Supplementary Materials

to

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

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Supplementary Results

3.5. Additional Results on Association of Lateness with 4 Sleep Concerns and Daily Variation in Sleepiness

3.5.1. Additional Results on Association of Lateness with 4 Sleep Concerns

3.5.2 Additional Results on Daily Variation in Sleepiness

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Supplementary Tables S1-S9

Table S1. Coefficients of correlation (Spearman's rho) among and between 3 pairs of earliness-lateness scales.

Questionnaire		SWPAQ	SWAT	KSS in VJT	Questionnaire	
	Assessment	M	MS	≤11	Assessment	
SWPAQ	E	0.205***	0.731***	0.334***	M	SWPAQ
SWAT	NW	0.642***	0.141***	0.411***	MS	SWAT
KSS in VJT	≥21	-0. 433***	-0.426***	-0.014	≤11	KSS in VJT
	Assessment	E	NW	≥21	Assessment	

Notes. The questionnaires for assessments of individual variation in morning and evening components of earliness-lateness: 1) the 72-statement Sleep Wake Pattern Assessment Questionnaire (SWPAQ) for self-assessment of sleep-wake adaptability; 2) the reduced (60-item) version of the Sleep-Wake Adaptability test (SWAT) that was also designed for self-assessment of sleep-wake adaptability; and 3) a slightly modified version of the 19-time point Visuo-verbal Judgment Task (VJT) for predicting sleepiness levels on the 1.5-day interval of permanent wakefulness. The correlated scores on paired scales were: 1. In the SWPAQ: Scores on 12-item scales for self-assessment of Morning Lateness (M) and Evening Lateness (E). 2. In the SWAT: Scores on 10-item scales for self-assessment of Morning Sleepability (MS) and Nighttime Wakeability (NW). 3. In the VJT: KSS (Karolinska Sleepiness Scale) score expected for clock times from 8:00 to 11:00 and from 21:00 and 4:00. Level of significance for correlation coefficient: ***p < 0.001 (n=1582).

Table S2. Age, sex, and problems with health, mood and sleep.

Age or health self-report	Sex	Male	Female	Total	Age or health self-report	Sex	Male	Female	Total
	n	439	1143	1582		n	439	1143	1582
Age in years	Mean	19.76	19.41	19.51	Good health (n)	Good	309	579	888
	SD	1.98	1.52	1.76		So-so	120	531	651
Depressed mood (n)	Depressed	50	188	238		Bad	10	33	43
	Normal	339	831	1170	Major sleep concern (n)	1. Evening	108	190	298
	Euphoric	34	78	112		2. Nighttime	18	45	63
	Other	16	46	62		3. Morning	33	72	105
Partner's concern (n)	No	246	630	876		4. Daytime	73	327	400
	Yes	193	513	706		None	207	509	716

Notes. The following subdivisions were used in regression analyses and ANOVAs reported in Table 2, S3 and S8 and illustrated in Figures 1, 2, S1 and S2. Good health: Health is self-scored as either good or lower (888 vs. 694). Depressed mood: Either depressed or other mood states (238 vs. 1344). 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?" (554 vs. 1028). Sleep concerns: At least one of the following major concerns about sleep – evening, nighttime, morning, and daytime - was vs. was not chosen (866 vs. 616, respectively). These evening (1), nighttime (2), morning (3) and daytime (4) sleep concerns were described as 1: Difficulty initiating sleep (298 vs. 1284), 2: Difficulty maintaining sleep (63 vs. 1519), 3: Early morning awakening (105 vs. 1477), and 4: Excessive daytime sleepiness (400 vs. 1182). Sex was coded in the statistical analyses as 1 and 2 (Male and Female, respectively). The assessments of morning-evening earliness-lateness of these subdivisions are reported in Tables S4-S7.

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Table S3. Beta coefficients for predictors of 4 major problems with sleep.

# of predictors	2 of 3						1 of 2		
Predictor	SWPAQ		SWAT		KSS in VJT		SWPAQ	SWAT	KSS in VJT
Predictor(s)	M	E	MS	NW	≤11	≥21	M+E	MS+NW	≤11-≥21
1. Evening concern	0.157***	-0.124**	0.059***	0.066***	0.030**	0.035**	0.033***	0.062***	0.113**
2. Nighttime concern	0.091	-0.116	-0.063*	-0.034	-0.053*	-0.021	-0.036**	-0.051**	-0.149
3. Morning concern	-0.029	-0.039	-0.116***	-0.031	-0.101***	-0.041*	-0.069***	-0.08***	-0.121
4. Daytime concern	0.233***	0.106**	0.086***	-0.007	0.090***	-0.018	0.032***	0.046***	0.034

Notes. The two of three predictors were scores on morning lateness and evening lateness scales of each questionnaire, and one of two predictors was the combination of scores on morning and evening lateness scales of each questionnaire. Sex was the third and second, respectively. It was coded as 1 and 2, male and female student, respectively (see its contribution in Figures S1 and S2 with the odds ratios for all three predictors illustrated as Exp(B), the exponentiation of regression coefficient with 95% Confidence Intervals). Scores on morning and evening earliness-lateness scales as the 1st and 2nd predictors included scores on 12-item scales for self-assessment of Morning Lateness (M) and Evening Lateness (E) from the SWPAQ, scores on 10-item scales for self-assessment of Morning Sleepability (MS) and Nighttime Wakeability (NW) from the SWAT, and KSS (Karolinska Sleepiness Scale) score expected for clock times from 8:00 to 11:00 and from 21:00 and 4:00 from the VJT. Combinations of the paired morning and evening scales provided the following 3 additional scores: sum of M and E scores, sum of MS and NW scores (M+E and MS+NW, respectively), and difference between morning and evening/early night sleepiness (≤11-≥21). The following dependent variables (sleep concerns) were predicted: One of major concerns about sleep – evening, nighttime, morning, and daytime - were described as 1. Difficulty initiating sleep. 2. Difficulty maintaining sleep. 3. Early morning awakening. 4. Excessive daytime sleepiness. Level of significance for B (beta coefficient): $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

Table S4. Assessments of earliness-lateness in healthy and other students.

Questionnaire	Health	Good		Lower		Health	Good		Lower	
	Assessment	Mean	SEM	Mean	SEM	Assessment	Mean	SEM	Mean	SEM
SWPAQ	M***	1.66	0.20	3.31	0.21	E	1.23	0.21	1.34	0.24
SWAT	MS***	1.39	0.17	2.98	0.20	NW	0.24	0.14	0.33	0.17
KSS in VJT	≤11***	3.99	0.05	4.51	0.06	≥21	6.06	0.05	6.20	0.06

	Health	Good			Lower	
	Assessment	Mean	SEM		Mean	SEM
SWPAQ	M plus E***	2.88	0.31		4.65	0.35
SWAT	MS plus NW***	1.63	0.23		3.31	0.28
KSS in VJT	≤11 minus ≥21*	0.05	0.05		0.22	0.06

Notes. Results of testing null hypothesis that mean score does not differ between subdivisions into subsamples of participants with and without good health. Upper part, left, and upper part, right: Morning and Evening scales, respectively. Lower part: Combination of morning and evening scales. Good health: Health was dichotomized as Good vs. other (either Intermediate or Bad). Level of significance for t-test (independent subsamples consisting of 888 healthy vs. 694 other students, respectively): $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$. See other notes to Tables 2, S1 and S3.

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Table S5. Assessments of earliness-lateness in depressed and other students.

Questionnaire	Mood Assessment	Depressed Mean	Depressed SEM	Other states Mean	Other states SEM	Mood Assessment	Depressed Mean	Depressed SEM	Other states Mean	Other states SEM
SWPAQ	M***	4.17	0.34	2.01	0.16	E	1.25	0.38	1.28	0.17
SWAT	MS***	3.86	0.30	1.72	0.14	NW	0.37	0.27	0.26	0.12
KSS in VJT	≤11***	4.70	0.10	4.12	0.04	≥21	6.29	0.10	6.09	0.04

	Mood Assessment	Depressed Mean	Depressed SEM		Other states Mean	Other states SEM
SWPAQ	M plus E**	5.42	0.56		3.29	0.26
SWAT	MS plus NW***	4.23	0.42		1.99	0.20
KSS in VJT	≤11 minus ≥21	0.22	0.10		0.10	0.04

Notes. Results of testing null hypothesis that mean score does not differ between subdivisions into subsamples of participants with and without depressed mood. Mood was dichotomized as Depressed vs. any other mood state (Normal or Euphoric or Other). Level of significance for t-test (independent subsamples consisting of 238 depressed and 1344 other students, respectively): $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$. See other notes to Tables 2, S1, S3 and S4.

Table S6. Assessments of earliness-lateness in students with and without major sleep concern.

Questionnaire	Sleep concern Assessment	Yes Mean	Yes SEM	No Mean	No SEM	Sleep concern Assessment	Yes Mean	Yes SEM	No Mean	No SEM
SWPAQ	M***	3.06	0.19	1.46	0.22	E	1.35	0.21	1.18	0.23
SWAT	MS***	2.75	0.17	1.20	0.20	NW*	0.52	0.14	-0.02	0.16
KSS in VJT	≤11***	4.53	0.06	3.81	0.05	≥21	6.10	0.05	6.14	0.06

	Sleep concern Assessment	Yes Mean	Yes SEM		No Mean	No SEM
SWPAQ	M plus E***	4.41	0.32		2.63	0.35
SWAT	MS plus NW***	3.27	0.24		1.18	0.27
KSS in VJT	≤11 minus ≥21	0.17	0.06		0.06	0.05

Notes. Results of testing null hypothesis that mean score does not differ between subdivisions into subsamples of participants with and without major sleep concern: One of 4 options to respond to the question: "What is your main concern about your sleep?" was chosen or was not chosen (866 or 616, respectively). These 4 - evening (1), nighttime (2), morning (3) and daytime (4) - sleep concerns were 1: Difficulty initiating sleep (298 vs. 1284), 2: Difficulty maintaining sleep (63 vs. 1519), 3: Early morning awakening (105 vs. 1477), 4: Excessive daytime sleepiness (400 vs. 1182). Level of significance for t-test (independent subsamples consisting of 866 concerning vs. 616 other students, respectively): $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$. See other notes to Tables 2, S1, S3 and S4.

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Table S7. Assessments of earliness-lateness in male and female students.

Questionnaire	Sex	Male		Female		Sex	Male		Female	
	Assessment	Mean	SEM	Mean	SEM	Assessment	Mean	SEM	Mean	SEM
SWPAQ	M***	1.22	0.27	2.76	0.17	E*	1.75	0.26	1.09	0.19
SWAT	MS***	1.08	0.24	2.42	0.15	NW***	1.44	0.19	-0.17	0.13
KSS in VJT	≤11***	3.94	0.08	4.30	0.05	≥21***	5.74	0.08	6.26	0.04

	Sex	Male			Female	
	Assessment	Mean	SEM		Mean	SEM
SWPAQ	M plus E	2.97	0.41		3.85	0.28
SWAT	MS plus NW	2.51	0.32		2.25	0.22
KSS in VJT	≤11 minus ≥21	0.11	0.07		0.12	0.05

Notes. Results of testing null hypothesis that mean score does not differ between subdivisions into male and female study participants. Level of significance for t-test (independent subsamples consisting of 439 male and 1143 female students): $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$. See other notes to Tables 2, S1 and S3.

Table S8. Two-way ANOVAs testing null hypothesis of non-significance difference between male and female subdivisions of the whole sample.

	Separate morning and evening scales						Combination of two scales		
Predictor	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: mean score does not differ between subsamples of male and female study participants									
Good health	11.3**	1.7	9.9**	37.6***	4.3*	23.1***	1.4	1.9	0.9
Depressed mood	7.9**	0.0	11.0**	18.4***	17.5***	9.7**	3.0	0.0	2.6
Partner's concern	23.1***	3.7	21.3***	48.1***	16.6***	37.5***	2.8	0.7	0.0
Sleep concerns	23.3***	3.9*	22.7***	48.4***	16.9***	37.3***	2.7	0.5	0.1

Notes. $F_{1/1578}$ for the results of testing null hypothesis that mean score does not differ between subdivisions into male and female study participants. The first and second independent factors were Problem and Sex in two-way ANOVAs. Score on morning and evening-lateness scales in the SWPAQ were scores on 12-item scales for self-assessment of Morning Lateness (M) and Evening Lateness (E); in the SWAT these were scores on 10-item scales for self-assessment of Morning Sleepability (MS) and Nighttime Wakeability (NW); and in the VJT these were KSS (Karolinska Sleepiness Scale) scores expected for clock times from 8:00 to 11:00 and from 21:00 and 4:00. Combinations of the paired scores provided the following additional lateness scores: sums of M and E scores (M+E), sum of MS and NW scores (MS+NW) and difference between scores of morning and evening/early night sleepiness (≤11-≥21). Good health: Health is self-scored as either good or lower (888 vs. 694). Depressed mood: Either depressed or other mood states (238 vs. 1344). 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?" (554 yes vs. 1028 no). Sleep concerns: One of the following major concerns about sleep either was or was not chosen (either 866 or 616, respectively). These evening (1), nighttime (2), morning (3) and daytime (4) sleep concerns are described as: 1: Difficulty initiating sleep (298 vs. 1284), 2: Difficulty maintaining sleep (63 vs. 1519), 3: Early morning awakening (105 vs. 1477), 4: Excessive daytime sleepiness (400 vs. 1182). Null hypothesis was rejected with $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$. See also results for the difference between subdivisions with and without health, mood and sleep problems in the lower part of Table 2.

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Table S9. F-ratio for the effects on sleepiness of two factors and their interaction with time of the day.

Factor	Health or mood or sleep		Sex	
Effect	Main	Interaction	Main	Interaction
Factor	$F_{1/1578}$	$F_{18/28404}$	$F_{1/1578}$	$F_{18/28404}$
Good health	22.67***	2.53**	26.45***	1.77
Depressed mood	13.51***	0.98	20.69***	1.87
Partner's concern	3.52	3.01**	49.60***	1.92*
Sleep concerns	26.76***	12.51***	48.11***	2.01*
1. Evening	0.03	5.26***	36.09***	2.07*
2. Nighttime	0.02	4.75***	7.46**	0.80
3. Morning	1.51	4.55***	13.97***	2.03*
4. Daytime	48.06***	1.96*	13.65***	1.01

Notes. Three-way rANOVAs of sleepiness (KSS scores expected for 19 time points including morning and evening/early night hours). Main: Main effect of the 1st independent factor Problem (Health or Mood or Sleep) or of the 2nd independent factor Sex (439 male and 1143 female students, coded as 1 and 2, respectively). Interaction: Interaction between an independent factor and time of the day (19 clock times). Good health: Health is self-scored as either good or lower (888 vs. 694). Depressed mood: Either depressed or other mood states (238 vs. 1344). 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?" (554 vs. 1028). Sleep concerns: One of the following major concerns about sleep – evening (1), nighttime (2), morning (3) and daytime (4) sleep concern - was or was not chosen (866 or. 616, respectively). These evening (1), nighttime (2), morning (3) and daytime (4) sleep concerns are described as: 1: Difficulty initiating sleep (298 vs. 1284), 2: Difficulty maintaining sleep (63 vs. 1519), 3: Early morning awakening (105 vs. 1477), 4: Excessive daytime sleepiness (400 vs. 1182). $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$: Level of significance for $F_{1/1578}$ (independent factor) or $F_{1/28404}$ (its interaction with time of the day; Mauchly's test was conducted to assess the sphericity and, if necessary, the Greenhouse-Geiser correction was used to adjust the degrees of freedom, but the original degrees of freedom, 28404, are reported here). See other notes to Tables 2 and S3, and see illustration of these results in Figures S3 and S4.

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Supplementary Figure Legends

Figure S1. Scores on morning and evening scales and sex of students as predictors of each of 4 sleep concerns.

Results of the binary logistic regression analyses aimed on prediction of one of the following major concerns about sleep: evening (A), nighttime (B), morning (C), and daytime (D). Such major sleep concern either was or was not chosen (866 vs. 616). These sleep concerns were described as: A: Difficulty initiating sleep (298 vs. 1284), B: Difficulty maintaining sleep (63 vs. 1519), C: Early morning awakening (105 vs. 1477), D: Excessive daytime sleepiness (400 vs. 1182). See also Table 2.

Figure S2. Combinations of scores on morning and evening scales and sex of students as predictors of each of 4 sleep concerns.

Results of the binary logistic regression analyses aimed on prediction of health, mood and sleep concerns. Results of prediction were non-significant (Omnibus and Hosmer-Lemeshow tests) for predicting Difficulty maintaining sleep and Early morning awakening with VJT). See also the legend to Figure S1 and Table 2.

Figure S3. Time courses of alertness-sleepiness in students with and without health, mood and sleep concerns and in male and female students.

KSS scores assessed with a slightly modified version of the VJT. Score denotes sleepiness levels on verbally anchored Likert scale: 1- Extremely alert, 2- Very alert, 3- Alert, 4- Rather alert, 5- Neither alert nor sleepy, 6- Some signs of sleepiness, 7- Sleepiness, but no effort to keep awake, 8- Sleepiness, but some effort to keep awake, 9- Very sleepy, great effort to keep awake, fighting sleep, 10- Extremely sleepy, can't keep awake. Good health: Health is self-scored as either good or lower (888 vs. 694). Depressed mood: Either depressed or other mood states (238 vs. 1344). 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? (554 vs. 1028). Sleep concerns: One of the following major concerns about sleep – evening (1), nighttime (2), morning (3) and daytime (4) sleep concern- was or was not chosen (866 or. 616, respectively. See results of statistical analysis of sleepiness curves (rANOVAs with two independent factors, Sleep concern and Sex) in Table S9.

Figure S4. Time courses of alertness-sleepiness in students with and without 4 sleep concerns.

Evening (1), nighttime (2), morning (3) and daytime (4) sleep concerns were described as (A): Difficulty initiating sleep (298 vs. 1284) and Difficulty maintaining sleep (63 vs. 1519), and (B): Early morning awakening (105 vs. 1477) and Excessive daytime sleepiness (400 vs. 1182). See results of statistical analysis of sleepiness curves (rANOVAs with two independent factors, Sleep concern and Sex) in Table S9.

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Supplementary Figures S1-S4

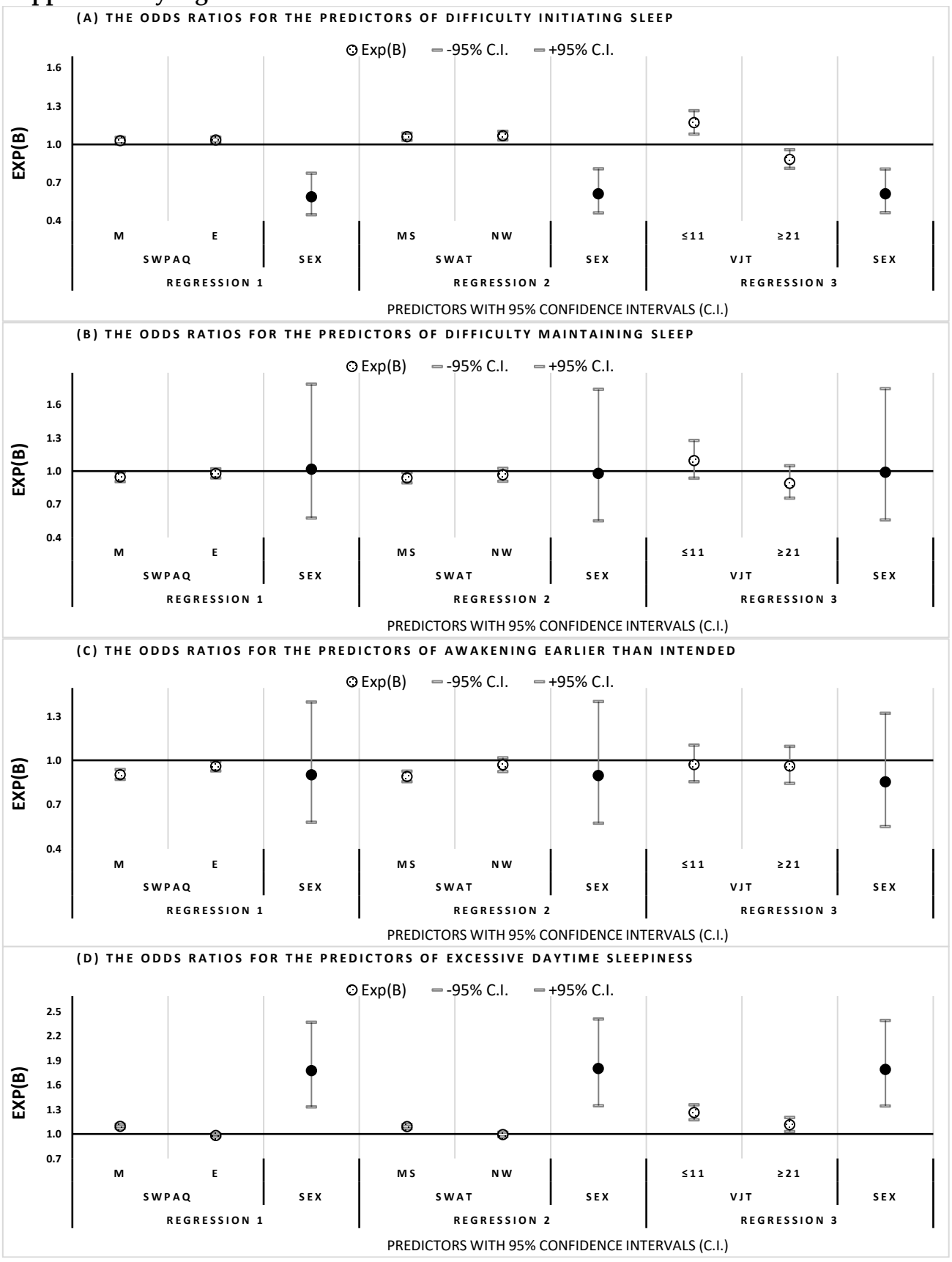

Figure S1

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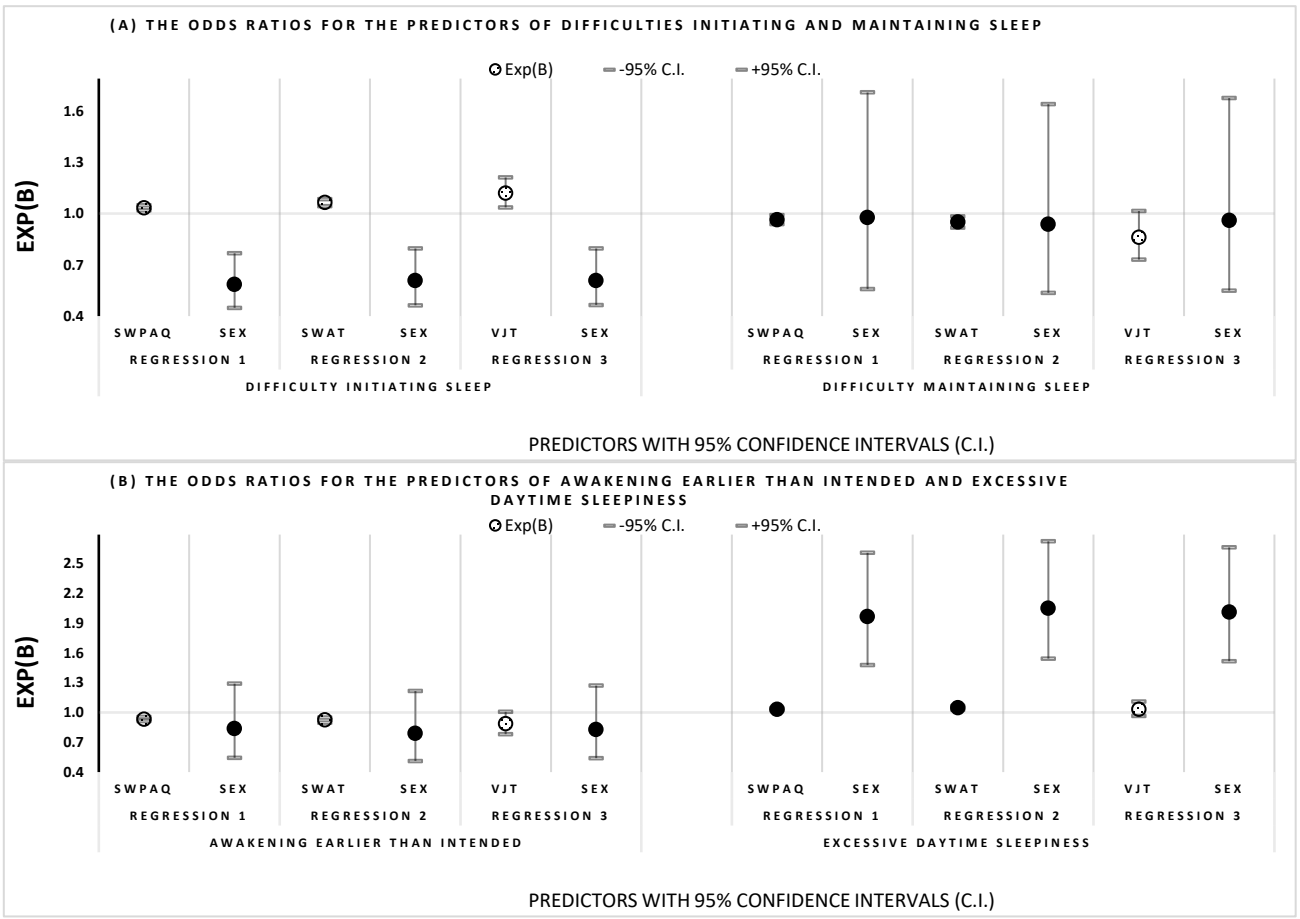

Figure S2

Information Classification: General

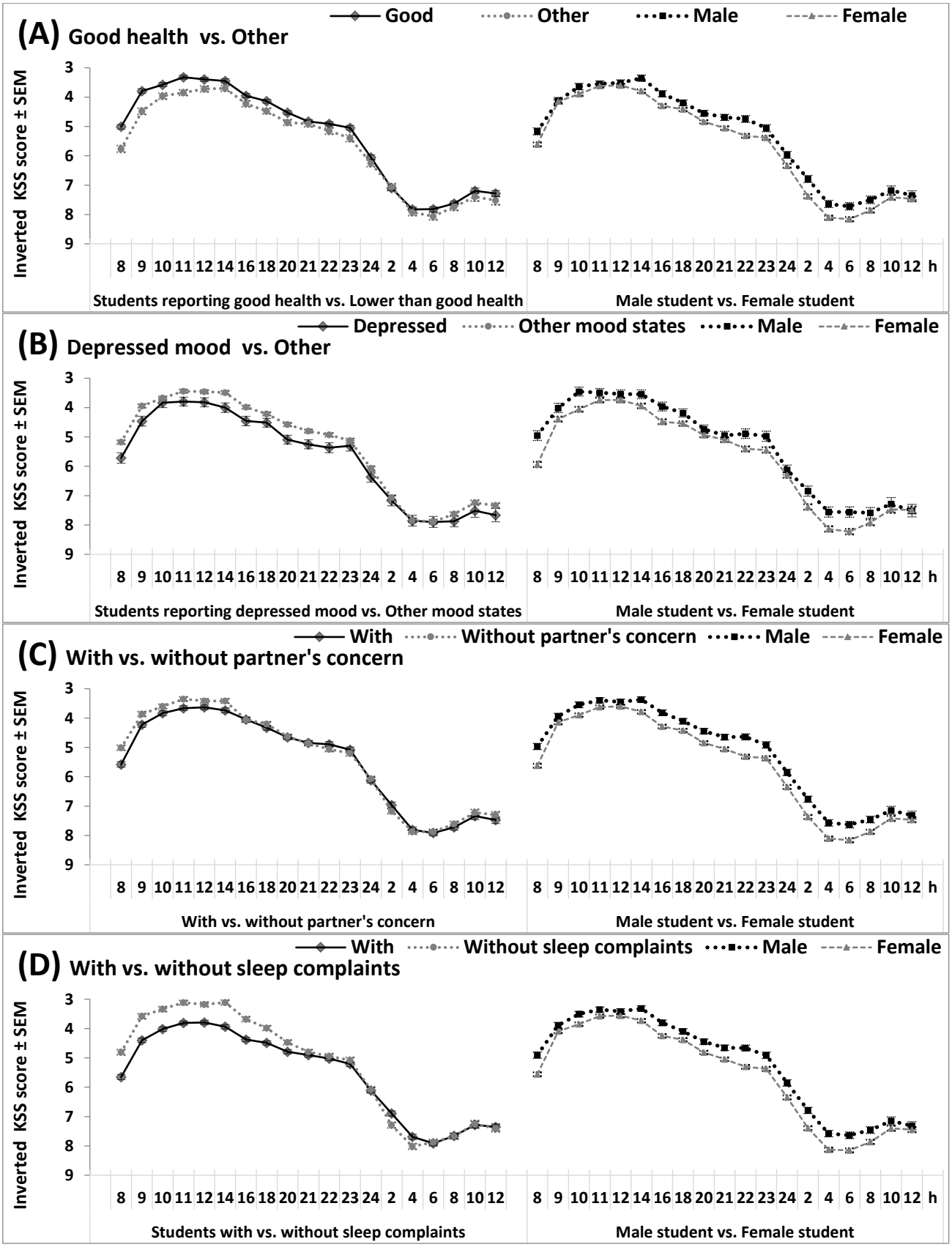

Figure S3

Information Classification: General

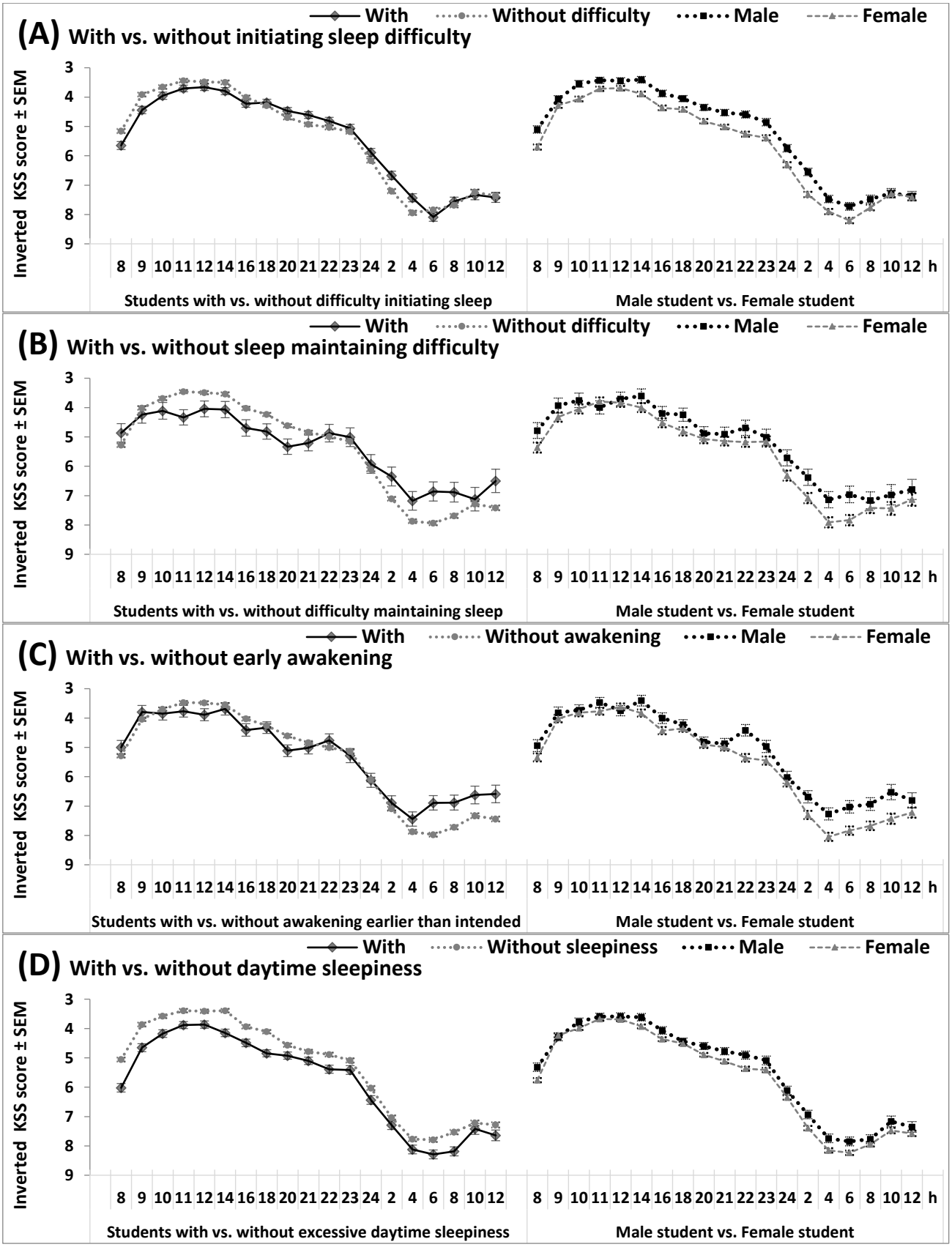

Figure S4

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Supplementary Results

3.5. Additional Results on Association of Lateness with 4 Sleep Concerns and Daily Variation in Sleepiness

3.5.1. Results on Association of Lateness with 4 Sleep Concerns

Separate sleep concerns were analyzed in addition to analysis of reporting none or one of four major sleep concerns (Figures S1 and S2).

The question about major sleep concern has five response options: 1) difficulty initiating sleep (evening concern), 2) difficulty maintaining sleep (nighttime concern), 3) early morning awakening (morning concern), 4) excessive daytime sleepiness (daytime concern), and 5) none. Table S3 and Figures S1 and S2 show the results of regression analysis of each of 4 sleep concerns in addition to analysis of one of four or none of these concerns illustrated in Figures 1 and 2 and analyzed in Table 2. The results supported the expectation of differential relationship of various sleep concerns with morning and evening components of earliness-lateness. For example, morning earliness was more often associated with the morning concern than evening lateness, and evening lateness was more often associated with the evening concern than evening earliness. Nevertheless, morning lateness was, in total, associated with, at least, one of these concerns more often than morning earliness (Table 2 and Figure 1D).

Besides, morning lateness was also more often than evening lateness associated with other people concern about sleep of a study participant (i.e., as indicated by the response "Yes" 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?" (Table 2 and Figure 1C).

3.5.2 Additional Results on Daily Variation in Sleepiness

The differential relationship of morning and evening components of earliness-lateness to sex and problems with health, mood and sleep were provided by results of rANOVAs (Table S9) and they are illustrated in more details in Figure S3. We used the time course of KSS scores obtained with the VJT as an example of such a relationship because sleepiness was reported for as many as 19 clock times. Female students were found to be sleepier than male students both in the morning and evening/early night hours, while students with and without problems differed in sleepiness in the morning rather than evening/early night hours (right vs. left graphs in Figure S3).

Such difference between assessments of earliness-lateness in the morning and evening hours was confirmed by significant interaction between a problem and time of the day in the results of rANOVAs (Table S9). The results of these rANOVAs were also supported the results of regression analyses of sex as predictor

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of health, mood and sleep problems that suggested that sex is a significant contributor to health and mood problems (Figures 1A, 1B, and 2A).

Figure S4 additionally illustrates the expected difference between 4 – evening, nighttime, morning, and daytime - sleep concerns in the time course of sleepiness on the 1.5-day interval of permanent wakefulness. For instance, the daily curve of students reported difficulty of sleep initiation was characterized by a higher level of sleepiness in the morning hours and lower levels in the evening/early night hours (Figure S4A), while sleepiness those students who reported excessive daytime sleepiness remained more or less elevated during the whole 1.5-day interval of permanent wakefulness compared to that of students without excessive daytime sleepiness (Figure S4D).

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