Study sample characteristics in chronobiology and sleep research

Selma Tir[1,2], Rhiannon White[1,3], & Manuel Spitschan[1,4,5]

[1] Department of Experimental Psychology, University of Oxford
[2] Sleep and Circadian Neuroscience Institute, Nuffield Department of Clinical Neurosciences, University of Oxford
[3] Warwick Medical School, University of Warwick, United Kingdom
[4] Centre for Chronobiology, Psychiatric Hospital of the University of Basel, Switzerland
[5] Transfaculty Research Platform Molecular and Cognitive Neurosciences, University of Basel, Switzerland

Many aspects of sleep and circadian physiology appear to be sensitive to participant-level characteristics. While recent research robustly highlights the importance of considering participant-level demographic information, it is not clear to what extent this information is available in the large body of already published literature. Here, we investigated study sample characteristics in the published sleep and chronobiology research over the past 40 years. 6,777 articles were identified and a random sample of 20% was included. The reporting of sample size, age, sex, gender, ethnicity, level of education, socio-economic status, and profession of the study population was scored, and any reported aggregate summary statistics for these variables were recorded. We found that while >90% of studies reported age or sex, all other variables were reported in <10% of cases. Sex balance greatly changed over the years, from a ~3:1 male to female ratio in the 1990s to a near-equal representation in the 2010s. We found that the majority of studies report at least sex or age, while other variables are typically not reported. Reporting quality is highly variable, indicating an opportunity to standardize reporting guidelines for participant-level characteristics to facilitate meta analyses.

Keywords: demographics, ethnicity, sex, research participants, reporting, publishing, meta-science
Word count: X

Introduction

Many aspects of sleep and circadian physiology appear to be sensitive to characteristics of the studied population, most notably sex (Anderson & FitzGerald, 2020; Cain et al., 2010; Mong et al., 2011; Redline et al., 2004; Santhi et al., 2016), age (Benloucif et al., 2006; Bliwise, 1993; Desforges, Prinz, Vitiello, Raskind, & Thorpy, 1990; Duffy, Zitting, & Chinoy, 2015; Espiritu, 2008; Li, Vitiello, & Gooneratne, 2018; Mander, Winer, & Walker, 2017; Redline et al., 2004) and ethnicity (Ahn et al., 2021; Eastman, Molina, Dziepak, & Smith, 2012; Eastman, Tomaka, & Crowley, 2016; Goldstein, Gaston, McGrath, & Jackson, 2020). More generally, there is a large literature on individual differences on sleep and circadian physiology (Baehr, Revelle, & Eastman, 2000; Burgess & Fogg, 2008; Chellappa, 2021; Dongen, Vitellaro, & Dinges, 2005; Horne & Östberg, 1977; Kerkhof, 1985; Santhi et al., 2012; Tankova, Adan, & Buela-Casal, 1994), demonstrating the need to consider participant-level data.

The extent to which a scientific field's findings are generalisable depend very much on the representativeness of a given study sample. As an example, a recent study reviewed the reporting and analysis of sex in biological sciences research (Woitowich, Beery, & Woodruff, 2020). The authors found that while sex inclusion has significantly increased over the past 10 years (Beery & Zucker, 2011), sex-based analysis has not improved, despite recent policies and funder mandates (Clayton & Collins, 2014).

While research findings converge on participant-level demographic characteristics affecting outcomes, it is not clear to what extent this information is available in the large body of already published literature, nor to what extent it is even reported. Here, we address the question of participant-level demographic characteristics (age, sex, gender, ethnicity, level of education, socio-economic status, and profession of the study population) and reporting thereof in chronobiology and sleep research. Here, we extracted the study sample character-

Corresponding author: Manuel Spitschan (manuel.spitschan@psy.ox.ac.uk). This work ws funded by the Wellcome Trust (Sir Henry Wellcome Fellowship to MS 204686/Z/16/Z; Research Enrichment – Diversity & Inclusion WT 204686/Z/16/A) and Linacre College (Biomedical Sciences Junior Research Fellowship to MS).

The authors made the following contributions. Selma Tir: Data curation, Investigation, Software, Visualization, Writing – original draft, Writing – review & editing; Rhiannon White: Investigation, Writing – original draft, Writing – review & editing; Manuel Spitschan: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Software, Writing – original draft, Writing – review & editing.

istics in a total of 1356 randomly sampled publications across the 8 top (ranked by the Journal Impact Factor) chronobiology and sleep research and subjected them to a comprehensive analysis.

Methods

Procedure. Journal articles published between 1979 and 2019 (odd years) in the top eight sleep and chronobiology journals were considered. The listing of possible of target journals was based on a previously established list of journals implementing a hybrid strategy by consulting the Web of Science Master Journal List, domain-relevant expertise in sleep and chronobiology and consulting with a senior researcher with >25 years of experience in the field (Spitschan, Schmidt, & Blume, 2020). From this previously derived list, we selected eight journals were selected based on their five-year Impact Factor, and included *Journal of Pineal Research* (ISSN: 0742-3098 / 1600-079X; 2018 5-year IF: 12.197), *Sleep* (0161-8105 / 1550-9109; 5.588), *Journal of Sleep Research* (0962-1105 / 1365-2869; 3.951), *Sleep Medicine* (1389-9457 / 1878-5506; 3.934), *Journal of Clinical Sleep Medicine* (1550-9389 / 1550-9397; 3.855), *Journal of Biological Rhythms* (0748-7304 / 1552-4531; 3.349), Behavioral Sleep Medicine (1540-2002 / 1540-2010; 3.162), and *Chronobiology International* (0742-0528 / 1525-6073; 2.998). While *Sleep Medicine Reviews* also features in the list of journals, we did not include it as it primarily publishes reviews.

Article inclusion. 6,777 articles were identified through a MEDLINE search by the journal and including odd years. A random sample of 20% was initially selected for screening. Inclusion requirements included conducting original research in the English language, reporting human data, and recruiting volunteers. As such, animal studies, bibliographies, case reports, comments, conference proceedings, editorials, guidelines, letters, retracted publications, reviews, errata and corrigenda were excluded.

Review and article extraction. All included articles were reviewed for eligibility and coded by RW. The reporting of sample size, age, sex, gender, ethnicity, level of education, socioeconomic status, and profession of the study population was scored binarily (0 = not reported, 1 = reported), and any reported aggregate summary statistics for these variables were recorded. Funding source, geographical location and clinical focus of the article were examined, as well as whether data were analyzed by including any of the demographic variables as covariates.

Data were coded in an Excel Spreadsheet and analyzed in R Studio (version 4.0.5). Reporting of funding, geographical location, and number of sub-studies for each article were investigated for the sample of articles that passed all eligibility criteria.

Pre-registration. We pre-registered our protocol (specified using the PRISMA-P template (PRISMA-P Group et al., 2015; Shamseer et al., 2015)) on the Open Science Framework (https://osf.io/cu3we/).

Materials, data and code availability. All data underlying this manuscript are available on a public GitHub repository (https://github.com/hcvnl/sleep_circadian_demographics_data). The article was written in R (R Core Team, 2021) using RMarkdown and papaja (Aust & Barth, 2020), employing a series of additional R packages (Arnold, 2021; Attali & Baker, 2019; Auguie, 2017; Bates & Maechler, 2021; Borchers, 2021; Edwards, 2020; Henry, Wickham, & Chang, 2020; Kaplan & Pruim, 2021; Morey & Rouder, 2018; Müller & Wickham, 2021; Pruim, Kaplan, & Horton, 2021; Pruim, Kaplan, & Horton, 2017; Sarkar, 2008; Sarkar & Andrews, 2019; Wei & Simko, 2017; Wickham, 2007, 2016, 2019, 2021; Wickham & Bryan, 2019; Wickham, François, Henry, & Müller, 2021; Wickham & Hester, 2020; Wilke, 2021; Xiao, 2018; Xie, 2015) and is fully reproducible.

Results

Inclusion & Exclusion. 85% of the sampled articles met eligibility criteria during the review.

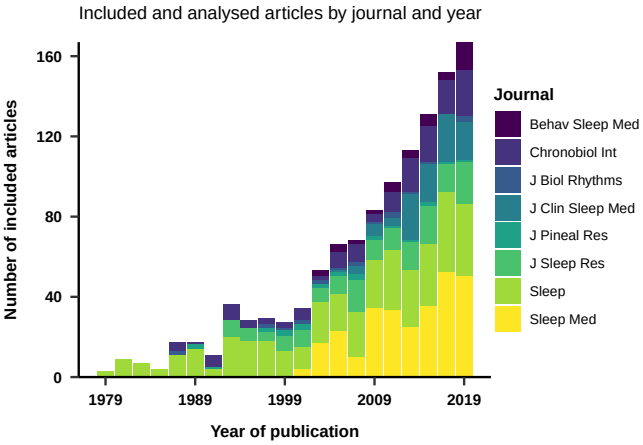


Figure 1. Funding sources and geographical location of the studies. A. Reporting of funding across the years. B. Distribution of articles by study location. The eight most represented countries are individually shown.

Funding. Funding sources were reported by 62% of studies, while funding number was also reported in 69% of these cases. Overall, funding by the United States' National Institutes of Health (NIH) represented 19% of the reported funding agencies. 92% of the studies funded by the NIH also reported funding number. The second most represented funding agencies were the Australian National Health and Medical Research Council (NHMRC) and the Canadian Institutes of Health Research (CIHR).

Geographical location. 93% of articles were conducted in a single country. The geographical location of the study was

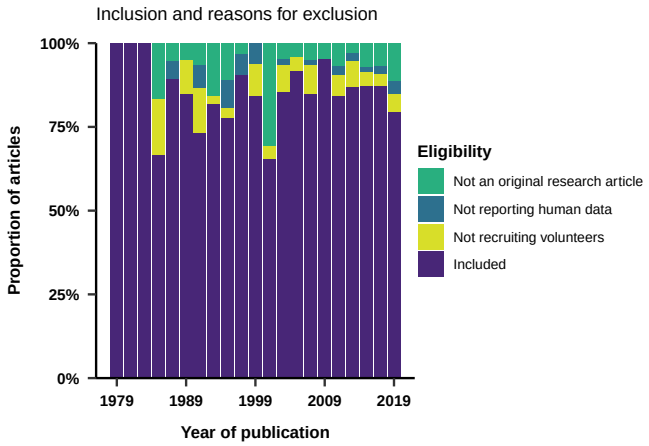


Figure 2. Funding sources and geographical location of the studies. A. Reporting of funding across the years. B. Distribution of articles by study location. The eight most represented countries are individually shown.

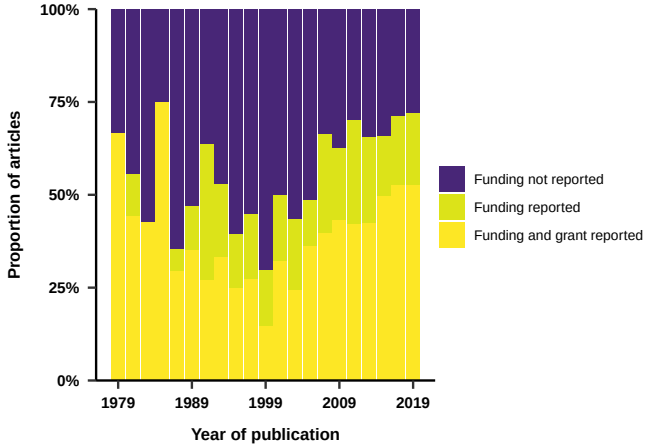


Figure 3. Funding sources and geographical location of the studies. A. Reporting of funding across the years. B. Distribution of articles by study location. The eight most represented countries are individually shown.

explicitly reported in 57% of studies. The country of study was inferred for the rest of the sampled articles. Inference was primarily based on the first author's affiliation. Overall, 53 countries were represented. 77% of articles reported multiple countries of study. Figure 2B shows the distribution of study location across time with the eight most represented countries.

Sample size. Sample size was reported in 92% of studies, while 98% investigated a single sampled population.

Age. 93% of articles reported a variable describing age. Figure 4A and 4B show the use of various age variables by year and journal of publication. Overall, the mean age of the study populations was 39 years old.

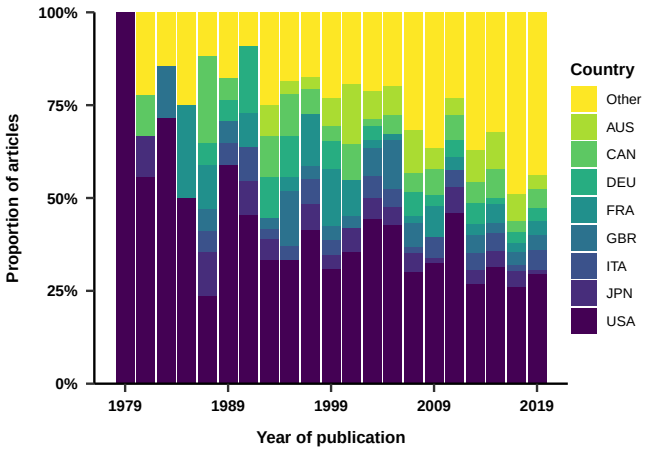


Figure 4. Funding sources and geographical location of the studies. A. Reporting of funding across the years. B. Distribution of articles by study location. The eight most represented countries are individually shown.

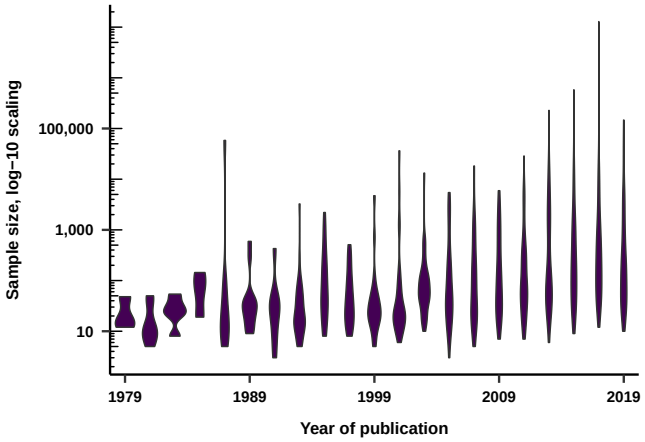
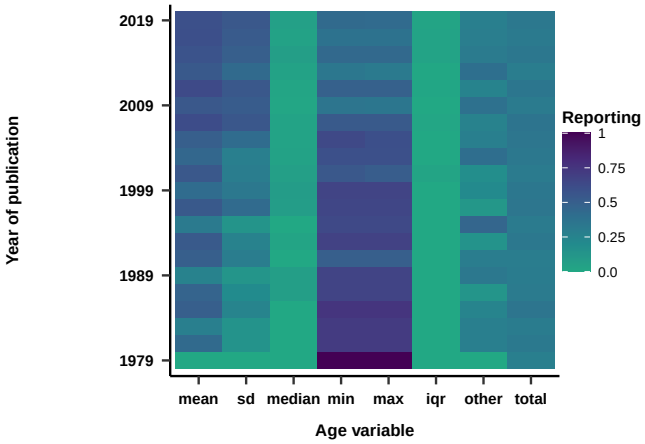


Figure 5. Sample size of the recruited volunteers. Numbers are computed with a log-10 scale.



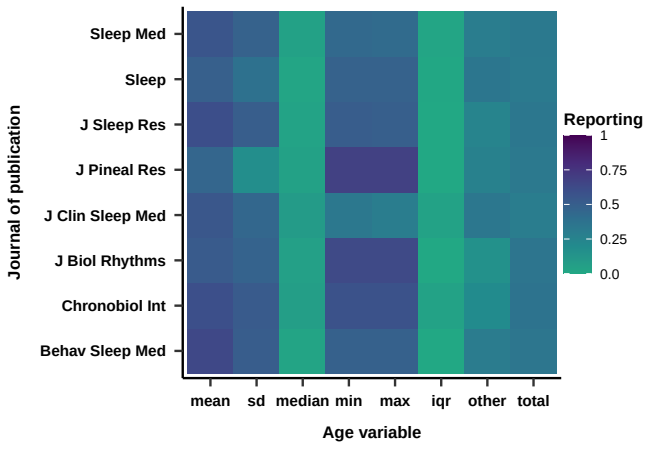


Figure 6. Reporting of age variables. Correlation between the reporting of the mean, standrad deviation of the mean, median, minimum, maximum, interquartile range and other age variables by A. year of publication and B. journal of publication. C. Mean age by year of publication.

Sex. Sex was reported in 89% of the studies. Figure 5 displays the proportion of studies that recruited male subjects, female subjects, both sexes or did not specify the sex of the participants. 13% of the studies reporting sex only recruited male participants, while 10% only employed females. Out of the studies focusing on a single gender, 1% of the male studies focused on a sex dependent feature, while 2% of the female studies did. 4% of studies reported age by sex.

Ethnicity, education, profession and socio-economic status. Other demographics variables were reported in 12% of studies for education, 15% for ethnicity, 2% for profession, and 4% for socio-economic status. Figure 6 shows the distribution of this reporting across the years. Figures 7 show the number of categories reported for each variable.

Study focus. 3% of articles focused on a sex dependent feature, while 50% investigated a clinical feature. 1% of studies focused on twins, 1% on pregnant women, 2% on shift workers and 4% on university students.

Analysis disaggregation. A

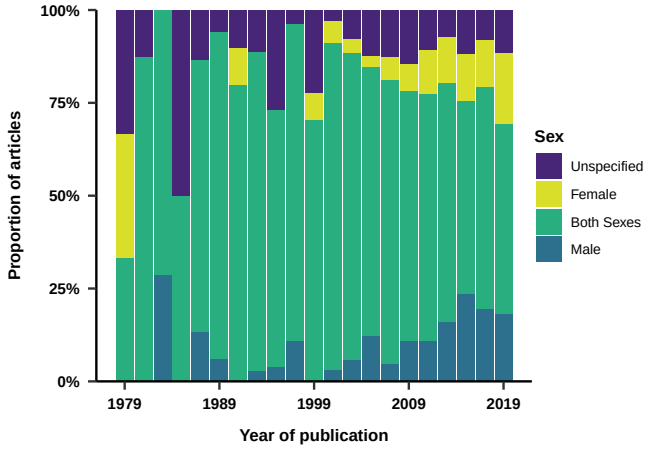


Figure 7. Sex inclusion. Proportion of studies that recruited male subjects, female subjects, both sexes, or did not specify the sex of the participants.

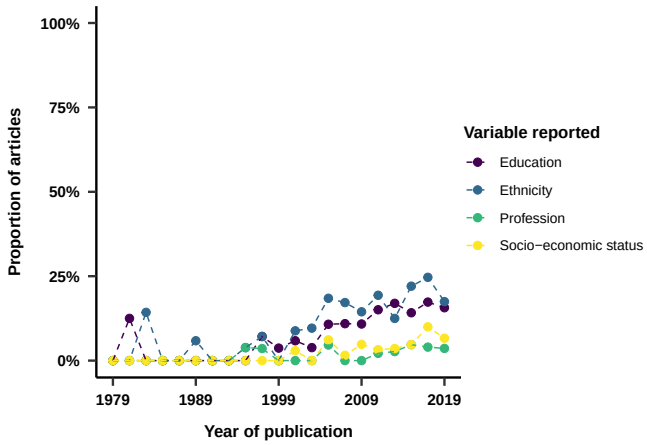


Figure 8. Reporting of education, ethinicity, profession and socio-economic status.

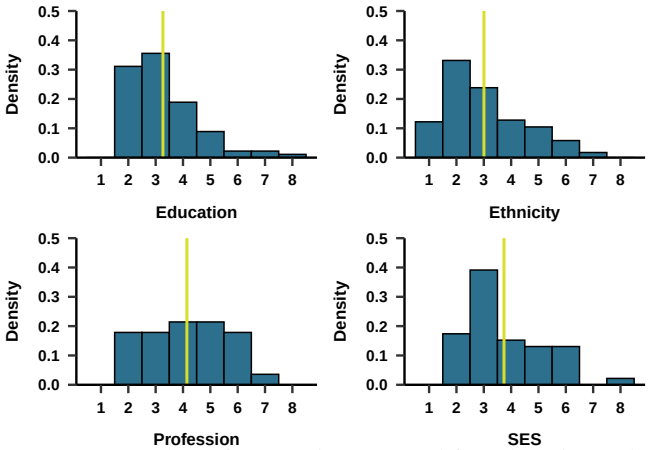


Figure 9. Number of categories reported for education, ethnicity, profession and socio-economic status.

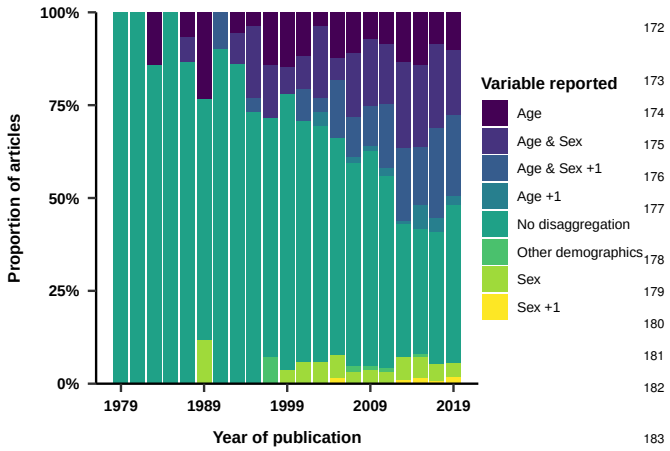


Figure 10. Use of study population characteristics as variables in the analysis.

Discussion

In the clinical domain, the need to time therapy based on a patient's individual circadian rhythm has more recently become the focus of the emerging field of chronotherapy or chronotherapeutics (Adam, 2019; Dijk & Duffy, 2020; Greco & Sassone-Corsi, 2020; Hill, Innominato, Lévi, & Ballesta, 2020).

The ability to generalise findings from the scientific literature to wide and diverse populations of people hinges upon the representativeness of the study sample with respect to demographic categories. The question to what extent the composition of a given study sample can make the generalisability of findings difficult or impossible has received attention in the field of psychology, where many articles published in prominent journals reflected participants from WEIRD (Western, Educated, Industrialized, Rich, and Democratic) contexts (Henrich, Heine, & Norenzayan, 2010; Muthukrishna et al., 2020).

Conclusion

References

Adam, D. (2019). Core Concept: Emerging science of chronotherapy offers big opportunities to optimize drug delivery. *Proceedings of the National Academy of Sciences*, *116*(44), 21957–21959. https://doi.org/10.1073/pnas.1916118116

Ahn, S., Lobo, J. M., Logan, J. G., Kang, H., Kwon, Y., & Sohn, M.-W. (2021). A scoping review of racial/ethnic disparities in sleep. *Sleep Medicine*, *81*, 169–179. https://doi.org/10.1016/j.sleep.2021.02.027

Anderson, S. T., & FitzGerald, G. A. (2020). Sexual dimorphism in body clocks. *Science (New York, N.Y.)*, *369*(6508), 1164–1165. https://doi.org/10.1126/science.abd4964

Arnold, J. B. (2021). *Ggthemes: Extra themes, scales and geoms for 'ggplot2'*. Retrieved from https://CRAN.R-project.org/package=ggthemes

Attali, D., & Baker, C. (2019). *ggExtra: Add marginal histograms to 'ggplot2', and more 'ggplot2' enhancements*. Retrieved from https://CRAN.R-project.org/package=ggExtra

Auguie, B. (2017). *gridExtra: Miscellaneous functions for "grid" graphics*. Retrieved from https://CRAN.R-project.org/package=gridExtra

Aust, F., & Barth, M. (2020). *papaja: Create APA manuscripts with R Markdown*. Retrieved from https://github.com/crsh/papaja

Baehr, E. K., Revelle, W., & Eastman, C. I. (2000). Individual differences in the phase and amplitude of the human circadian temperature rhythm: With an emphasis on morningness-eveningness: Phase and amplitude of the temperature rhythm. *Journal of Sleep Research*, *9*(2), 117–127. https://doi.org/10.1046/j.1365-2869.2000.00196.x

Bates, D., & Maechler, M. (2021). *Matrix: Sparse and dense matrix classes and methods*. Retrieved from https://CRAN.R-project.org/package=Matrix

Beery, A. K., & Zucker, I. (2011). Sex bias in neuroscience and biomedical research. *Neuroscience and Biobehavioral Reviews*, *35*(3), 565–572. https://doi.org/10.1016/j.neubiorev.2010.07.002

Benloucif, S., Green, K., L'Hermite-Balériaux, M., Weintraub, S., Wolfe, L. F., & Zee, P. C. (2006). Responsiveness of the aging circadian clock to

light. *Neurobiology of Aging*, *27*(12), 1870–1879. https://doi.org/10.1016/j.neurobiolaging.2005.10.011

Bliwise, D. L. (1993). Sleep in Normal Aging and Dementia. *Sleep*, *16*(1), 40–81. https://doi.org/10.1093/sleep/16.1.40

Borchers, H. W. (2021). *Pracma: Practical numerical math functions*. Retrieved from https://CRAN.R-project.org/package=pracma

Burgess, H. J., & Fogg, L. F. (2008). Individual Differences in the Amount and Timing of Salivary Melatonin Secretion. *PLoS ONE*, *3*(8), e3055. https://doi.org/10.1371/journal.pone.0003055

Cain, S. W., Dennison, C. F., Zeitzer, J. M., Guzik, A. M., Khalsa, S. B. S., Santhi, N., … Duffy, J. F. (2010). Sex differences in phase angle of entrainment and melatonin amplitude in humans. *Journal of Biological Rhythms*, *25*(4), 288–296. https://doi.org/10.1177/0748730410374943

Chellappa, S. L. (2021). Individual differences in light sensitivity affect sleep and circadian rhythms. *Sleep*, *44*(2), zsaa214. https://doi.org/10.1093/sleep/zsaa214

Clayton, J. A., & Collins, F. S. (2014). Policy: NIH to balance sex in cell and animal studies. *Nature*, *509*(7500), 282–283. https://doi.org/10.1038/509282a

Desforges, J. F., Prinz, P. N., Vitiello, M. V., Raskind, M. A., & Thorpy, M. J. (1990). Sleep Disorders and Aging. *New England Journal of Medicine*, *323*(8), 520–526. https://doi.org/10.1056/NEJM199008233230805

Dijk, D.-J., & Duffy, J. F. (2020). Novel Approaches for Assessing Circadian Rhythmicity in Humans: A Review. *Journal of Biological Rhythms*, *35*(5), 421–438. https://doi.org/10.1177/0748730420940483

Dongen, H. P. A. van, Vitellaro, K. M., & Dinges, D. F. (2005). Individual Differences in Adult Human Sleep and Wakefulness: Leitmotif for a Research Agenda. *Sleep*, *28*(4), 479–498. https://doi.org/10.1093/sleep/28.4.479

Duffy, J. F., Zitting, K.-M., & Chinoy, E. D. (2015). Aging and Circadian Rhythms. *Sleep Medicine Clinics*, *10*(4), 423–434. https://doi.org/10.1016/j.jsmc.2015.08.002

Eastman, C. I., Molina, T. A., Dziepak, M. E., & Smith, M. R. (2012). Blacks (African Americans) have shorter free-running circadian periods than whites (Caucasian Americans). *Chronobiology International*, *29*(8), 1072–1077. https://doi.org/10.3109/07420528.2012.700670

Eastman, C. I., Tomaka, V. A., & Crowley, S. J. (2016). Circadian rhythms of European and African-Americans after a large delay of sleep as in jet lag and night work. *Scientific Reports*, *6*(1), 36716. https://doi.org/10.1038/srep36716

Edwards, S. M. (2020). *Lemon: Freshing up your 'ggplot2' plots*. Retrieved from https://CRAN.R-project.org/package=lemon

Espiritu, J. R. D. (2008). Aging-Related Sleep Changes. *Clinics in Geriatric Medicine*, *24*(1), 1–14. https://doi.org/10.1016/j.cger.2007.08.007

Goldstein, S. J., Gaston, S. A., McGrath, J. A., & Jackson, C. L. (2020). Sleep Health and Serious Psychological Distress: A Nationally Representative Study of the United States among White, Black, and Hispanic/Latinx Adults. *Nature and Science of Sleep*, *12*, 1091–1104. https://doi.org/10.2147/NSS.S268087

Greco, C. M., & Sassone-Corsi, P. (2020). Personalized medicine and circadian rhythms: Opportunities for modern society. *Journal of Experimental Medicine*, *217*(6), e20200702. https://doi.org/10.1084/jem.20200702

Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world? *Behavioral and Brain Sciences*, *33*(2-3), 61–83. https://doi.org/10.1017/S0140525X0999152X

Henry, L., Wickham, H., & Chang, W. (2020). *Ggstance: Horizontal 'ggplot2' components*. Retrieved from https://CRAN.R-project.org/package=ggstance

Hill, R. J. W., Innominato, P. F., Lévi, F., & Ballesta, A. (2020). Optimizing circadian drug infusion schedules towards personalized cancer chronotherapy. *PLOS Computational Biology*, *16*(1), e1007218. https://doi.org/10.1371/journal.pcbi.1007218

Horne, J. A., & Östberg, O. (1977). Individual differences in human circadian rhythms. *Biological Psychology*, *5*(3), 179–190. https://doi.org/10.1016/0301-0511(77)90001-1

Kaplan, D., & Pruim, R. (2021). *Ggformula: Formula interface to the grammar of graphics*. Retrieved from https://CRAN.R-project.org/pack

age=ggformula

Kerkhof, G. A. (1985). Inter-individual differences in the human circadian system: A review. *Biological Psychology*, *20*(2), 83–112. https://doi.org/10.1016/0301-0511(85)90019-5

Li, J., Vitiello, M. V., & Gooneratne, N. S. (2018). Sleep in Normal Aging. *Sleep Medicine Clinics*, *13*(1), 1–11. https://doi.org/10.1016/j.jsmc.2017.09.001

Mander, B. A., Winer, J. R., & Walker, M. P. (2017). Sleep and Human Aging. *Neuron*, *94*(1), 19–36. https://doi.org/10.1016/j.neuron.2017.02.004

Mong, J. A., Baker, F. C., Mahoney, M. M., Paul, K. N., Schwartz, M. D., Semba, K., & Silver, R. (2011). Sleep, rhythms, and the endocrine brain: Influence of sex and gonadal hormones. *The Journal of Neuroscience: The Official Journal of the Society for Neuroscience*, *31*(45), 16107–16116. https://doi.org/10.1523/JNEUROSCI.4175-11.2011

Morey, R. D., & Rouder, J. N. (2018). *BayesFactor: Computation of bayes factors for common designs*. Retrieved from https://CRAN.R-project.org/package=BayesFactor

Muthukrishna, M., Bell, A. V., Henrich, J., Curtin, C. M., Gedranovich, A., McInerney, J., & Thue, B. (2020). Beyond Western, Educated, Industrial, Rich, and Democratic (WEIRD) Psychology: Measuring and Mapping Scales of Cultural and Psychological Distance. *Psychological Science*, *31*(6), 678–701. https://doi.org/10.1177/0956797620916782

Müller, K., & Wickham, H. (2021). *Tibble: Simple data frames*. Retrieved from https://CRAN.R-project.org/package=tibble

PRISMA-P Group, Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., … Stewart, L. A. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Systematic Reviews*, *4*(1), 1. https://doi.org/10.1186/2046-4053-4-1

Pruim, R., Kaplan, D., & Horton, N. (2021). *mosaicData: Project MOSAIC data sets*. Retrieved from https://CRAN.R-project.org/package=mosaicData

Pruim, R., Kaplan, D. T., & Horton, N. J. (2017). The mosaic package: Helping students to 'think with data' using r. *The R Journal*, *9*(1), 77–102. Retrieved from https://journal.r-project.org/archive/2017/RJ-2017-024/index.html

R Core Team. (2021). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from https://www.R-project.org/

Redline, S., Kirchner, H. L., Quan, S. F., Gottlieb, D. J., Kapur, V., & Newman, A. (2004). The effects of age, sex, ethnicity, and sleep-disordered breathing on sleep architecture. *Archives of Internal Medicine*, *164*(4), 406–418. https://doi.org/10.1001/archinte.164.4.406

Santhi, N., Lazar, A. S., McCabe, P. J., Lo, J. C., Groeger, J. A., & Dijk, D.-J. (2016). Sex differences in the circadian regulation of sleep and waking cognition in humans. *Proceedings of the National Academy of Sciences of the United States of America*, *113*(19), E2730–2739. https://doi.org/10.1073/pnas.1521637113

Santhi, N., Thorne, H. C., Veen, D. R. van der, Johnsen, S., Mills, S. L., Hommes, V., … Dijk, D.-J. (2012). The spectral composition of evening light and individual differences in the suppression of melatonin and delay of sleep in humans: Artificial evening light suppresses melatonin and delays sleep. *Journal of Pineal Research*, *53*(1), 47–59. https://doi.org/10.1111/j.1600-079X.2011.00970.x

Sarkar, D. (2008). *Lattice: Multivariate data visualization with r*. New York: Springer. Retrieved from http://lmdvr.r-forge.r-project.org

Sarkar, D., & Andrews, F. (2019). *latticeExtra: Extra graphical utilities based on lattice*. Retrieved from https://CRAN.R-project.org/package=latticeExtra

Shamseer, L., Moher, D., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., … the PRISMA-P Group. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: Elaboration and explanation. *BMJ*, *349*(jan02 1), g7647–g7647. https://doi.org/10.1136/bmj.g7647

Spitschan, M., Schmidt, M. H., & Blume, C. (2020). Transparency and open science principles in reporting guidelines in sleep research and chronobiology journals. *Wellcome Open Research*, *5*, 172. https://doi.org/10.12688/wellcomeopenres.16111.1

Tankova, I., Adan, A., & Buela-Casal, G. (1994). Circadian typology and individual differences. A review. *Personality and Individual Differences*, *16*(5), 671–684. https://doi.org/10.1016/0191-8869(94)90209-7

Wei, T., & Simko, V. (2017). *R package "corrplot": Visualization of a correlation matrix*. Retrieved from https://github.com/taiyun/corrplot

Wickham, H. (2007). Reshaping data with the reshape package. *Journal of Statistical Software*, *21*(12), 1–20. Retrieved from http://www.jstatsoft.org/v21/i12/

Wickham, H. (2016). *ggplot2: Elegant graphics for data analysis*. Springer-Verlag New York. Retrieved from https://ggplot2.tidyverse.org

Wickham, H. (2019). *Stringr: Simple, consistent wrappers for common string operations*. Retrieved from https://CRAN.R-project.org/package=stringr

Wickham, H. (2021). *Tidyr: Tidy messy data*. Retrieved from https://CRAN.R-project.org/package=tidyr

Wickham, H., & Bryan, J. (2019). *Readxl: Read excel files*. Retrieved from https://CRAN.R-project.org/package=readxl

Wickham, H., François, R., Henry, L., & Müller, K. (2021). *Dplyr: A grammar of data manipulation*. Retrieved from https://CRAN.R-project.org/package=dplyr

Wickham, H., & Hester, J. (2020). *Readr: Read rectangular text data*. Retrieved from https://CRAN.R-project.org/package=readr

Wilke, C. O. (2021). *Ggridges: Ridgeline plots in 'ggplot2'*. Retrieved from https://CRAN.R-project.org/package=ggridges

Woitowich, N. C., Beery, A., & Woodruff, T. (2020). A 10-year follow-up study of sex inclusion in the biological sciences. *eLife*, *9*, e56344. https://doi.org/10.7554/eLife.56344

Xiao, N. (2018). *Ggsci: Scientific journal and sci-fi themed color palettes for 'ggplot2'*. Retrieved from https://CRAN.R-project.org/package=ggsci

Xie, Y. (2015). *Dynamic documents with R and knitr* (2nd ed.). Boca Raton, Florida: Chapman; Hall/CRC. Retrieved from https://yihui.org/knitr/