Michels et al. Supplemental Materials

Supplemental Tables

Table S1. Differences in hormone concentrations over the menstrual cycle associated with reporting an average of <7 hours of sleep per day leading up to clinic visits: results from non-linear mixed models with harmonic terms

	Average <7 hours per day					
	Change in mean levels over the menstrual cycle		Change in amplitude over the menstrual cycle		Change in phasing over the menstrual cycle (days)	
	Coefficient[a]	95% CI	Coefficient[a]	95% CI	Coefficient[a]	95% CI
Testosterone	0.0059	-0.0092, 0.0209	-0.0064	-0.0909, 0.0781	0.0260	-0.0175, 0.0695
Estradiol	**-0.0466**	**-0.0856, -0.0075**	-0.0382	-0.1030, 0.0265	-0.0191	-0.0414, 0.0031
LH	**-0.0603**	**-0.1115, -0.0091**	0.0347	-0.0374, 0.1069	**-0.0268**	**-0.0520, -0.0017**
FSH	-0.0069	-0.0397, 0.0260	-0.0243	-0.0968, 0.0481	**-0.0401**	**-0.0691, -0.0110**
Progesterone	-0.0330	-0.0743, 0.0083	-0.0028	-0.0342, 0.0285	**-0.0228**	**-0.0424, -0.0031**

CI=confidence interval, LH=luteinizing hormone, FSH=follicle stimulating hormone. Intervals in bold are statistically significant at alpha=0.05.

These models take repeated observations into account: up to eight clinic visits per menstrual cycle and up to two menstrual cycles per woman. The reference group for the effect estimates are women reporting ≥7 hours of sleep per day; estimates reflect the difference in hormone levels, amplitude, or phasing between women sleeping <7 hours per day and those sleeping longer. Models are adjusted for: age, race, BMI, chronotype, night/shift work status, average daily caloric intake, average daily caffeine intake, cigarette use, season, and the percent of energy intake attributable to alcohol, fat, protein, and carbohydrates.

Please see Supplemental Figures S2-S4 for examples of the: change in mean levels and suggested phase shift for estradiol; change in mean levels and phase shift for LH; and the phase shift in FSH.

[a]Coefficient units are concentrations for the changes in mean or amplitude and days for the changes in phasing.

Table S2. Differences in hormone concentrations over the menstrual cycle associated with night/shift work: results from non-linear mixed models with harmonic terms

	Employment=Unemployed					
	Difference in mean levels		Difference in amplitude		Difference in phasing (days)	
	Coefficient[a]	95% CI	Coefficient[a]	95% CI	Coefficient[a]	95% CI
Testosterone	**-0.1376**	**-0.2525, -0.0227**	0.0035	-0.1481, 0.1552	0.0146	-0.0422, 0.0715
Estradiol	-0.0600	-0.1703, 0.0503	0.0211	-0.0774, 0.1195	-0.0030	-0.0307, 0.0248
LH	0.0589	-0.0619, 0.1797	-0.0361	-0.1398, 0.0675	0.0160	-0.0187, 0.0508
FSH	-0.0401	-0.1428, 0.0626	0.0189	-0.0933, 0.1310	-0.0017	-0.0384, 0.0350
Progesterone	0.0086	-0.0788, 0.0960	0.0077	-0.0505, 0.0659	-0.0128	-0.0362, 0.0107
	Employment=Employed with night/shift work					
	Difference in mean levels		Difference in amplitude		Difference in phasing (days)	
	Coefficient[a]	95% CI	Coefficient[a]	95% CI	Coefficient[a]	95% CI
Testosterone	-0.0781	-0.1791, 0.0228	-0.0848	-0.2231, 0.0535	-0.0187	-0.0714, 0.0340
Estradiol	-0.0105	-0.1076, 0.0867	-0.0383	-0.1274, 0.0509	-0.0015	-0.0271, 0.0241
LH	**0.1155**	**0.0093, 0.2217**	-0.0110	-0.1033, 0.0812	-0.0113	-0.0415, 0.0189
FSH	-0.0087	-0.0991, 0.0816	0.0386	-0.0616, 0.1387	-0.0243	-0.0567, 0.0081
Progesterone	0.0586	-0.0187, 0.1360	-0.0017	-0.0533, 0.0498	0.0023	-0.0195, 0.0240

CI=confidence interval, LH=luteinizing hormone, FSH=follicle stimulating hormone. Intervals in bold are statistically significant at alpha=0.05.

These models take repeated observations into account: up to eight clinic visits per menstrual cycle and up to two menstrual cycles per woman. The reference group for the effect estimates are women with employment that does NOT involve night/shift work. Models are adjusted for age, race, BMI, chronotype, and season.

Please see corresponding Supplemental Figures S5-S6 for examples of the change in mean levels for testosterone and LH.

[a]Coefficient units are concentrations for the changes in mean or amplitude and days for the changes in phasing.

Table S3. Differences in hormone concentrations over the menstrual cycle associated with chronotype: results from non-linear mixed models with harmonic terms

	Chronotype=Morning type					
	Difference in mean levels		Difference in amplitude		Difference in phasing (days)	
	Coefficient[a]	95% CI	Coefficient	95% CI	Coefficient	95% CI
Testosterone	-0.0132	-0.1365, 0.1101	0.0635	-0.1012, 0.2283	-0.0228	-0.0832, 0.0376
Estradiol	-0.0873	-0.2057, 0.0311	0.0554	-0.0538, 0.1646	**-0.0326**	**-0.0626, -0.0026**
LH	-0.0439	-0.1689, 0.0811	0.0656	-0.0292, 0.1604	-0.0338	-0.0704, 0.0028
FSH	-0.0187	-0.1259, 0.0885	0.0485	-0.0375, 0.1345	-0.0224	-0.0621, 0.0173
Progesterone	-0.0318	-0.1255, 0.0619	0.0284	-0.0322, 0.0889	-0.0123	-0.0367, 0.0121
	Chronotype=Evening type					
	Difference in mean levels		Difference in amplitude		Difference in phasing (days)	
	Coefficient[a]	95% CI	Coefficient[a]	95% CI	Coefficient[a]	95% CI
Testosterone	-0.0066	-0.1345, 0.1213	-0.0148	-0.1920, 0.1623	0.0391	-0.0290, 0.1071
Estradiol	0.0121	-0.1118, 0.1360	-0.0269	-0.1398, 0.0860	-0.0213	-0.0545, 0.0120
LH	-0.02715	-0.1580, 0.1037	0.0038	-0.1057, 0.1133	0.0353	-0.0071, 0.0777
FSH	0.0227	-0.0894, 0.1348	-0.0479	-0.1475, 0.0517	-0.0291	-0.0753, 0.0170
Progesterone	0.0193	-0.0798, 0.1184	-0.0578	-0.1252, 0.0097	-0.0095	-0.0397, 0.0207

CI=confidence interval, LH=luteinizing hormone, FSH=follicle stimulating hormone. Intervals in bold are statistically significant at alpha=0.05.

These models take repeated observations into account: up to eight clinic visits per menstrual cycle and up to two menstrual cycles per woman. The reference group for the effect estimates are women with an intermediate chronotype. Models are adjusted for age, race, BMI, night/shift work status, and season.

Please see corresponding Supplemental Figure S7-S9 for examples of the phase shift for estradiol, the suggested phase shift for LH, and the suggested amplitude change for progesterone.

[a]Coefficient units are concentrations for the changes in mean or amplitude and days for the changes in phasing.

Supplemental Figure Captions

Figure S1. Population least squared means for daily sleep reported across the menstrual cycle.

Women reported shorter daily sleep durations around ovulation and their longest sleep durations in the mid-luteal phase; the difference between these two time points reached statistical significance, while other comparisons across the cycle did not (Bonferroni corrected, p=0.02). Note that data from two cycles are included for most women.

Figure S2. Lower mean concentrations and suggested earlier phasing for estradiol associated with <7 hours of average daily sleep: results from non-linear mixed models with harmonic terms.

This figure shows difference in estradiol concentrations and the suggested phase shift reported in Table S1. In the example figure, adjustment variables were held to population median values/most common categorizations. For example, the differences in estradiol associated with daily sleep are shown among: white and black women, aged 24 years, with a body mass index of 23.5 kg/m^2.

Figure S3. Lower mean LH concentrations and earlier phasing associated with <7 hours of average daily sleep: results from non-linear mixed models with harmonic terms.

This figure shows difference in LH concentrations and the phase shift reported in Table S1. In the example figure, adjustment variables were held to population median values/most common categorizations. For example, the differences in estradiol associated with daily sleep are shown among: white and black women, aged 24 years, with a body mass index of 23.5 kg/m^2.

Figure S4. Earlier FSH phasing associated with <7 hours of average daily sleep: results from non-linear mixed models with harmonic terms.

This figure shows FSH phase shift reported in Table S1. In the example figure, adjustment variables were held to population median values/most common categorizations. For example, the differences in estradiol associated with daily sleep are shown among: white and black women, aged 24 years, with a body mass index of 23.5 kg/m^2.

Figure S5. Lower mean testosterone concentrations associated with unemployment and night/shift work: results from non-linear mixed models with harmonic terms.

This figure shows difference in testosterone concentrations reported in Table S2. In the example figure, adjustment variables were held to population median values/most common categorizations. For example, the differences in estradiol associated with daily sleep are shown among: white and black women, aged 24 years, with a body mass index of 23.5 kg/m^2.

Figure S6. Higher mean LH concentrations associated with night/shift work: results from non-linear mixed models with harmonic terms.

This figure shows difference in LH concentrations reported in Table S2. In the example figure, adjustment variables were held to population median values/most common categorizations. For example, the differences in estradiol associated with daily sleep are shown among: white and black women, aged 24 years, with a body mass index of 23.5 kg/m^2.

Figure S7. Earlier estradiol phasing associated with morning chronotype: results from non-linear mixed models with harmonic terms.

This figure shows the estradiol phase shift reported in Table S3. In the example figure, adjustment variables were held to population median values/most common categorizations. For example, the differences in estradiol associated with daily sleep are shown among: white and black women, aged 24 years, with a body mass index of 23.5 kg/m^2.

Figure S8. Suggested lower peak amplitude for progesterone associated with evening chronotype: results from non-linear mixed models with harmonic terms.

This figure shows the suggested lower amplitude for progesterone reported in Table S3. In the example figure, adjustment variables were held to population median values/most common categorizations. For example, the differences in estradiol associated with daily sleep are shown among: white and black women, aged 24 years, with a body mass index of 23.5 kg/m^2.

Figure S9. Suggested later LH phasing associated with evening chronotype: results from non-linear mixed models with harmonic terms.

This figure shows the suggested phase shift for LH reported in Table S3. In the example figure, adjustment variables were held to population median values/most common categorizations. For example, the differences in estradiol associated with daily sleep are shown among: white and black women, aged 24 years, with a body mass index of 23.5 kg/m^2.

Figure S1. Population least squared means for daily sleep reported across the menstrual cycle.

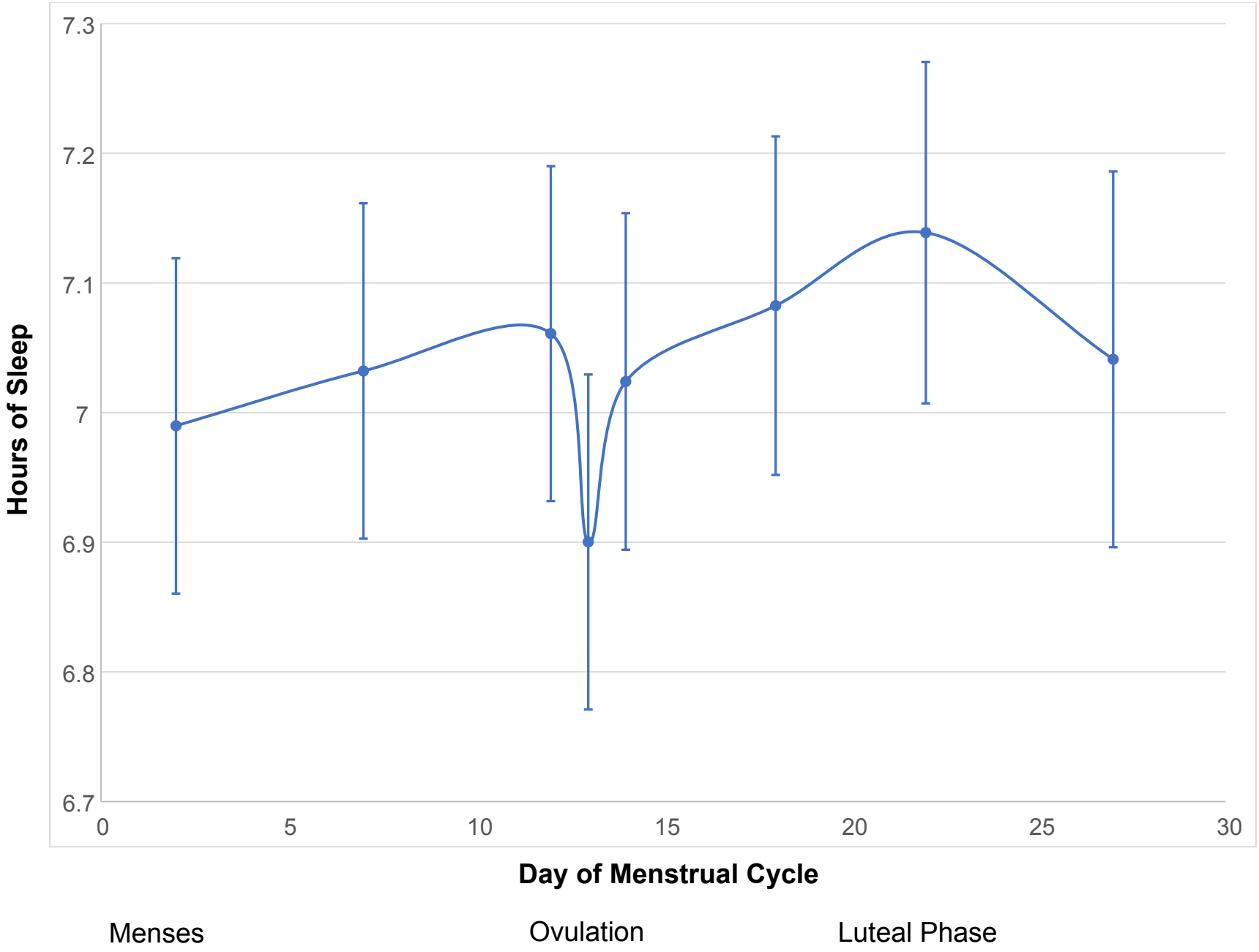

Figure S2. Lower mean concentrations and suggested earlier phasing for estradiol associated with <7 hours of average daily sleep: results from non-linear mixed models with harmonic terms.

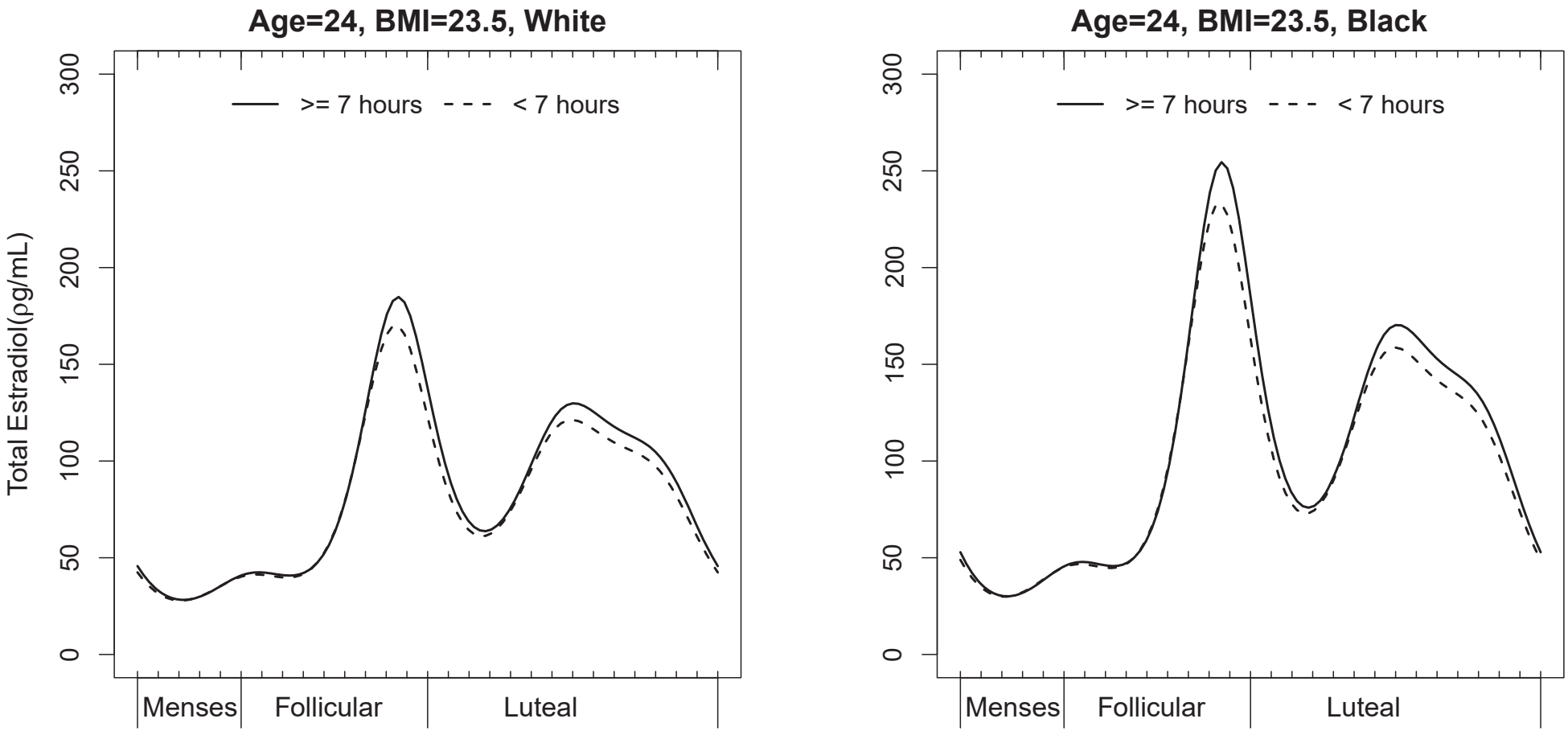

Figure S3. Lower mean LH concentrations and earlier phasing associated with <7 hours of average daily sleep: results from non-linear mixed models with harmonic terms.

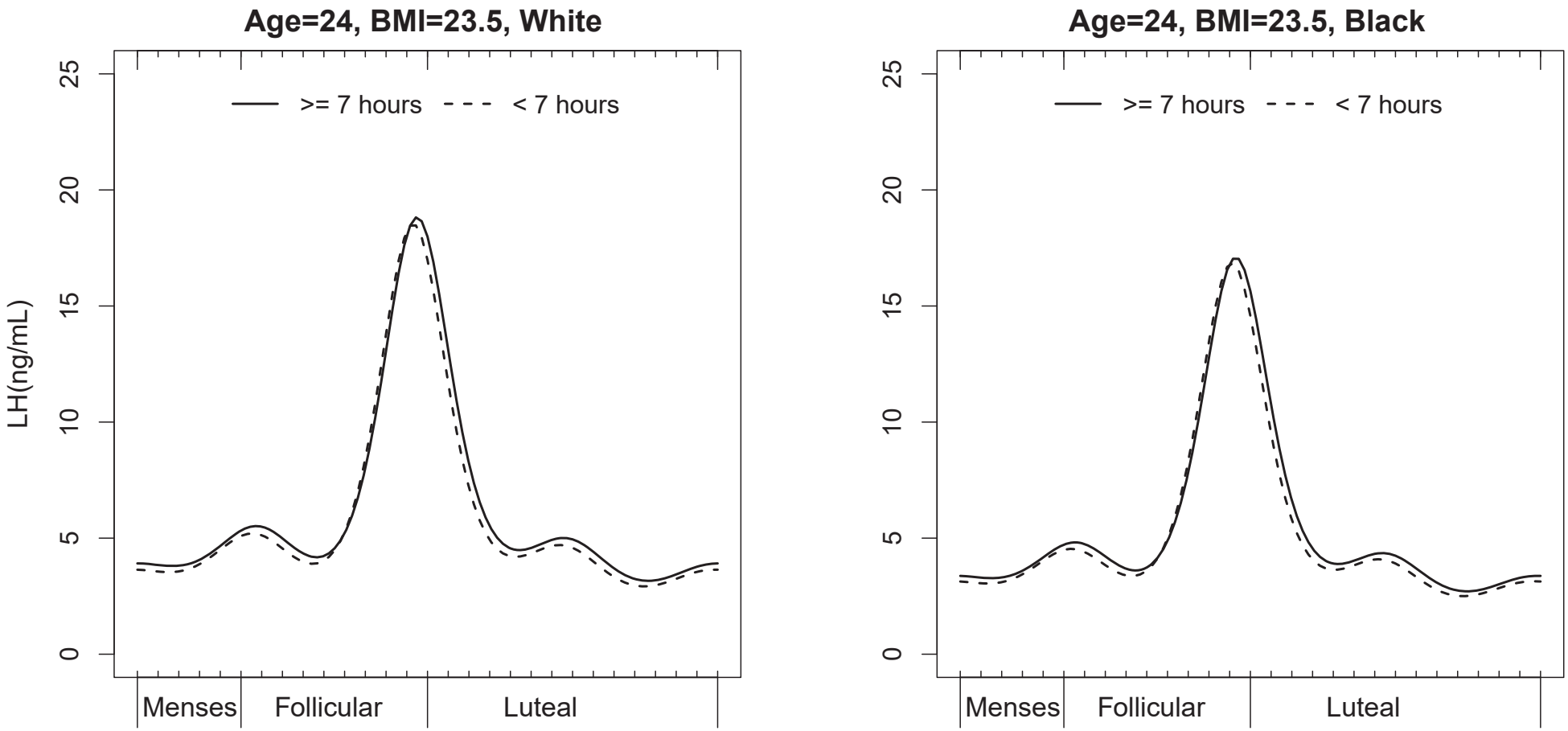

Figure S4. Earlier FSH phasing associated with <7 hours of average daily sleep: results from non-linear mixed models with harmonic terms.

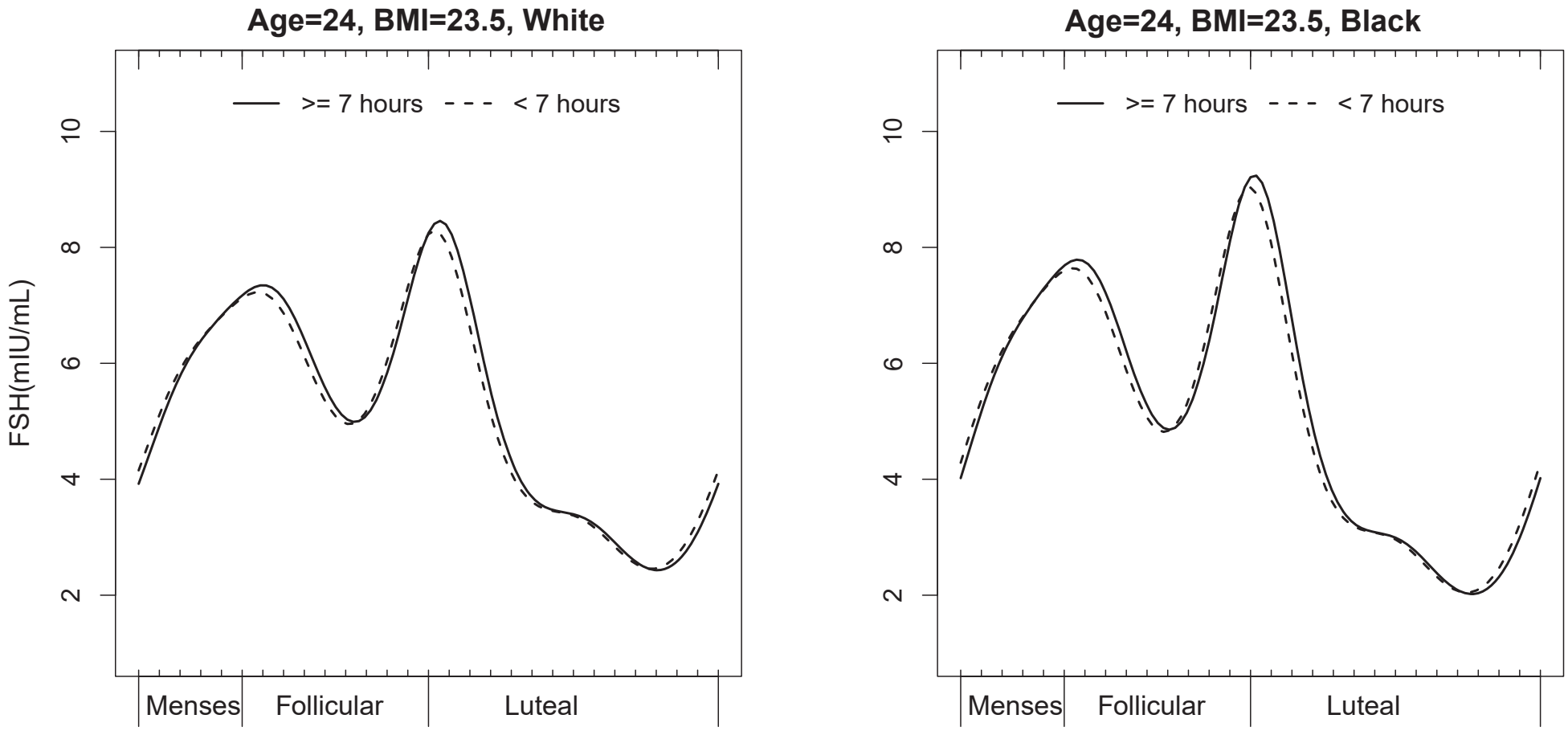

Figure S5. Lower mean testosterone concentrations associated with unemployment and night/shift work: results from non-linear mixed models with harmonic terms.

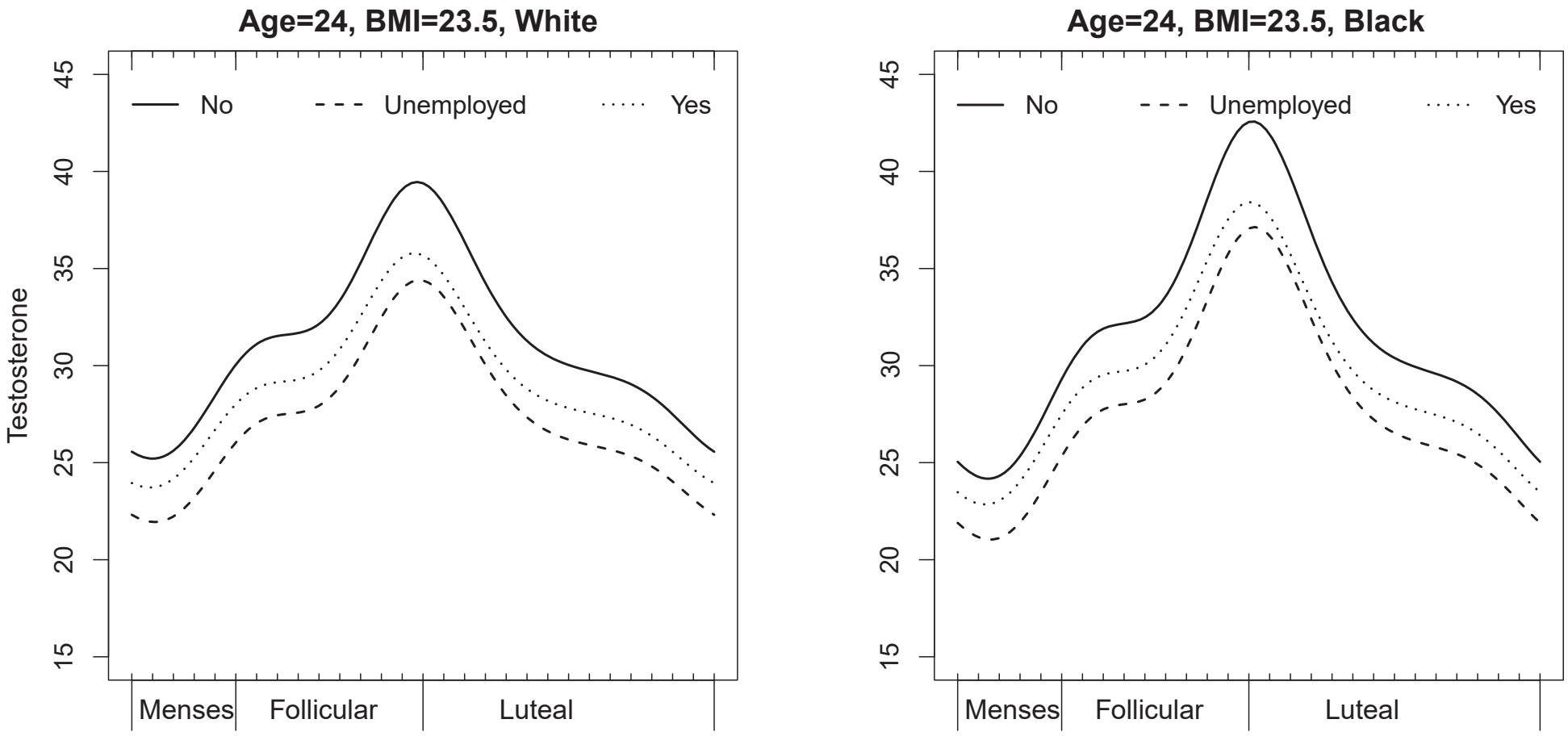

Figure S6. Higher mean LH concentrations associated with night/shift work: results from non-linear mixed models with harmonic terms.

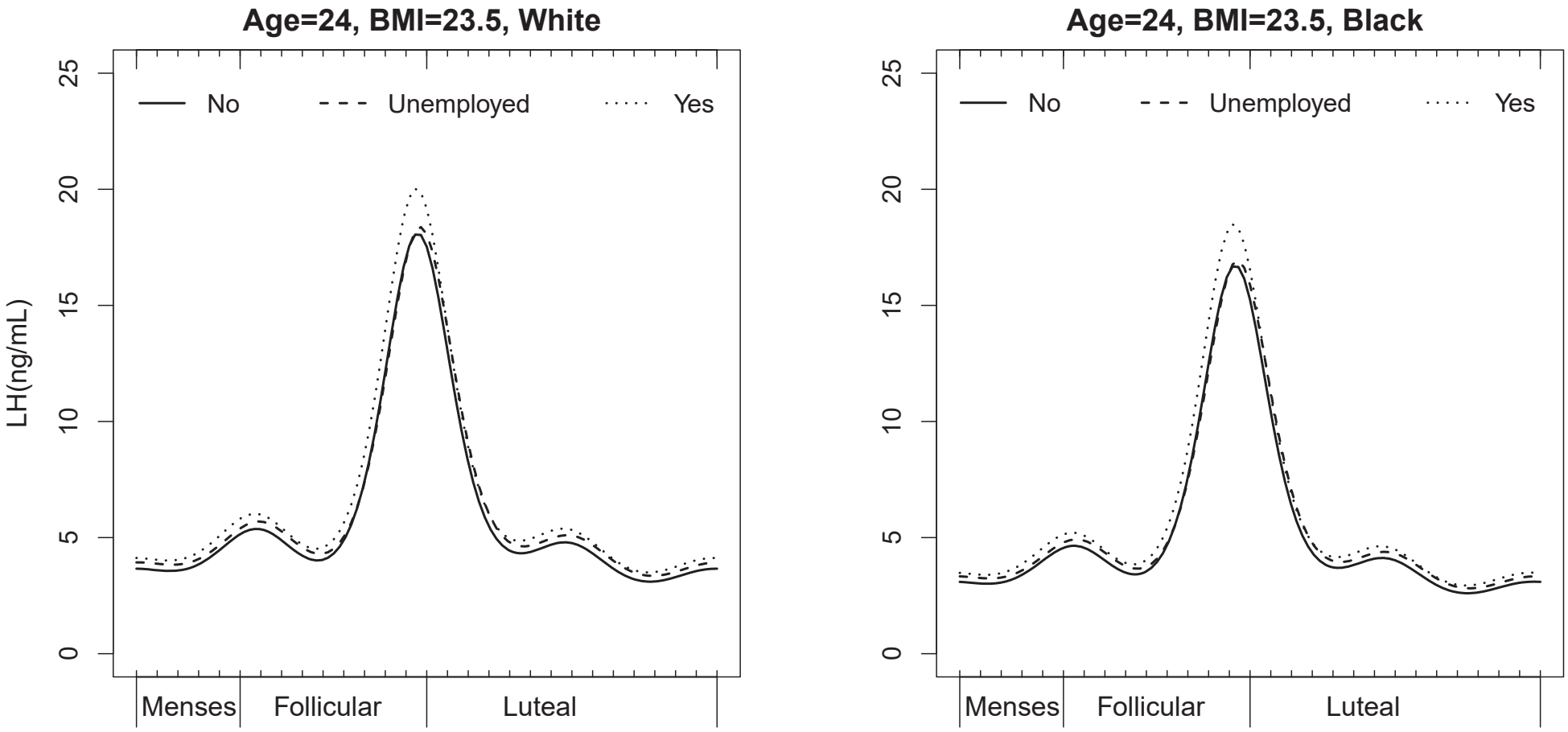

Figure S7. Earlier estradiol phasing associated with morning chronotype: results from non-linear mixed models with harmonic terms.

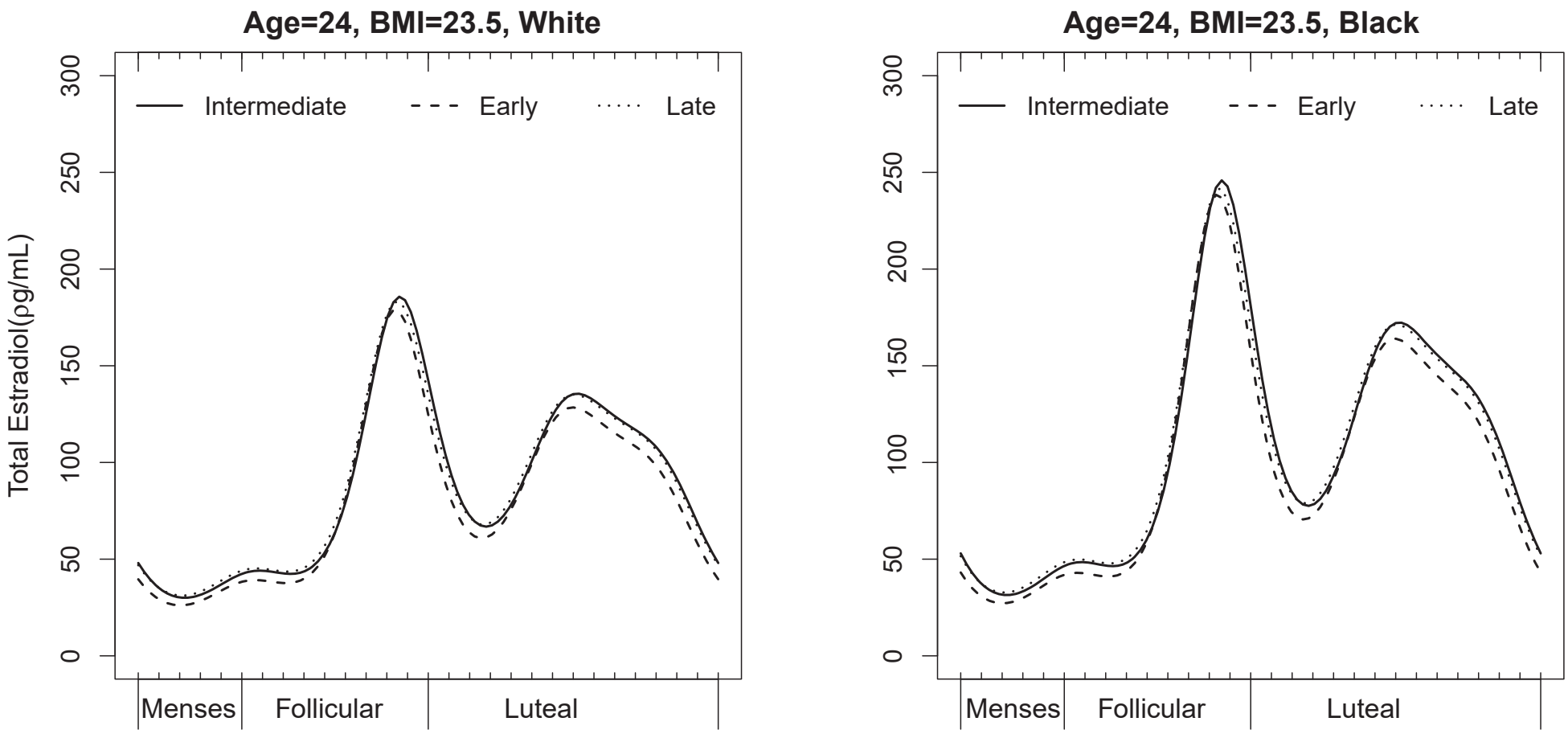

Figure S8. Suggested lower peak amplitude for progesterone associated with evening chronotype: results from non-linear mixed models with harmonic terms.

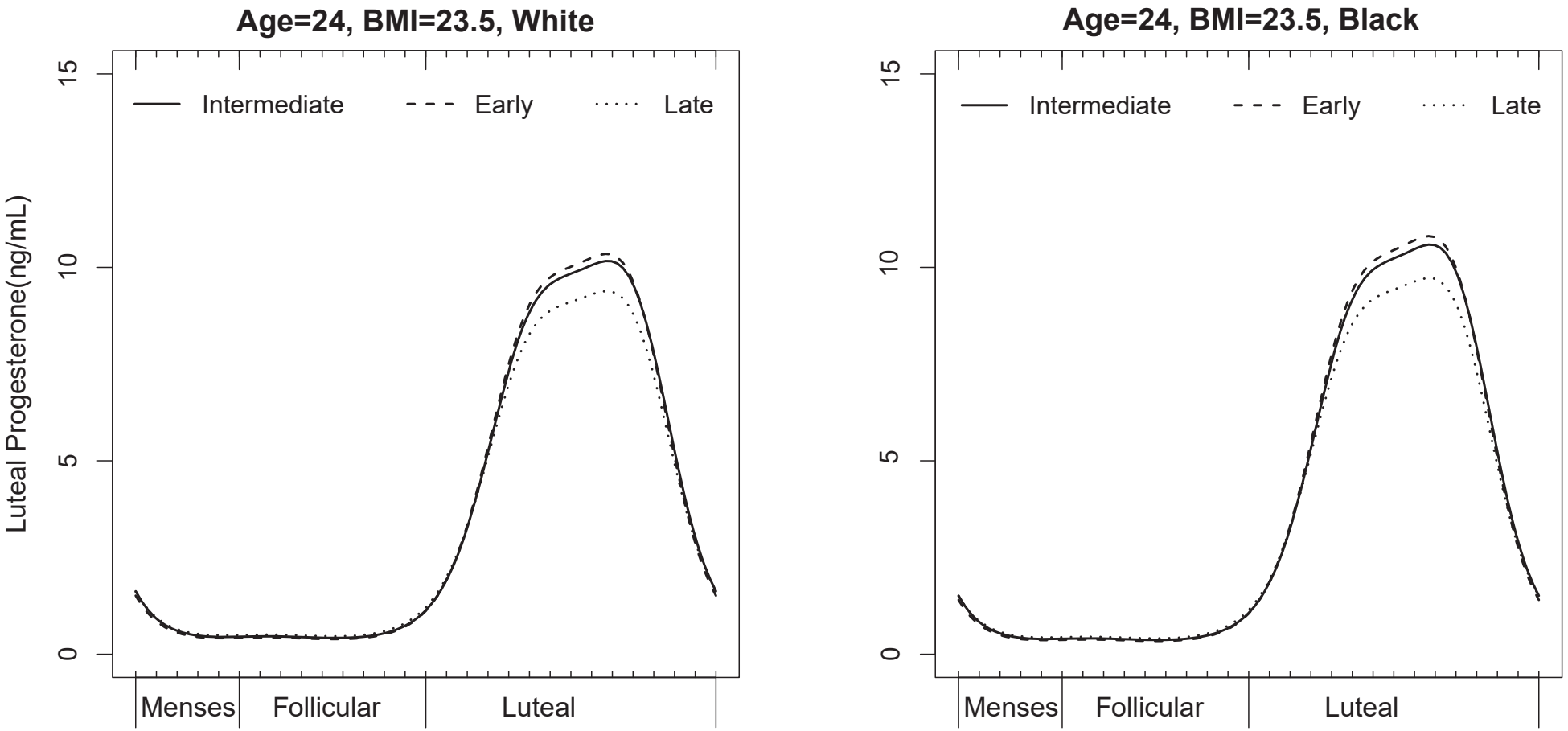

Figure S9. Suggested later LH phasing associated with evening chronotype: results from non-linear mixed models with harmonic terms.