVID-19 | -0.13 | 0.08 | [-0.34, 0.09] | -1.53 | .127 | .005 |
| Stress Russian invasion of Ukraine | -0.09 | 0.08 | [-0.29, 0.11] | -1.15 | .250 | .001 |
| **Intermediate type (*n* = 409)** | | | | | | |
| Female[1] | -0.07 | 0.08 | [-0.29, 0.14] | -0.89 | .373 | .007 |
| Age | 0.01 | 0.003 | [0.003, 0.02] | 3.40 | **.001** | .018 |
| Self-reported health | 0.23 | 0.05 | [0.09, 0.36] | 4.27 | **< .001** | .048 |
| Stress COVID-19 | -0.06 | 0.06 | [-0.22, 0.10] | -0.98 | .329 | .005 |
| Stress Russian invasion of Ukraine | 0.03 | 0.07 | [-0.14, 0.20] | 0.39 | .701 | .001 |
| **Evening type (*n* = 132)** | | | | | | |
| Female[1] | -0.07 | 0.15 | [-0.47, 0.33] | -0.47 | .638 | .000 |
| Age | -0.01 | 0.01 | [-0.02, 0.01] | -0.98 | .328 | .000 |
| Self-reported health | 0.43 | 0.10 | [0.18, 0.68] | 4.50 | **< .001** | .127 |
| Stress COVID-19 | -0.18 | 0.12 | [-0.48, 0.12] | -1.55 | .123 | .011 |
| Stress Russian invasion of Ukraine | 0.16 | 0.12 | [-0.29, 0.14] | 1.35 | .179 | .006 |

*Note*. The association between covariates and self-reported sleep quality in the total sample and among chronotypes was analysed with GLM. A statistical significance level is set at alpha level .01 and is bolded in the table. Near statistical significance .01-.025 is highlighted with grey colour. Partial Omega squared ($\omega^2 p$) was used as an effect size estimator.

CI = confidence interval, LL = lower limit, UL = upper limit.

[1] Gender is the covariate variable in which male is a redundant parameter, which means that the female gender is compared to the male gender.

[2,3] Chronotype is the covariate variable, only in the total sample, in which morning chronotype is a redundant parameter, which means that evening types and intermediate types are compared with morning types.

## Supplementary data Table 5

The association between covariates and SJL in total sample and among chronotypes analysed with GLM

| | SJL | | | | | |
|---|---|---|---|---|---|---|
| **Covariates** | ***B*** | ***SE*** | **99% *CI*** | ***t*** | ***p*** | **$\omega^2_p$** |
| **Total sample (*n* = 830)** | | | | | | |
| Female[1] | -0.09 | 0.06 | [-0.25, 0.07] | -1.45 | .149 | .001 |
| Age | 0.001 | 0.003 | [-0.01, 0.01] | 0.25 | .804 | .000 |
| Self-reported health | 0.03 | 0.04 | [-0.07, 0.14] | 0.85 | .393 | .000 |
| Stress COVID-19 | -0.02 | 0.05 | [-0.14, 0.11] | -0.38 | .704 | .000 |
| Stress Russian invasion of Ukraine | 0.05 | 0.05 | [-0.07, 0.18] | 1.10 | .273 | .001 |
| Chronotype | | | | | **< .001** | .047 |
| Evening type[2] | 0.54 | 0.09 | [0.30, 0.78] | 5.82 | **< .001** | |
| Intermediate type[3] | 0.35 | 0.07 | [0.18, 0.53] | 5.21 | **< .001** | |
| **Morning type (*n* = 289)** | | | | | | |
| Female[1] | -0.03 | 0.10 | [-0.28, 0.22] | -0.31 | .758 | .000 |
| Age | > -.001 | 0.004 | [-0.01, 0.01] | -0.01 | .996 | .000 |
| Self-reported health | 0.06 | 0.06 | [-0.10, 0.22] | 1.04 | .298 | .001 |
| Stress COVID-19 | 0.003 | 0.08 | [-0.21, 0.22] | 0.03 | .974 | .000 |
| Stress Russian invasion of Ukraine | 0.06 | 0.08 | [-0.14, 0.26] | 0.74 | .459 | .000 |
| **Intermediate type (*n* = 409)** | | | | | | |
| Female[1] | -0.15 | 0.09 | [-0.38, 0.09] | -1.60 | .110 | .004 |
| Age | -0.002 | 0.004 | [-0.01, 0.01] | -0.52 | .605 | .000 |
| Self-reported health | 0.03 | 0.06 | [-0.12, 0.18] | 0.57 | .572 | .000 |
| Stress COVID-19 | -0.07 | 0.07 | [-0.24, 0.11] | -0.98 | .326 | .000 |
| Stress Russian invasion of Ukraine | 0.04 | 0.07 | [-0.15, 0.23] | 0.54 | .590 | .000 |
| **Evening type (*n* = 132)** | | | | | | |
| Female[1] | -0.11 | 0.19 | [-0.59, 0.37] | -0.60 | .548 | .000 |
| Age | 0.01 | 0.01 | [-0.01, 0.03] | 1.22 | .226 | .004 |
| Self-reported health | -0.05 | 0.12 | [-0.35, 0.25] | -0.42 | .679 | .000 |
| Stress COVID-19 | 0.05 | 0.14 | [-0.31, 0.41] | 0.37 | .714 | .000 |
| Stress Russian invasion of Ukraine | 0.10 | 0.15 | [-0.28, 0.48] | 0.70 | .483 | .000 |

*Note*. The association between covariates and SJL in the total sample and among chronotypes was analysed with GLM. A statistical significance level is set at alpha level .01 and is bolded in the table. Near statistical significance .01-.025 is highlighted with grey colour. Partial Omega squared ($\omega^2$p) was used as an effect size estimator.

CI = confidence interval, LL = lower limit, UL = upper limit.

[1] Gender is the covariate variable in which male is a redundant parameter, which means that the female gender is compared to the male gender.

[2,3] Chronotype is the covariate variable, only in the total sample, in which morning chronotype is a redundant parameter, which means that evening types and intermediate types are compared with morning types.