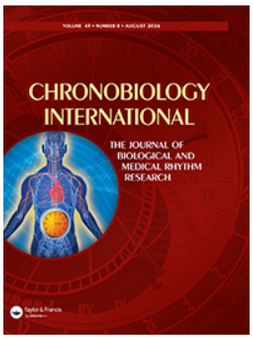

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ORIGINAL ARTICLE

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# Differential relationship of morning and evening components of earliness-lateness with sex and compromised sleep, mood, and health

Arcady A. Putilov[a], Dmitry S. Sveshnikov[b], Zarina V. Bakaeva[b], Elena B. Yakunina[b], Olga V. Mankaeva[b], Vladimir I. Torshin[b], Elena A. Trutneva[c], Michael M. Lapkin[c], Zhanna N. Lopatskaya[d], Roman O. Budkevich[e], Elena V. Budkevich[e], Dmitry E. Shumov[b,f], Anton I. Taranov[f], Olga N. Tkachenko[f], Eugenia O. Gandina[f], Alexander E. Manaenkov[f], Evgeniy A. Cheremushkin[f], Natalya V. Ligun[f], Alexandra N. Puchkova[f], and Vladimir B. Dorokhov[f]

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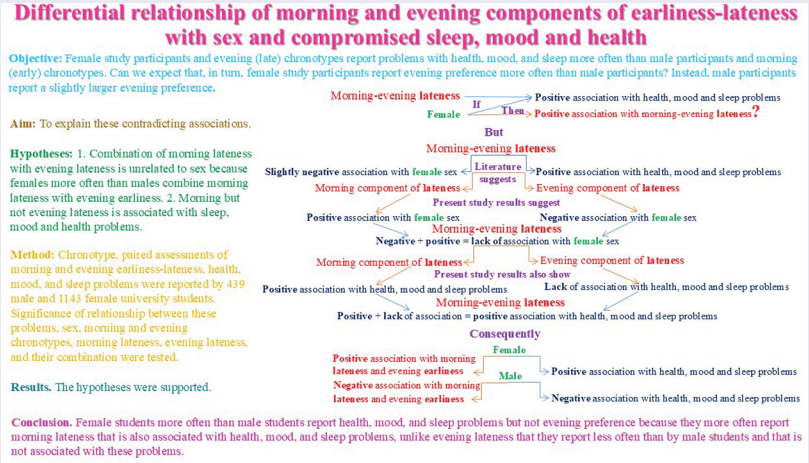
## ABSTRACT

Women and evening (late) chronotypes more often than men and morning (early) chronotypes report problems with health, mood, and sleep. Can we expect that, in turn, women report evening preference more often than men? Instead, the literature on chronotypes suggests that men report a slightly larger evening preference than women. To explain this paradoxical finding, we investigated the role of morning and evening components of earliness-lateness. Previous studies have shown that preferences for earliness-lateness (i.e. morningness-eveningness) can vary depending on whether the morning or evening hours are considered. Therefore, we tested the following hypotheses: 1. Sex is unrelated to the combination of lateness in the morning hours with lateness in the evening hours because women more often than men combine morning lateness with evening earliness rather than with evening lateness. 2. Only morning lateness is associated with sleep, mood, and health problems, while evening lateness is not. Paired assessments of morning and evening earliness-lateness and problems with health, mood, and sleep were reported by 439 male and 1143 female university students. We examined relationships between these problems, sex, morning lateness, evening lateness, and their combination. Results supported the study hypotheses. Evening lateness did not contribute to the link of combination of morning and evening lateness to health, mood, and sleep problems and 2) this combination was unrelated to sex of students. Namely, female students less often than male students reported evening lateness that did not contribute to the association of combination of morning and evening lateness with health, mood, and sleep problems. Instead, they more often reported morning lateness that was also associated with health, mood, and sleep problems. As a result, they more often reported problems with health, mood, and sleep, while sex of students was not related to combination of morning lateness with evening lateness (i.e. with morning-evening preference).

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## Introduction

Morningness-eveningness (Horne and Östberg 1977) or chronotype (Adan 1994) usually refers to the propensity to become more or less active (physically and/or mentally) and to sleep at particular times during a 24-hour period (Kerkhof 1985; Adan et al. 2012; Di Milia et al. 2013; Levandovski et al. 2013). Most often, morningness-eveningness is self-assessed as an individual trait using a morning-evening preference scale (Putilov 2026), such as the pioneer 19-item Morningness-Eveningness Questionnaire (MEQ; Horne and Östberg 1976) and two related to its questionnaires, the 5-item reduced Morningness-Eveningness Questionnaire (rMEQ; Adan and Almirall 1991) and the 13-item Composite Scale of Morningness (CSM; Smith et al. 1989).

The development of such scales was encouraged by the expectation that the individual differences in the phase parameter of the circadian rhythms are suitable for self-assessment using a morning-evening preference questionnaire. Therefore, it is believed that this difference in the circadian phase underlies the difference in scores on a morningness-eveningness scale. However, it seems that the self-assessment of morningness-eveningness trait cannot fully replace an objective measurement of the circadian phase of the rhythms-markers of the central circadian clock. Although the circadian phase of the melatonin rhythm correlates with scores on morningness-eveningness scales (Kantermann et al. 2015; Reiter et al. 2021), the correlation coefficients are not strong when a studied sample consists of unselected individuals on sleep timing (Reiter et al. 2021). Therefore, categorizations into morning and evening types based on such scores demonstrate low concordance with categorization based on circadian phase measurement (Reiter et al. 2021).

If the individual difference in the phase parameter underlies the difference in score on a morningness-eveningness scale, the scale is expected to be based on a single latent factor. However, factor analysis of these scales revealed their multidimensional nature (Larsen 1985; Smith et al. 1989; Neubauer 1992; Brown 1993; Monk and Kupfer 2007; Di Milia et al. 2013; Panjeh et al. 2020; Budkevich et al. 2021). For instance, two distinct, albeit correlated, scales were developed to separately assess morning and evening components of morningness-eveningness (Booker et al. 1991; Roberts 1998; Randler et al. 2016; Preckel et al. 2020). The terms "morning lateness" and "evening lateness" were coined to such two "lateness scales" (Putilov 2000). These terms were used to avoid the ambiguity of meaning of words "morning" and "evening" that can refer, depending on the context, to either time of the day or morning-evening preference. It was shown that high proportions of study participants can combine morning lateness with evening earliness and morning earliness with evening lateness (Putilov et al. 2015, 2019).

Morning component also emerged from factor analysis of the earlier established morningness-eveningness scales, such as the MEQ and CSM (Smith et al. 1989; Caci et al. 2005; Di Milia and Bohle 2009; Di Milia and Randler 2013; Randler et al. 2016; Carciofo 2020; Gorgol et al. 2024). It is usually named "morning affect" and determined as the subjective feeling of alertness and energy upon waking and the time it takes to feel fully awake. Carciofo (2023) found that morning affect is more conceptually overlap with sleep inertia (that is the transitional state between sleep and being fully awake; Tassi and Muzet 2000) rather than with the circadian timing of sleep and wakefulness.

The morningness-eveningness questionnaires were implemented in a huge number of studies searching for the associations between chronotype and problems with health (e.g. Knutson and von Schantz 2018; Makarem et al. 2020; Tan et al. 2020; Mito et al. 2021; Montaruli et al. 2021, Putilov et al. 2023; von Fingerhut et al. 2025; Partonen 2026), mood (e.g. Drennan et al. 1991; Hidalgo et al. 2009; Kitamura et al. 2010; Merikanto et al. 2013; Fares et al. 2015; Jankowski 2016; Au and Reece 2017; Kivelä et al. 2018; Taylor and Hasler 2018; Norbury 2019; Magnani et al. 2023; Balter et al. 2024; Dong et al. 2026) and sleep (e.g. Carrier et al. 1997; Ong et al. 2007; Fernández-Mendoza et al. 2010; Martin et al. 2012; Merikanto et al. 2012; Roeser et al. 2012; Vitale et al. 2015; Barbosa et al. 2016; Passos et al. 2017; Peeri et al. 2022; Putilov et al. 2022; Choo et al. 2023; Chauhan et al. 2024; Lamprou et al. 2024; Poon et al. 2024; Horváth et al. 2025). The results of the vast majority of such studies suggested that these problems were more frequently associated with evening than morning type (or, in other terms, with late than early type).

Research of sex-associated differences in health, mood, and sleep problems consistently indicated that women report these problems more often than men (e.g. Barsky et al. 2001; Leach et al. 2008; Grandner et al. 2012). Therefore, the following question arises: if females and evening (or late) chronotypes more often than males and morning (or early) chronotypes report problems with health, mood, and sleep, can we expect that, in turn, females more often than males report evening rather than morning preference? Paradoxically, the literature on morning-evening preference mostly

suggests, instead, a slightly larger eveningness (or, in other terms, lateness) in males than females (e.g. Ishihara et al. 1988; Steele et al. 1997; Harada and Inoue 1999; Adan and Natale 2002; Randler and Engelke 2019). This contradiction between expected and reported associations requires explanation.

This contradiction can be explained in light of studies examining sex difference in scores on separate scales for assessment of morning and evening subconstructs of morningness-eveningness construct (or, in other terms, earliness-lateness in the morning and in the evening, respectively). The results suggested a differential relationship of these scales with sex of study participants. For example, female participants showed a greater lateness in the morning and a lesser lateness in the evening than male participants in any age (Putilov et al. 2008, 2021b). Moreover, relatively more females than males were shown to combine morning eveningness with evening morningness and relatively more males than females combined morning morningness with evening eveningness (Preckel et al. 2020). Similarly, separate assessment of morningness-eveningness in the morning and evening hours revealed their differential relationship with health, mood, and sleep problems (Booker et al. 1991; Putilov et al. 1994; Putilov 2008, 2017, 2018; Konttinen et al. 2014; Jankowski 2016; Hasan et al. 2022; Burns et al. 2024; Puig-Navarro et al. 2025). Therefore, we proposed and tested here the following hypotheses of relationships of morningness-eveningness (or, in other terms, earliness-lateness) with sex and health, mood, and sleep problems (Table 1):

- Morning lateness can be associated with sleep, mood, and health problems,

- and it can be more often reported by female study participants;

- in contrast, evening lateness can be more often reported by male study participants,

- but it can be unrelated to health, mood, and sleep problems.

- Consequently, the combination of morning lateness with evening lateness can be associated with health, mood, and sleep problems,

- but it can be unrelated to sex (i.e.) because female study participants can report morning lateness more often than male participants but less often report evening lateness (Table 1).

## Materials and Methods

In the methods and results sections, we tried to avoid the ambiguity of meaning of "morning" and "evening" terms that can refer, depending on the context, to either time of the day or morning-evening preference. Therefore, we use here these terms only for distinguishing between two times of the day, morning and evening. As for the distinguishing between study participants on either morning or evening trait/state/ability, we use the terms "earliness" and "lateness" instead of more traditional terms, such as "morningness" and "eveningness" or "morning" and "evening preference" or "morning" and "evening orientation" or "early" and "late (chrono)type." In other words, (1) morning lateness (or morning earliness-lateness) is used here as the synonym of the morning component of eveningness (or morningness-eveningness), (2) evening lateness (or evening earliness-lateness) is used as synonym of the evening component of eveningness (or evening morningness-eveningness), and (3) lateness (or earliness-lateness) is used as synonym of eveningness (or morningness-eveningness).

### *Survey Participants*

In winter season (several months before the exams), lecturers invited students attending their classes on physiology to respond to a set of questions asking about their sleep–wake traits, abilities, habits and behavior. Google

**Table 1.** Hypothesized relationships between lateness, sex, and health, mood, and sleep problems.

| Variation in | | Lateness: | | | | | | Problems | |
|---|---|---|---|---|---|---|---|---|---|
| Sex or Problems | | Morning | | Evening | | Combined | | | |
| | | Earlier | Later | Earlier | Later | Earlier | Later | More | Less |
| Sex | Male | + | – | – | + | + and - = 0 | - and + = 0 | – | + |
| | Female | – | + | + | – | - and + = 0 | + and - = 0 | + | – |
| Problems | More | – | + | 0 | 0 | - and 0 = - | + and 0 = + | | |
| | Less | + | – | 0 | 0 | + and 0 = + | - and 0 = - | | |

Notes. Sex: Either male or female students. Problems: Either more or less frequently reported problems with health, mood, and sleep. Combined: Combination of scales for assessment of Morning Earliness-Lateness and Evening Earliness-Lateness. Hypothetic relationship: Either + or - : Either positive or negative relationship. Either + and - = 0 or – and + = 0: No relationship due to combination of positive relationship with negative relationship. 0: No relationship. Either – and 0 = - or +and 0 = +: Combination of relationship, either negative or positive, with no relationship gives either negative or positive relationship, respectively. See Table 2 and Figures 1 and 2 for the results of testing the hypotheses by regression analyses and ANOVAs, and see Table 3 and Figure 3 for the summary of the present study results based on regression and other analyses.

Forms questionnaires were used to collect the responses from the smartphones of 439 male and 1143 female students. Informed consent was obtained from each student in the form of response "Agree" to the first question: "I give informed consent to anonymously and voluntarily participate in this online survey of sleep-wake habits and behavior."

### The List of Assessments

Survey participants responded to each question/statement included in: 1) the 72-item Sleep-Wake Pattern Assessment Questionnaire (SWPAQ) for self-assessing sleep and wake abilities (Putilov 2007), 2) the reduced (60-item) version (Putilov et al. 2021a) of the Sleep-Wake Adaptability Test (SWAT) for self-assessment of abilities to sleep or wake on demand at different times of the day (Putilov 2016), 3) the 19-item Visuo-verbal Judgment Task (VJT) asking about sleepiness level expected at 19 time points on the 1.5-day interval of permanent wakefulness (Marcoen et al. 2015), in a slightly modified version (Putilov et al. 2021c), and 4) a set of four questions about health, mood, and sleep concerns.

### Questionnaires for Assessment of Earliness-Lateness in Detail

The 72-item SWPAQ (Putilov 2007) was constructed for assessment of several abilities to sleep or wake at either appropriate or inappropriate times for sleeping and waking. The SWPAQ includes two 12-item scales for assessment of morning and evening components of earliness-lateness, Morning Lateness (M) and Evening Lateness (E). The list of items was included in the journal publication of the SWPAQ (Putilov 2007).

The lateness scales of the SWPAQ were cross-validated against other questionnaires for assessments of morningness-eveningness (Putilov et al. 2021a, 2021b, 2021c, 2023, 2025, 2026) including the pioneer MEQ (Putilov and Onischenko 2005; Putilov and Putilov 2005; Budkevich et al. 2021). Moreover, the external validity of these scales was supported in the studies of the objective markers of circadian period (Danilenko et al. 2004) and phase (Putilov et al. 1999; Putilov 2000; Budkevich et al. 2024), daily rhythms of objective (e.g. spectral EEG) indexes of sleepiness (Putilov et al. 2010, 2014), the 24-h time courses of subjective alertness level (Putilov 2015; Putilov et al. 2015), and several single nucleotide polymorphisms in circadian clock genes (Dorokhov et al. 2017, 2018).

Similar to the SWPAQ, the SWAT was designed to assess abilities to sleep or wake at either appropriate or inappropriate times for sleeping and waking (Putilov 2016). Its 60-item version (Putilov et al. 2021a) includes two 10-item scales for assessment of morning and evening components of earliness-lateness, Morning Sleepability (MS) and Nighttime Wakeability (NW), that are the counterparts of two SWPAQ's scales, M and E, respectively (Table S1). The whole list of the SWAT's items was included in its journal publication (Putilov 2016).

A positive/negative score on each of the SWPAQ's and SWAT's scales (Tables S3-S7) indicates ability/inability to sleep or wake on demand in the morning hours (M and MS) and in the evening/early night hours (E and NW).

The VJT (Marcoen et al. 2015) was designed to evaluate how sleepy an individual is expected to be when performing a sleepiness-neutral activity (sitting and reading) at different randomly presented times after having habitual night sleep. Such sleep is suggested to be terminated at approximately 7:30, either by a waking up signal or due to spontaneous awakening. The time cues from 8 a.m. to midday and from 8 p.m. to midnight are presented with one-h intervals, while time cues between midday and 8 p.m. and after midnight are presented with two-h intervals (Figures S3 and S4). Moreover, the participants would see on the screen a visual aid consisting of clock times for illustration of the daily variation in the outdoor illumination level and for indication of the duration of the waking period (for illustration of the VJT see Marcoen et al. 2015). Sleepiness is assessed by scoring on KSS (Åkerstedt and Gillberg 1990) The randomly collected 19 KSS scores are then subsequently ordered to construct a curve of variation in expected sleepiness scores (Figures S3 and S4).

The previously performed factor analysis suggested that 19 KSS sleepiness scores can be organized in four scales to assess morning, daytime, evening-early night, and next day sleepiness, from 8:00 to 11:00, from 12:00 to 20:00, from 21:00 to 4:00, at 6:00 or later (Putilov et al. 2021c). Scores for morning and evening-early night intervals ($\leq$11 and $\geq$21, respectively) were used for the present analyses.

All these chronobiological questionnaires were previously cross-validated and validated against daily alertness-sleepiness curves obtained with the VJT (e.g. Putilov et al. 2021b). The following scales of earliness-lateness in the morning vs. evening-early night were analyzed (Table S1): (1) scores on 12-item scales for assessing Morning Lateness (M) vs. Evening Lateness (E) from the SWPAQ (Putilov 2007), (2) scores on 10-

item scales for assessing Morning Sleepability (MS) vs. Nighttime Wakeability (NW) from the reduced version (Putilov et al. 2021a) of the SWAT (Putilov 2016), and (3) KSS (Karolinska Sleepiness Scale Åkerstedt and Gillberg 1990) scores expected for clock times from 8:00 to 11:00 vs. from 21:00 and 4:00 of the slightly modified version (Putilov et al. 2021c) of the VJT (Marcoen et al. 2015).

### Questions About Health, Mood, and Sleep Concerns

A set of four questions asks about problems with health, mood, and sleep. It provides the possibility of rapid and user-friendly self-rating of these problems in the survey aimed on more detailed assessment of sleep–wake traits, abilities, habits, and behavior. In our previous studies, all these questions were validated against different multi-item questionnaires for assessment of health mood and sleep disturbances (e.g. Booker et al. 1991; Putilov et al. 1994, 2021a, 2021b, 2021c; Putilov et al. 2022; Putilov 2008, 2017, 2018).

### Statistical Methods

The $SPSS_{26.0}$ statistical software package (IBM, Armonk, NY, USA) was applied for all statistical analyses, and major results of these analyses were included in Tables 2, S1, S3-S9 and Figures 1, 2, S1 and S2). Morning and evening assessments of earliness-lateness were intercorrelated using Spearman's rho (Table S1), significance of differences between subdivisions of the whole sample in subsamples with and without health, mood, and sleep problems was tested using independent samples t-test (Tables S3-S7) and two-way ANOVA (with sex as another independent factor; Tables 2 and S8), sleepiness curves of participants with and without health, mood, and sleep problems were compared by running repeated measure ANOVA (rANOVA (Table S9), and these problems were predicted by applying logistic regression analyses (Tables 2 and S3, Figures 1, 2, S1 and S2).

In more details, regression analysis was performed separately for each of three questionnaires (see Regression 1, 2 and 3 in Figures 1, 2, S1 and S2). The predictors included either separate assessments of morning and evening lateness, the 1st and 2nd predictors (e.g. Tables 2, left upper part, and S3, left, and Figures 1 and S1), or the combined assessment of morning and evening lateness, the 1st predictor (e.g. Tables 2, right upper part, and S3, right, and Figures 2 and S2). Sex was either the 3rd or 2nd predictor, respectively (e.g. Tables 2 and S3, either left or right part, respectively, and either Figures 1 and S1 or Figures 2 and S2, respectively). To measure goodness-of-fit, the Omnibus test and Hosmer-Lemeshow test were applied. The first test ensures significance of $p$-value indicating that at least one predictor has a non-zero coefficient and the second test ensures a good fit due to practical identity of

**Table 2.** Relation of scores on lateness scales to problems with health, mood, and sleep.

| # of scales | Two separate – morning and evening – scales | | | | | | Combination of two scales | | |
|---|---|---|---|---|---|---|---|---|---|
| Questionnaire | SWPAQ | | SWAT | | KSS in VJT | | SWPAQ | SWAT | KSS in VJT |
| Predictor(s) | M | E | MS | NW | ≤11 | ≥21 | M+E | MS+NW | ≤11-≥21 |
| Hypothesis: score on a scale predicts (significant beta coefficient): | | | | | | | | | |
| Good health | 0.21*** | 0.07 | 0.09*** | −0.00 | 0.07*** | −0.01 | −0.02** | −0.04*** | −0.07* |
| Depressed mood | 0.20*** | −0.03 | 0.05*** | −0.01 | 0.05*** | 0.00 | 0.02** | 0.05*** | 0.05 |
| Partner's concern | 0.08*** | 0.00 | 0.07*** | 0.03* | 0.29*** | −0.08* | 0.04*** | 0.05*** | 0.07* |
| Sleep concerns | 0.30*** | −0.03 | 0.06*** | 0.02 | 0.05*** | −0.01 | 0.02*** | 0.06*** | 0.05 |
| Hypothesis: mean score does not differ between participants who reported and did not report: | | | | | | | | | |
| Good health | 20.4*** | 0.1 | 25.2*** | 0.8 | 0.8 | 0.4 | 6.8** | 16.8*** | 8.4** |
| Depressed mood | 18.6*** | 0.8 | 19.6*** | 0.2 | 8.8** | 3.6 | 4.2* | 11.7** | 0.1 |
| Partner's concern | 14.8*** | 2.6 | 19.2*** | 11.6** | 17.3*** | 1.1 | 11.8** | 26.4*** | 6.5** |
| Sleep concerns | 34.2*** | 0.0 | 41.4*** | 2.6 | 77.1*** | 0.6 | 13.9*** | 30.6*** | 3.4 |

Notes. Upper part. In regression analyses, two of three predictors of either health or mood or sleep problems were scores on morning lateness and evening lateness scales of each of 3 questionnaires (left), and one of two predictors was the combination of scores on morning and evening lateness scales of each of 3 questionnaires (right). Sex was the 3rd and 2nd predictor, respectively. It was coded as 1 and 2, male and female student, respectively (see its contribution in Figures 1, 2, S1 and S2 with the odds ratios for all three predictors illustrated as Exp(B), the exponentiation of regression coefficient with 95% Confidence Intervals). In the regression analyses the 1st and 2nd predictors are scores on scales of either the SWPAQ, 12-item scales for self-assessment of Morning Lateness (M) and Evening Lateness (E), or SWAT, 10-item scales for self-assessment of Morning Sleepability (MS) and Nighttime Wakeability (NW), or VJT, KSS (Karolinska Sleepiness Scale) score expected for clock times from 8:00 to 11:00 and from 21:00 and 4:00. A combination of the scores is either sums of M and E scores (M+E) or sum of MS and NW scores (MS+NW) or difference between morning and evening/early night sleepiness (≤11-≥21). The following dependent variables were predicted. Good health: Health is self-scored as either good or lower. Depressed mood: Either depressed or other mood states. Partner's concern: "Do people around you notice that you have problems with sleep or changes in performance during the day caused by these problems?" Sleep concerns: At least one of major concerns about sleep – evening, nighttime, morning, and daytime – was vs. was not chosen. These 4 concerns were difficulty initiating sleep, difficulty maintaining sleep, early morning awakening, and excessive daytime sleepiness. Lower part. $F_{1/1578}$ from ANOVAs aimed on testing null hypothesis that mean score does not differ between subdivisions into male and female participants with and without a problem. The independent factors were Problem and Sex (see also Table S8). Level of significance for B (beta coefficient) or F-ratio for rejecting null hypothesis: *$p$ < 0.05, **$p$ < 0.01, ***$p$ < 0.001.

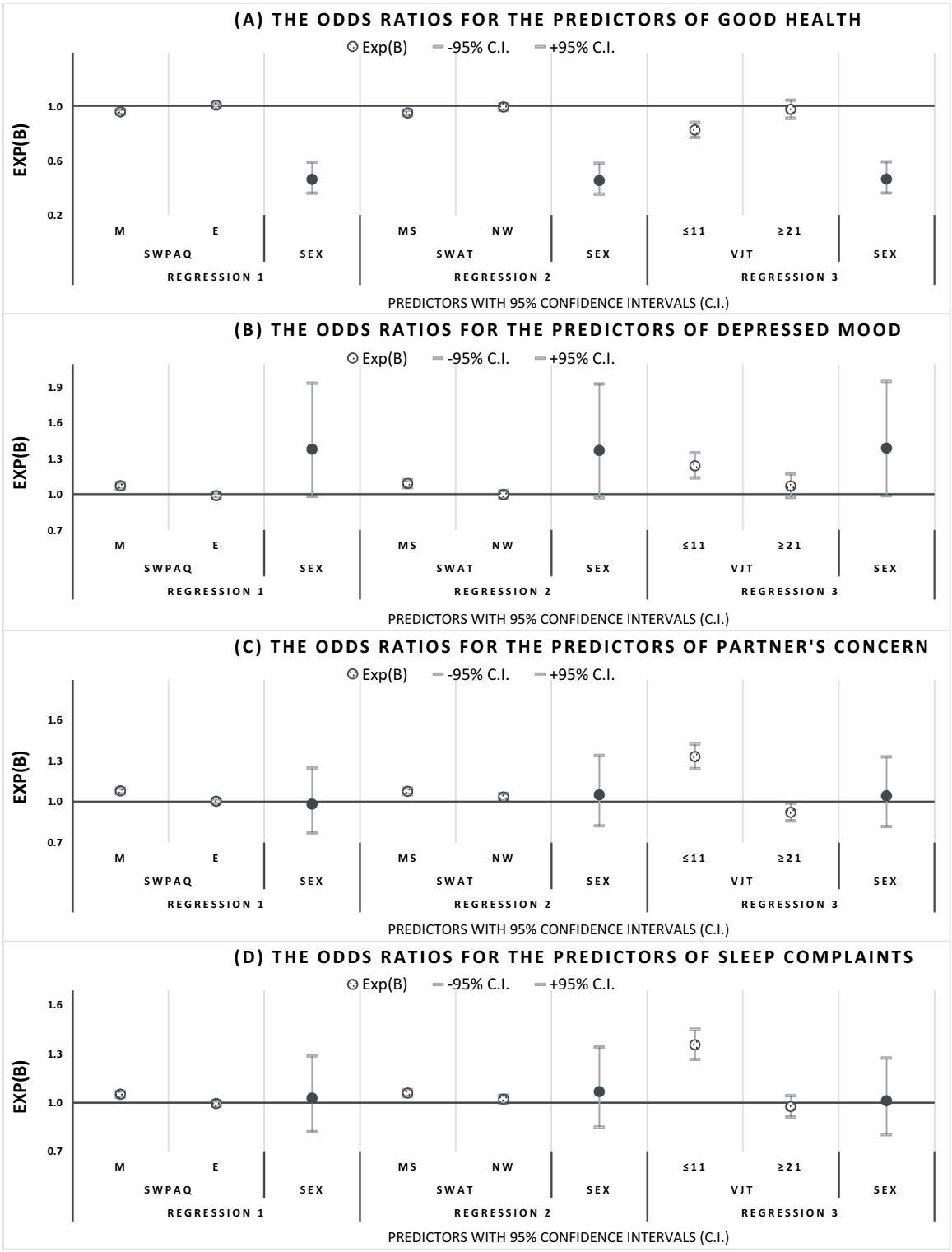


**Figure 1.** Scores on morning and evening scales and sex of students as predictors of health, mood, and sleep concerns. Results of binary logistic regression analyses aimed on prediction of dependent variable (either self-rated health or mood or partner's concern or, at least, one sleep concern) with morning and evening components of earliness-lateness and sex as predictors. Predictors are scores on morning and evening scales and sex. (A) Good health: Health is self-rated as either good or lower (888 vs. 694). (B) Depressed mood: Either depressed or other mood states (238 vs. 1344). (C) Partner's concern: The answer to the question: "Do people around you notice that you have problems with sleep or changes in performance during the day caused by these problems?" (554 vs. 1028). (D) Sleep concerns: One of the following major – evening (1), nighttime (2), morning (3) and daytime (4) – sleep concerns – was vs. was not chosen (866 vs. 616). Exp(B), –95% CI, +95% CI: The odds ratios for predictors (the exponentiation of regression coefficient) with 95% Confidence Intervals. See also notes for Table 2.

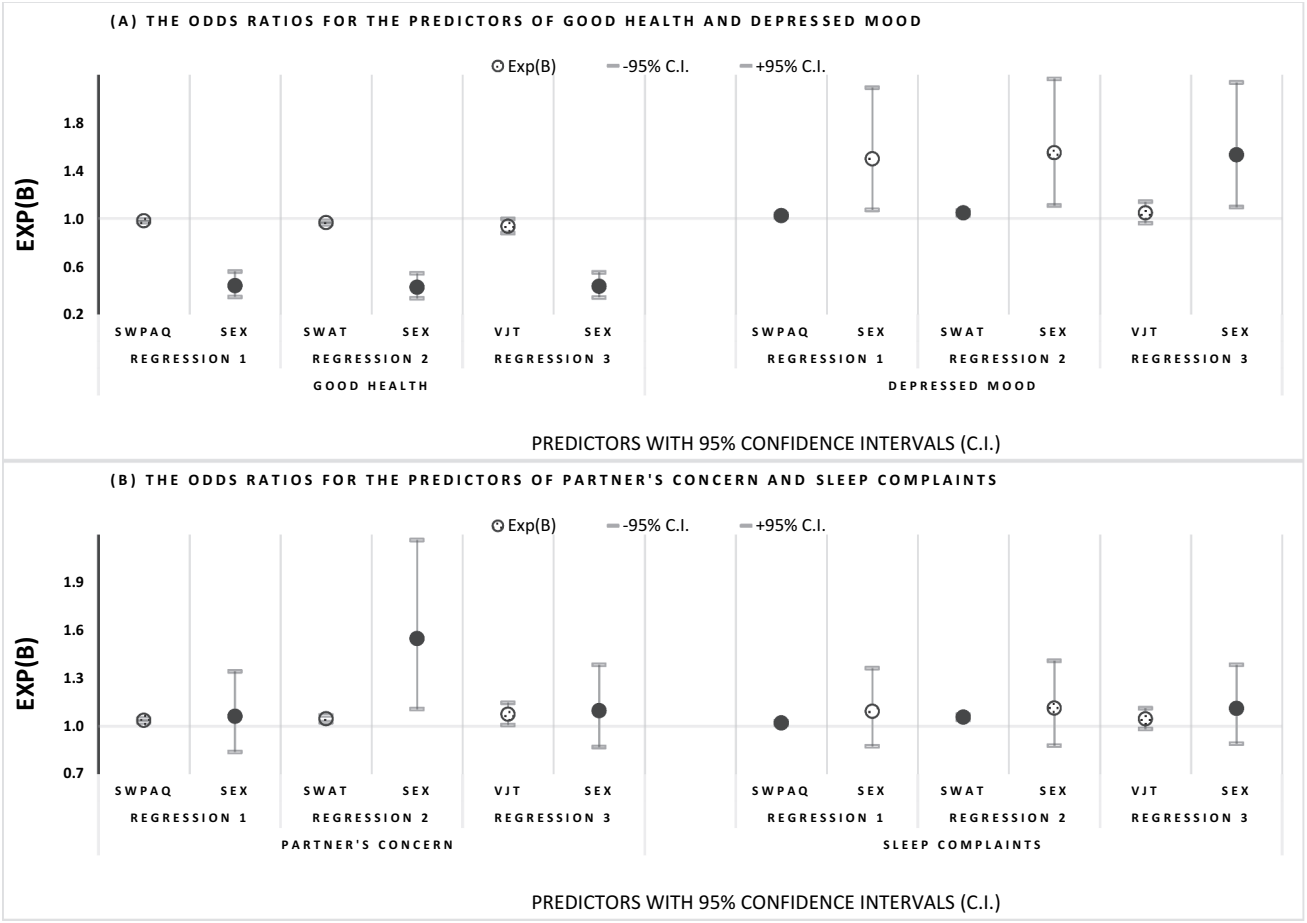


**Figure 2.** Scores on combinations of morning and evening scales of earliness-lateness and sex of students as predictors of health, mood, and sleep concerns. Results of binary logistic regression analyses aimed on prediction of dependent variable (either self-rated health or mood or partner's concern or, at least, one sleep concern) with combined earliness-lateness and sex as predictors. Predictors are combination of scores on morning and evening scales and sex. (A) Good health, left, and Depressed mood, right. (B) Partner's concern, left, and Sleep concern(s), right. Results of prediction were non-significant (in accord with the Omnibus and Hosmer-Lemeshow tests) only for predicting Sleep concern with the VJT. See also the legend to Figure 1 and notes to Table 2.

observed and predicted values. When, sometimes, good fit was not supported by the results on these tests, this was mentioned in a figure legend (see the legends to Figures 2 and S2).

## Results

Age and well-being in the whole sample and in the subsamples of male and female participants are reported in Table S2. Female dominance among the participants of the present study reflects their prevalence among the students of the surveyed faculties. Bad health was reported by only 2% of male students and less than 3% of female students, while the vast majority of students reported good health (Table S2). Depressed mood was reported by 11% of male and 16% of female students, and at least one of 4 sleep problems was reported by more than a half of the sample (53% and 55% of male and female students, respectively). Moreover, irrespective of sex, almost a half of students (44%) agreed that people around noticed their problems with sleep or changes in performance during the day (Table S2).

The differences between sexes in assessments of earliness-lateness are reported in Table S7.

### *Correlations Among Morning, Evening, and Combined Lateness Scales*

Table S1 shows that correlations among 3 scales assessing morning component of earliness-lateness or correlations among 3 scales assessing evening component of earliness-lateness were stronger than correlations between pairs of morning and evening scales in the same questionnaire. The correlation coefficients (Spearman's rho) for 3 assessments of morning and evening component of earliness-lateness varied from 0.334 to 0.731 and from |0.426| to 0.642, respectively,

while correlations between pairs of morning and evening scales of the same questionnaire varied from −0.014 to 0.205.

### Associations of Three Paired Assessments of Lateness with Health, Mood, and Sleep Problems

We expected that participants reporting morning lateness can suffer from health, mood, and sleep problems more often than participants reporting morning earliness. The left upper part of Table 2 contains the results of predicting health, mood, and sleep problems by separate scales of morning earliness-lateness and evening earliness-lateness and the right upper part of Tables 2 contains the results of predicting these problems by the combination of morning and evening assessments of earliness-lateness. Morning lateness assessed with the SWPAQ, SWAT and VJT was significantly associated with lower self-rated health, depressed mood, and sleep concerns, while evening lateness assessed with the same 3 questionnaires did not significantly contribute to the association of combined morning and evening lateness with lower health score, depressed mood, and sleep concerns (Table 2, upper left part, and Figure 1).

Thus, the association of combined morning and evening lateness scores with lower health self-rating, depressed mood, and sleep concerns (Table 2, upper right part, and Figure 2) was explained exclusively by the significant association of morning but not evening lateness scores (Table 2, upper left part, and Figure 1).

### Comparison of Subdivisions with and Without Health, Mood, and Sleep Problems

Tables S4-S6 contain the results of comparison of earliness-lateness scores in subsamples of study participants with good and lower self-rated health (Table S4), depressed and other mood states (Table S5), and with and without, at least, one of 4 (evening, nighttime, morning, and daytime) sleep concerns (Table S6). We tested null hypothesis that the groups with and without problems did not differ on earliness-lateness scores. In all comparisons, a morning lateness score was significantly, most often with $p < 0.001$, higher in participants with lower health rating, depressed mood, and sleep concerns (Tables S3-S5, upper left part), while a week significant association of evening lateness score ($p < 0.05$) was found only in one of 9 comparisons (Tables S4-S6, upper right part). Consequently, the association of combined morning and evening scores with lower health score, depressed mood and sleep concerns mostly remained significant exclusively due to the significant impact of morning lateness in this association, while evening lateness usually failed to contribute to this association (Tables S4-S6, lower part). Similar results were obtained by applying ANOVA to test null hypothesis that the groups with and without problems did not differ on earliness-lateness scores (Table 2, lower part).

Thus, the results of regression analysis (Table 2, upper part) were supported by comparison of subsamples with good and lower self-scored health (Table S4 and S2, lower part), depressed and other mood states (Table S5 and S2, lower part), and with and without, at least, one of 4 (evening, nighttime, morning, and daytime) sleep concerns (Table S6 and S2, lower part). They revealed significant association of morning lateness with lower health rating, depressed mood and sleep concerns along the lack of contribution of evening lateness to significant association of lateness with these problems (Tables 2, S4-S6 and Figures 1 and 2).

### Association of Sex with Health, Mood, and Sleep Problems and Lateness

It was expected that female students can report health, mood, and sleep problems more often than male students. This expectation was confirmed by the results of all analyses including the binary logistic regression analyses aimed on prediction of self-rated health, mood, and sleep problems with sex as one of predictors (Figures 1 and 2). Moreover, Tables S7 and S8 contain the results of statistical comparison of lateness scores in the subsamples of male and female students. They suggested differential relationship of morning and evening components of earliness-lateness with sex. Morning lateness was more often revealed in female than male students, while evening lateness was, in contrast, more frequently found in male than female students. The combinations of morning and evening earliness-lateness scores were unrelated to sex of students due to such a differential relationship (Tables S7 and S8).

### Additional Results on Association of Lateness with Four Sleep Concerns and Daily Variation in Sleepiness

In addition to the analyses of binary responses suggesting either none or one of four major sleep concerns (Figures 1D and 2B, right), separate sleep concerns were analyzed and illustrated in Figures S1 and S2. The results of statistical analyses of separate sleep concerns are included in Supplementary Materials (Tables S3 and Figures S1 and S2).

To support the results of analysis of associations of 3 paired earliness-lateness scales with sex and health, mood, and sleep problems (Tables 2, left part, and

Tables S3-S6, upper parts), we analyzed the associations of problems with the pattern of daily variation in sleepiness were added (Table S9 and Figures S3 and S4). These results are described in detail in Supplementary Materials.

## Discussion

Results of numerous studies suggested that women and evening (late) types more often report problems with health, mood, and sleep than men and morning (early) types (e.g. Barsky et al. 2001; Grandner et al. 2012; Leach et al. 2008; Au and Reece 2017; Balter et al. 2024; Barbosa et al. 2016; Carrier et al. 1997; Chauhan et al. 2024; Choo et al. 2023; Drennan et al. 1991; Fares et al. 2015; Fernández-Mendoza et al. 2010; Hidalgo et al. 2009; Horváth et al. 2025; Jankowski 2016; Kitamura et al. 2010; Knutson and von Schantz 2018; Magnani et al. 2023; Makarem et al. 2020; Martin et al. 2012; Merikanto et al. 2012, 2013; Mito et al. 2021; Montaruli et al. 2021; Norbury 2019; Ong et al. 2007; Passos et al. 2017; Peeri et al. 2022; Roeser et al. 2012; Poon et al. 2024; Putilov et al. 2022, 2023; Tan et al. 2020; Taylor and Hasler 2018; Vitale et al. 2015; von Fingerhut et al. 2025; Dong et al. 2026). However, women, in turn, do not report evening preference more often than men as can be expected from the association of this preference and female sex with health, mood, and sleep problems. Instead, the literature suggests that, a slightly larger evening preference is usually reported by males (Ishihara et al. 1988; Steele et al. 1997; Harada and Inoue 1999; Adan and Natale 2002; Randler and Engelke 2019). Given that differential relationship of morning and evening subconstructs of morningness-eveningness construct with sex and health, mood, and sleep problems was previously reported (Booker et al. 1991; Putilov et al. 1994, 2008, 2021b; Putilov 2008, 2017, 2018; Konttinen et al. 2014; Jankowski 2016; Preckel et al. 2020; Hasan et al. 2022; Burns et al. 2024; Puig-Navarro et al. 2025), we proposed and tested the following two hypotheses. 1. The combination of morning lateness with evening lateness is associated with health, mood, and sleep problems because, at least, morning lateness is associated with these problems. 2. However, this combination of morning and evening lateness is unrelated to sex because, although morning lateness is associated with female sex, evening lateness is, instead, associated with male sex (Table 1). The results of the present study supported these hypotheses (Table 3).

### *Lateness as a Correlate of Problems with Health, Mood, and Sleep*

The present study shed light on the nature of differential relationship of morning and evening components of morningness-eveningness to health, mood, and sleep problems. Evening component seems to be unrelated to these problems. The significant association of morningness-eveningness scales that was reliably yielded in numerous studies (see above) can be explained exclusively by the significant contribution of morning component of morningness-eveningness to this association. This explanation is in agreement with several of our previously reported results that also were based on separate assessment of associations of morning and evening subconstructs of morning-evening construct. Previously, such results were obtained by applying only one of the three questionnaires, the SWPAQ (Booker et al. 1991; Putilov et al. 1994, 2008, 2021b, 2017, 2018). In the present study, similar results were obtained with two other questionnaires allowing separate assessments of morning and evening components of earliness-lateness.

### *Lateness as a Correlate of Sex*

Moreover, we previously did not test simultaneously the associations with sex and problems. In the present study clarified the nature of link of morningness-eveningness to both sex and problems with health, mood, and sleep. If only one of subconstructs of morningness-eveningness

**Table 3.** Summary on relations of lateness scores to sex and problems with health, mood, and sleep.

| # of scales | Separate morning and evening scales | | | | | | Combination of two scales | | |
|---|---|---|---|---|---|---|---|---|---|
| Questionnaire | SWPAQ | | SWAT | | KSS in VJT | | SWPAQ | SWAT | KSS in VJT |
| Good health | M*** | E! | MS*** | NW! | ≤11*** | ≥21! | M+E** | MS+NW*** | ≤11-≥21* |
| Depressed mood | M*** | E! | MS*** | NW! | ≤11*** | ≥21! | M+E** | MS+NW*** | ≤11-≥21$^{n/s}$ |
| Sleep concerns | M*** | E! | MS*** | NW! | ≤11*** | ≥21! | M+E** | MS+NW*** | ≤11-≥21$^{n/s}$ |
| Sex | M*** | E ** | MS*** | NW *** | ≤11*** | ≥21*** | M+E! | MS+NW! | ≤11-≥21! |

Notes. Level of significance for B (beta coefficient) and F-ratio for results supporting the hypotheses of the study: either $^{n/s}$ $p > 0.05$ or *$p < 0.05$, **$p < 0.01$, and ***$p < 0.001$. In the case of hypothetical lack of association, "!" indicates that B and F-ratio support the hypotheses (when score on lateness scale is expected to be unrelated to a problem or sex). Separate morning and evening scales in the SWPAQ: 12-item scales for self-assessment of Morning Lateness (M) and Evening Lateness (E); in the SWAT: 10-item scales for self-assessment of Morning Sleepability (MS) and Nighttime Wakeability (NW); in the VJT: KSS (Karolinska Sleepiness Scale) scores expected for clock times from 8:00 to 11:00 (≤11) and from 21:00 and 4:00 (≥21). Combination of two scales: sums of M and E scores (M+E), sum of MS and NW scores (MS+NW), and difference between morning and evening/early night sleepiness (≤11-≥21). From the results reported in Tables 2 and S4-S8 and illustrated in Figures 1 and 2.

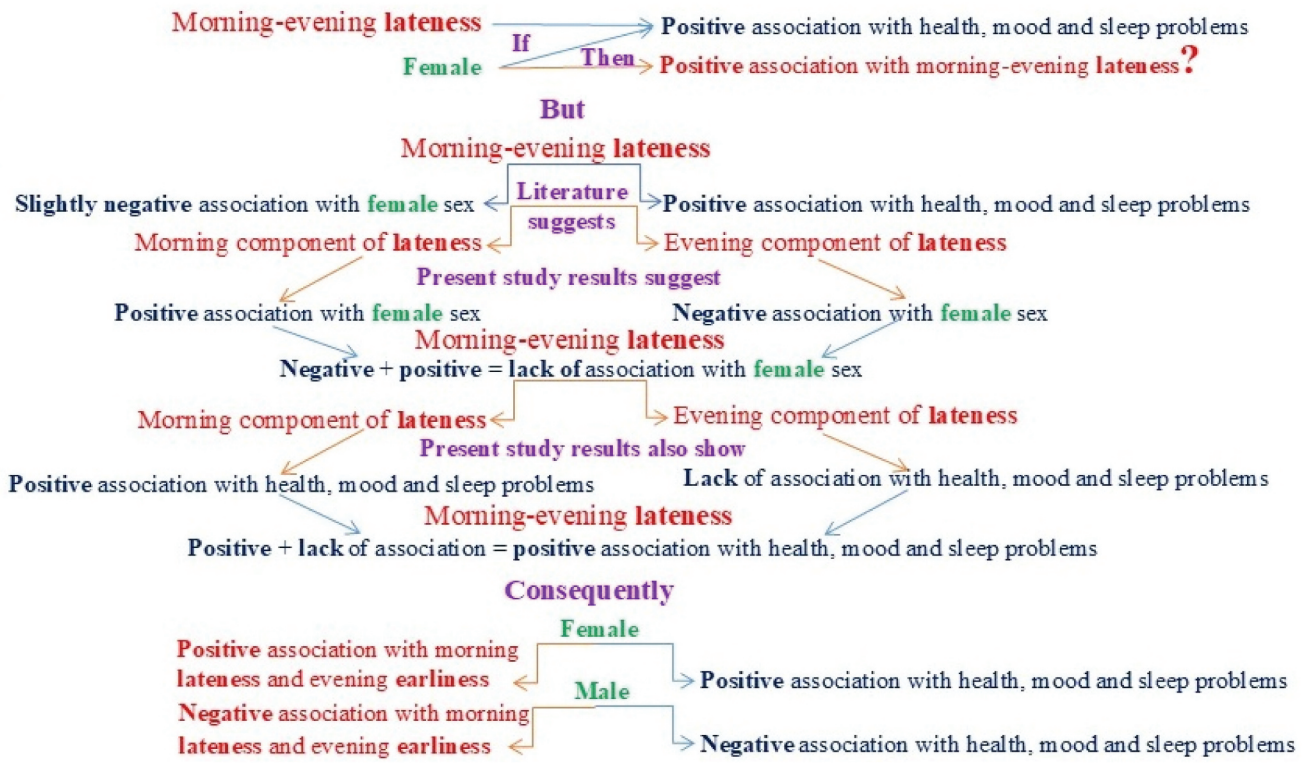


**Figure 3.** Summary on the results of testing the study hypotheses. It is known from the literature that female study participants and participants with morning-evening lateness report problems with health, mood, and sleep more often than male participants and participants with morning-evening earliness. The following question arises: can we expect that, in turn, female participants report morning-evening lateness more frequently than male participants? The answer is "No," because the literature suggests that, instead, male participants tend to report a slightly larger morning-evening lateness. To explain these paradoxical finding on associations of morning-evening earliness-lateness with sex and problems, we proposed and tested the following hypotheses: 1. Morning-evening lateness assessed as combination of morning lateness with evening lateness is unrelated to sex because females more often than males combine morning lateness with evening earliness. 2. Morning but not evening lateness is associated with sleep, mood, and health problems. Results of the present study supported these hypotheses. Therefore, it can be concluded that female participants more often than male participants report health, mood, and sleep problems but not morning-evening lateness. In other words, they more often report morning lateness that is associated with health, mood, and sleep problems, unlike evening lateness that is not associated with these problems and that they report less often than male study participants.

construct was found to be significantly associated with the problems, both subconstructs showed significant association with sex. Since such a significant link of the morning subconstruct opposes the significant link of the evening subconstruct, the resulting link of the morningness-eveningness construct to sex was found to be non-significant. This result agrees with the previous independently reported results of applying separate assessment of morning and evening subconstructs of morningness-eveningness construct to testing such link (Putilov et al. 2008, 2021b; Preckel et al. 2020). However, it disagrees with the conclusion of the review of sex-associated difference in score on a morningness-eveningness scale that suggested a slightly larger evening preference in males than females (Randler and Engelke 2019). This review was limited to studies applying three overlapping morningness-eveningness questionnaires, the 19-item MEQ (Horne and Östberg 1976), the 5-item rMEQ (Adan and Almirall 1991) and the 13-item CSM (Smith et al. 1989). The authors concluded that choosing one of these three questionnaires did not influence the difference in chronotype between genders (Randler and Engelke 2019). However, such influence was documented in the results of another study reported by Tonetti et al. (2024). They replicated gender difference (larger morning preference in women) only for the rMEQ but not for the 12-item Early-Late Preferences Scale (PS; Smith et al. 2002).

It seems that sex-associated difference in morningness-eveningness either can be or cannot be found depending on a scale applied for its assessment. In particular, the disagreement between results obtained with different questionnaires can be caused by the difference in ratio between items asking about behavior and habits in the morning and evening hours.

### Contradicting Results on Lateness as a Correlate of Sex

Moreover, it has to be noted that it is possible to find many publications that either did not confirm significance of sex-associated difference in a score on morningness-eveningness scale or, instead, revealed a larger evening preference in females. For instance, Zimmermann (2011) did not find significant sex-associated difference in chronotypes of college students. The following set of publications suggests the conflicting results on sex-associated differences. In Natale et al. (2009) study, a significantly higher proportion of morning types among females than among males was found only in the group born during April to September, but not in the group born during October to March. Díaz-Morales and Parra-Robledo (2018) found age-associated change of sex-associated difference: unlike men of younger age, men over 40 years old were more morning-oriented than women. Buekenhout et al. (2025) also showed that, after the age of 48, males exhibited greater morning preference than females, and Duarte et al. (2014) found that, on average, women were more morning-oriented than men only until the age of 30, while there were no significant differences between men and women from 30 to 45 years of age. Merikanto et al. (2012) reported that evening preference was more common among women than men. Gaina et al. (2006) revealed a greater evening preference in female than male students in the study of Japanese high school students aged from 12 to 15 years. Carskadon et al. (1993) found that sex-associated differences can vary even within a short age interval. With the onset of puberty, girls report a higher evening orientation than boys, and the tendency for eveningness progressively dissipates after the end of adolescence (Carskadon et al. 1993).

It seems that this list of such publications is far from comprehensive. These examples suggest that, if there is any sex-associated difference in morningness-eveningness, it is very small compared to, for instance, age-associated difference.

### Sex-Associated Difference in Lateness and Circadian Phase

The results suggesting that sex-associated differences in earliness-lateness can be questioned also disagree with the results of studies of sex-associated differences in the circadian period and phase. They pointed at a shorter circadian period (Duffy et al. 2011) and an earlier circadian phase in women than men (e.g. Mongrain et al. 2004). However, sex-associated differences in phase angle between a physiological marker of circadian phase and sleep timing were also reported in such studies. For instance, although the average 0.1-h (6-min) period difference between women and men was estimated by Duffy et al. (2011), it was associated with an average temperature phase angle difference of 0.36 h (22 min) and an average melatonin phase angle difference of 0.46 h (28 min). It was also shown (Cain et al. 2010) that sleep timing was the same in women and men, despite earlier timing of the circadian rhythms of temperature and melatonin relative to sleep time in women as compared to men (i.e. sleep therefore occurred at a later biological time for women than men, despite being at the same clock time).

Moreover, it is important to note that, as mentioned in the Introduction, the individual difference in the phase of the circadian clocks cannot be the only underlying cause of the difference in score on a multi-dimensional morningness-eveningness scale, and the lack of a strong correlation between the circadian phase and this score (e.g. Reiter et al. 2021) suggests the involvement of other causes.

Finally, it seems that the present study results supported the findings on male-female gap in *ad lib* sleep timing. Analysis of weekend sleep timing in 340 paired male and female subsamples collected from the literature revealed that, after averaging data over different ages from childhood to late adulthood, a slightly earlier bedtime (0.16-h) and a slightly later risetime (0.10-h) were found in female subsamples compared to male subsamples (Putilov and Verevkin 2025). Therefore, the disagreement with findings on sex-associated differences in the period and phase parameters of the circadian clock can be explained by the sex-associated difference in phase angle between the phase of the circadian clock and sleep timing. It seems to compensate for the difference in the circadian phase and period.

### Possible Underlying Mechanisms

The following question arises: what can be a possible underpinning of the findings suggesting a separation of morning and evening subconstructs of the earliness-lateness construct and their differential relationship with sex and health, mood, and sleep problems? Evidence is accumulating for the contribution of psychic rather than biological factors to both the division of the earliness-lateness construct into morning and evening subconstructs and the individual predisposition to morning but not evening lateness. For example, Corruble et al. (2014) observed a change towards morningness in patients receiving agomelatine treatment for a current major depressive episode and this change was greater in responders than non-responders. Hasler et al. (2016) reported the shifts toward morningness during behavioral sleep interventions that were also associated with improvements in depression,

positive affect, and sleep quality. Murray et al. (2003) observed that winter lowering of mood was associated with a shift towards eveningness. When trait- and state-like variation in morning and evening lateness were compared in women with and without diagnosis of winter depression before and after their bright light treatment in winter and during summer (Putilov 2017), morning lateness state was observed in depressed women, while their evening state was similar to that of controls. Moreover, the beneficial effect of treatment and the change of season was accompanied by normalization of morning state, and only morning lateness trait persisted after the treatment and in summer despite the improvement of morning state. The shift of state-like variation toward morning lateness among women suffering from sadness during winter season was explained by the influence of such depressive symptoms as lack of energy, social withdrawal, loss of interest in once enjoyable activities, etc. that can manifest in the time of transition from sleep to wakefulness (Putilov 2017).

Moreover, it has to be noted that the term "morning affect" was coined for the morning component that emerged from factor analysis of morningness-eveningness scales (Smith et al. 1989; Caci et al. 2005; Di Milia and Bohle 2009; Randler et al. 2016) and it was shown to conceptually overlap with sleep inertia (Carciofo 2023). The relationship of sleep inertia with mood was recently highlighted in an analysis of the longitudinal incidence of psychiatric disorders in the UK Biobank (Burns et al. 2024). The results showed that evening chronotype predicted an increased incidence of major depressive disorder, schizophrenia, generalized anxiety disorder, and bipolar disorder. However, this effect was dependent on sleep inertia, which was a much stronger predictor of these disorders, such that evening types without sleep inertia were at no higher risk compared to morning types (Burns et al. 2024).

It is important to note that individual variation in morning and evening lateness is more closely linked to individual differences in the 24-h pattern of alertness-sleepiness rhythm (Putilov et al. 2014, 2015; Putilov 2015) than to individual differences in the sleep-wake cycle (Putilov et al. 2025). The models suggested for explaining the processes underlying this rhythm are always more complex than the two-process model of regulation of the sleep-wake cycle (i.e. with only two – circadian and homeostatic – processes). They propose that, at least, one more process can be taken into account to explain the circadian rhythm of alertness or performance. The earliest of the suggested models postulated that this 3rd process is sleep inertia (Achermann and Borbély 1994; Åkerstedt and Folkard 1997). Therefore, sleep inertia can be viewed as a candidate for testing as the mechanism underlying morning lateness and for elaborating the cause of its association with sex and problems with health, mood, and sleep.

To sum up, it is unlikely that individual differences in the clock mechanism that underlie the differences in phase characteristic of the circadian rhythms can explain the separation of morning and evening components of individual differences in earliness-lateness. The differences in clock mechanism are also unlikely to explain the differential relationship of morning and evening lateness with sex and health, mood, and sleep problems. Future research can be aimed on elaboration of relation of sleep inertia, morning effect and some other traditional subconstructs of morningness-eveningness construct to morning and evening lateness scales applied in the present study. Moreover, future research can be aimed at testing psychic and biological mechanisms that cause the separation of subconstructs of morning and evening lateness and the link of the morning subconstruct to compromised sleep, mood, and health.

### *Limitations*

There are limitations to our dataset. The profound change in sleep-wake characteristics across ages does not allow the generalization of the present study results to the whole lifespan. Since all participants were Russian university students, these results require confirmation with samples representing younger (school and college) students, workers, and older adults from different countries around the globe.

Moreover, self-reported chronotypological characteristics may not be accurate, and, therefore, the confirmation of the present results with objective measures of daily changes in wake-sleep states and levels of alertness-sleepiness is required.

Finally, confirmation in studies based on multi-item assessment of health, mood, and sleep problems is also necessary.

## Conclusions

The results on sex-associated differences in chronotype contradict the results on sex-associated differences in reports on health, mood, and sleep problems (somewhat earlier type and more frequent reports in women contradict the well-established associations of later type with these problems). To explain these results, we proposed and empirically supported the following hypotheses. 1. Lateness is unrelated to sex due to a combination of positive and negative relationships of female sex with morning and evening components of lateness. 2. Association of lateness with health, mood, and sleep problems is significant because these problems are significantly associated with morning component of lateness, while evening component does not contribute to this association. The present study

results reliably separated these components and demonstrated their differential relationship with sex and health, mood, and sleep problems. Namely, we showed that the association of health, mood, and sleep problems with lateness is limited to their association with morning lateness and that the difference between sexes in morning-evening preference can be questioned.

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## Author Contributions

CRediT: **Arcady A. Putilov:** Conceptualization, Data curation, Formal analysis, Methodology, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing; **Dmitry S. Sveshnikov:** Data curation, Software, Supervision, Visualization, Writing – original draft; **Zarina V. Bakaeva:** Investigation, Writing – original draft; **Elena B. Yakunina:** Investigation, Writing – original draft; **Olga V. Mankaeva:** Investigation, Writing – original draft; **Vladimir I. Torshin:** Investigation, Writing – original draft; **Elena A. Trutneva:** Investigation, Writing – original draft; **Michael M. Lapkin:** Investigation, Writing – original draft; **Zhanna N. Lopatskaya:** Investigation, Writing – original draft; **Roman O. Budkevich:** Investigation, Writing – original draft; **Elena V. Budkevich:** Investigation, Writing – original draft; **Dmitry E. Shumov:** Investigation, Writing – original draft; **Anton I. Taranov:** Investigation, Writing – original draft; **Olga N. Tkachenko:** Investigation, Writing – original draft; **Eugenia O. Gandina:** Investigation, Writing – original draft; **Alexander E. Manaenkov:** Investigation, Writing – original draft; **Evgeniy A. Cheremushkin:** Investigation, Writing – original draft; **Natalya V. Ligun:** Investigation, Writing – original draft; **Alexandra N. Puchkova:** Investigation, Writing – original draft; **Vladimir B. Dorokhov:** Investigation, Supervision, Writing – original draft.

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## Data Availability Statement

Dataset of the survey is available from the first author on reasonable request.

## Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of the Institute of Higher Nervous Activity and Neuro-physiology (Approval#12402–02-7112 from 3 June 2019).

## Informed Consent Statement

The study participants were informed in detail about the survey procedure, and informed consent was obtained from each participant in the form of the response "Agree" to the following statement: "I give informed consent to anonymously and voluntarily participate in this online survey of sleep-wake behavior and habits."

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