

## Supplementary Materials

To

### **“The Irrecoverable Loss in Sleep on Weekdays of Two Distinct Chronotypes Can be Equalized by Permitting a >2 h Difference in Waking Time”**

This Supplementary Materials includes more details on selection, exclusion criteria, and various chronobiological and somnological characteristics of the participants from 8 samples.

#### **Procedure**

Lecturers from several Russian universities invited their students and colleagues (and some other people from the staff of these universities) to respond from their smartphones to the questions concerning sleep-wake behavior. No exclusion criteria were applied for participation in these surveys. Since all participants attended classes/office, this excludes a possibility of their being in unhealthy physical and mental condition at the time of the survey. Each potential participant of a survey was informed – either via e-mail or by personal communication – that, to collect anonymously his/her responses, a web site was developed.

In total, we collected responses from 4406 participants of four surveys using four web-sites, two web sites in Moscow and two web sites in Novosibirsk.

Informed consent was obtained from each individual participant in the form of response “Yes” to the first question of the survey. All responses of the participant were written in an excel file right after the responding to the last question. Although we cannot estimate the number of non-responders using such approach to Internet-based anonymous data collection, any potential difference between them and responders seems not to be critical for the achieving the main purpose of the study, i.e., to collect self-reported sleep times from M- and E-types and to simulate these times with a two-process model of sleep regulation for the development of methodology for equalizing chronotypes on weekday sleep loss (e.g., by calculation of delaying shift of wakeups of E-types relative to the clock times for M-types’ wakeups).

#### **Assessments**

Additional data on 17 chronobiological and somnological characteristics of lecturers and students of M- and E-types are reported in this Supplementary Materials for each of 8 samples (Table S1).

In order to classify survey participants into two distinct ChronoTypes (CT), we used the responses to the only question of the Single-Item-Chronotyping (SIC) [9], “Self-assess your chronotype by choosing one of six patterns of daily change in alertness level”. The SIC was developed for one-click self-chronotyping into the following 7 (LIVEMAN) types, “Lethargic”, “Inconclusive”, “Vigilant”, “Evening”, “Morning”, “Afternoon”, and “Napping”. Six of 7 response options (excluding the option for “Inconclusive”) were either illustrated by 6 simple graphs or explained by 6 brief descriptions of daily activity pattern (i.e., “morning type: high level in the morning, middle in the afternoon, low in the evening”, “evening type: low level in the morning, middle in the afternoon, high in the evening”, “lethargic type: low level in the morning, low in the afternoon, low in the evening”, “vigilant type: high level in the morning, high in the afternoon, high in the evening”, “afternoon type: low level in the morning, high in the afternoon, middle in the evening”, and “napping type: high level in the morning, low in the afternoon, middle in the evening”). The last option for inconclusive type was always only verbally described as either “none of the above” or “other”.

In the original publication on the SIC, 37% university students responded that they were either E- or M-types, while one of 5 other options was chosen by 63% university students [9]. Participants included in the further analyses chosen one of two responses, either “Evening” or “Morning”.

Sleep times were used in all surveys for accounting state-like individual variation in earliness-lateness. The participants were asked to report clock hours for bed- and risetimes on weekdays and weekends. Such self-reported bed- and risetime on weekdays and weekends were used to estimate time in bed (i.e., risetime-bedtime difference), weekend-weekday differences in sleep times, etc. Twelve sleep time estimates are included in Tables 4, 5, and S1.

The Sleep-Wake Adaptability Test (SWAT) [9–12] was used in all surveys to account for ability-like individual differences in morningness-eveningness (or earliness-lateness) and several other ability-like differences. We included in Table S1 the results on 5 10-item scales of the SWAT, Morning Sleepability (MS), Nighttime Wakeability (NW), Daytime Sleepability (DS), Daytime Wakeability (DW), and Nighttime Sleepability (NS). The SWAT was initially developed for testing the predictions of a three-dimensional model of individual variation in sleep-wake adaptability [13]. Positive

score on a scale of the SWAT (>0) indicates an ability rather than inability to sleep or wake at certain hours of the 24-h cycle (e.g., morning, daytime, evening, etc.).

### Content of Table S1

Table S1 of this Supplementary Materials contains mean and SEM (Standard Error of this Mean) calculated for 17 questionnaire assessments of self-chosen ChronoTypes (either M- or E-type) from each of 8 samples collected in four consecutive surveys (the participants of each survey were separated into two ages, either Lecturers or Students).

**Table S1.** Chronobiological and somnological assessments of M- and E-types from 8 samples collected in 4 surveys.

Survey. Site	1. Moscow				3. Moscow				2. Novosibirsk				4. Novosibirsk			
ChronoType	M-type		E-type		M-type		E-type		M-type		E-type		M-type		E-type	
	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM
Lecturers (n):	(15)		(15)		(24)		(9)		(41)		(37)		(58)		(46)	
Weekday BT	22.91	0.40	24.97	0.40	22.92	0.24	24.36	0.25	22.69	0.31	23.77	0.51	22.83	0.20	24.23	0.23
Weekend BT	23.46	0.42	1.74	0.42	23.50	0.26	1.38	0.27	23.21	0.33	24.56	0.54	23.28	0.21	24.91	0.24
Difference BT	0.55	0.39	0.78	0.39	0.58	0.23	1.01	0.25	0.52	0.31	0.79	0.50	0.44	0.20	0.68	0.22
Averaged BT	23.07	0.36	1.19	0.36	23.09	0.22	24.65	0.23	22.84	0.29	23.99	0.47	22.96	0.18	24.42	0.21
Weekday RT	6.43	0.32	7.07	0.32	6.57	0.19	7.66	0.20	6.17	0.25	7.37	0.41	6.45	0.16	7.34	0.18
Weekend RT	8.34	0.43	10.20	0.43	8.13	0.26	10.05	0.28	8.33	0.34	9.62	0.56	8.09	0.22	9.59	0.25
Difference RT	1.91	0.45	3.13	0.45	1.56	0.27	2.39	0.29	2.16	0.35	2.25	0.58	1.64	0.23	2.25	0.26
Averaged RT	6.98	0.29	7.97	0.29	7.02	0.18	8.35	0.19	6.79	0.23	8.01	0.38	6.92	0.15	7.98	0.17
Weekday TIB	7.52	0.43	6.11	0.43	7.65	0.26	7.30	0.28	7.48	0.34	7.60	0.56	7.62	0.22	7.12	0.25
Weekend TIB	8.88	0.44	8.46	0.44	8.63	0.27	8.68	0.28	9.12	0.35	9.07	0.57	8.81	0.22	8.68	0.25
Difference TIB	1.36	0.52	2.35	0.52	0.97	0.32	1.38	0.33	1.65	0.41	1.46	0.67	1.19	0.27	1.57	0.30
Averaged TIB	7.91	0.37	6.78	0.37	7.93	0.22	7.69	0.23	7.95	0.29	8.02	0.47	7.96	0.19	7.56	0.21
SWAT: MS	-5.27	1.19	3.47	1.19	-3.32	0.72	4.32	0.76	-2.42	0.94	3.67	1.54	-4.03	0.61	1.48	0.68
SWAT: NW	-6.73	1.09	3.40	1.09	-6.39	0.66	3.78	0.69	-4.54	0.86	1.33	1.40	-6.50	0.55	3.50	0.62
SWAT: DW	2.00	1.16	2.93	1.16	1.98	0.70	2.35	0.74	4.63	0.91	4.56	1.49	4.21	0.59	1.87	0.66
SWAT: DS	-0.33	1.30	1.60	1.30	-3.22	0.79	-4.16	0.83	-1.13	1.03	-5.00	1.68	-2.43	0.66	0.80	0.74
SWAT: NS	4.53	1.22	1.87	1.22	0.93	0.74	-4.78	0.78	-0.83	0.97	-3.33	1.58	-0.57	0.62	-1.59	0.70
Students (n):	(213)		(387)		(196)		(329)		(36)		(115)		(76)		(168)	
Weekday BT	23.77	0.11	1.17	0.08	23.26	0.26	24.48	0.14	23.73	0.11	1.04	0.08	22.73	0.18	24.05	0.12
Weekend BT	24.24	0.11	1.91	0.08	23.71	0.27	1.60	0.15	24.40	0.12	1.73	0.09	23.66	0.19	1.10	0.13
Difference BT	0.47	0.10	0.74	0.08	0.45	0.25	1.12	0.14	0.67	0.11	0.69	0.08	0.93	0.17	1.05	0.12
Averaged BT	23.91	0.10	1.38	0.07	23.39	0.23	24.80	0.13	23.93	0.10	1.24	0.08	23.00	0.16	24.35	0.11
Weekday RT	6.66	0.09	6.70	0.06	7.06	0.21	7.92	0.12	6.83	0.09	7.20	0.07	6.82	0.14	7.36	0.10
Weekend RT	9.35	0.12	11.06	0.09	8.99	0.28	10.69	0.16	9.23	0.12	10.67	0.09	8.96	0.19	10.43	0.13
Difference RT	2.69	0.12	4.36	0.09	1.94	0.29	2.77	0.16	2.40	0.12	3.47	0.10	2.14	0.20	3.07	0.13
Averaged RT	7.43	0.08	7.94	0.06	7.61	0.19	8.71	0.11	7.51	0.08	8.19	0.06	7.44	0.13	8.23	0.09
Weekday TIB	6.89	0.12	5.52	0.09	7.80	0.28	7.23	0.16	7.09	0.12	6.17	0.09	8.09	0.19	7.31	0.13
Weekend TIB	9.11	0.12	9.15	0.09	9.28	0.28	8.89	0.16	8.82	0.12	8.94	0.09	9.30	0.20	9.33	0.13
Difference TIB	2.23	0.14	3.63	0.10	1.49	0.34	1.65	0.19	1.73	0.14	2.78	0.11	1.21	0.23	2.02	0.16
Averaged TIB	7.52	0.10	6.56	0.07	8.22	0.24	7.71	0.13	7.59	0.10	6.96	0.08	8.44	0.16	7.89	0.11
SWAT: MS	-1.03	0.32	5.12	0.24	-2.97	0.77	4.66	0.43	-2.28	0.33	3.53	0.26	-2.08	0.53	2.91	0.36
SWAT: NW	-3.93	0.29	1.92	0.21	-4.56	0.70	3.91	0.39	-3.00	0.30	2.54	0.23	-2.70	0.48	3.20	0.33
SWAT: DW	2.57	0.31	0.41	0.23	3.28	0.75	1.67	0.42	2.83	0.32	1.37	0.25	4.61	0.51	2.99	0.35
SWAT: DS	-1.76	0.35	0.31	0.26	-3.97	0.84	-1.90	0.47	-1.84	0.36	0.36	0.28	-1.83	0.58	-0.89	0.39
SWAT: NS	1.48	0.32	0.37	0.24	0.28	0.79	-2.03	0.44	0.83	0.34	0.47	0.26	0.70	0.54	-1.18	0.37

Notes. Data on Lecturers and Students (upper and lower part, respectively) with one of self-chosen ChronoTypes (either Morning or Evening, either M- or E-type, respectively). "Survey": Four online surveys, 1–4 (see Table 1); BT: BedTime; RT: RiseTime; TIB: Time In Bed; Averaged: weekly Averaged sleep time. Difference BT (or RT or TIB): Difference between Weekend and Weekday in BT (or in RT or in TIB); MS, NW, DW, DS, and NS: 10-item Morning Sleepability, Nighttime

Wakeability, Daytime Wakeability, Daytime Sleepability, and Nighttime Sleepability scales of the SWAT. SEM: Standard Error of Mean.

## References

1. Borbély, A.A. A two process model of sleep regulation. *Hum. Neurobiol.* **1982**, *1*, 195–204.
2. Daan, S.; Beersma, D.G.M.; Borbély, A.A. Timing of human sleep: Recovery process gated by a circadian pacemaker. *Am. J. Physiol. Regul. Integr. Comp. Physiol.* **1984**, *246*, R161–R178.
3. Borbély, A.A.; Daan, S.; Wirz-Justice, A.; Deboer, T. The two-process model of sleep regulation: A reappraisal. *J. Sleep Res.* **2016**, *25*, 131–143.
4. Putilov, A.A. Sleep during “lockdown” highlighted the need to rethink the concept of weekend catch-up sleep. *Sleep Breath* **2022**. <https://doi.org/10.1007/s11325-021-02492-z>.
5. Putilov, A.A. Weekend sleep after early and later school start times confirmed a model-predicted failure to catch up sleep missed on weekdays. *Sleep Breath* **2023**. <https://doi.org/10.1007/s11325-022-02648-5>.
6. Putilov, A.A.; Verevkin, E.G. Simulation of the ontogeny of social jet lag: A shift in just one of the parameters of a model of sleep-wake regulating process accounts for the delay of sleep phase across adolescence. *Front. Physiol.* **2018**, *9*, 1529.
7. Putilov, A.A. The timing of sleep modelling: Circadian modulation of the homeostatic process. *Biol. Rhythm. Res.* **1995**, *26*, 1–19.
8. Putilov, A.A.; Donskaya, O.G. What can make the difference between chronotypes in sleep duration? Testing similarity of their homeostatic processes. *Front. Neurosci.* **2022**, *16*, 832807.
9. Putilov, A.A.; Sveshnikov, D.S.; Puchkova, A.N.; Dorokhov, V.B.; Bakaeva, Z.B.; Yakunina, E.B.; Starshinov, Y.P.; Torshin, V.I.; Alipov, N.N.; Sergeeva, O.V.; et al. Single-Item Chronotyping (SIC), a method to self-assess diurnal types by using 6 simple charts. *Pers. Ind. Differ.* **2021**, *168*, 110353.
10. Putilov, A.A.; Budkevich, E.V.; Tinkova, E.L.; Dyakovich, M.P.; Sveshnikov, D.S.; Donskaya, O.G.; Budkevich, R.O. A six-factor structure of individual variation in the tendencies to become sleepy and to sleep at different times of the day. *Acta Psychol.* **2021**, *217*, 103327.
11. Putilov, A.A.; Sveshnikov, D.S.; Bakaeva, Z.B.; Yakunina, E.B.; Starshinov, Y.P.; Torshin, V.I.; Alipov, N.N.; Sergeeva, O.V.; Trutneva, E.A.; Lapkin, M.M.; et al. Differences between male and female university students in sleepiness, weekday sleep loss, and weekend sleep duration. *J. Adolesc.* **2021**, *88*, 84–96.
12. Putilov, A.A.; Nechunaev, V.V.; Budkevich, R.O.; Budkevich, E.V.; Kolomeichuk, S.N.; Morozov, A.V.; Plusnin, J.M.; Donskaya, O.G.; Verevkin, E.G.; Puchkova, A.N.; et al. Overlap between individual variation in personality traits and sleep-wake behavior. *Curr. Psychol.* **2021**. <https://doi.org/10.1007/s12144-021-01495-z>.
13. Putilov, A.A. Three-dimensional structural representation of the sleep-wake adaptability. *Chronobiol. Int.* **2016**, *33*, 169–180.