

PRENATAL SUNLIGHT IN THE SECOND TRIMESTER PREDICTS TIMING OF MENARCHE IN POLISH WOMEN BORN BETWEEN 1985–1991

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Background: Seasonal variation in prenatal environmental conditions has been linked to developmental and health outcomes. Maternal sunlight exposure during pregnancy may influence foetal growth and reproductive maturation through vitamin D-related pathways. Age at menarche is an important marker of timing and a predictor of later metabolic and cardiovascular health. Despite evidence supporting programming of reproductive development, the association between sunshine exposure and age at menarche remains insufficiently investigated.

Objective: To examine the relationship between maternal sunshine exposure during pregnancy and age at menarche in daughters, while accounting for season of birth, birthweight, and socioeconomic characteristics.

Subjects and methods: The study included 1,635 Polish female university students aged 19–25 years. Age at menarche was retrospectively reported. Prenatal sunshine exposure was estimated using national meteorological data on average monthly sunshine duration in Poland and calculated separately for each trimester of pregnancy. Generalized linear models assessed associations between trimester-specific sunshine exposure, season of birth, and age at menarche, with progressive adjustment for birthweight, parental education, urbanization level, number of siblings, and birth order. Sequential multiple regression analyses evaluated independent trimester effects.

Results: The mean age at menarche was 12.70 ± 1.17 years. In unadjusted analyses, summer and autumn birth were associated with earlier menarche; however, these associations were fully attenuated after adjusting for prenatal sunshine exposure. Higher maternal sunshine exposure during the second trimester was consistently and robustly associated with earlier menarche across all models (e.g. for the final model $\beta = -0.145$, 95% CI: $-0.21 - -0.08$; adj. $R^2 = 0.256$).

Conclusions: Prenatal maternal sunshine exposure, particularly during the second trimester of pregnancy, is a significant predictor of age at menarche independent of season of birth. These findings strongly support the role of gestational sunlight exposure - likely reflecting maternal vitamin D status, in the developmental programming of female pubertal timing.

Keywords: Early-life environmental exposures; Season of birth; Vitamin D; Perinatal epidemiology; DOHaD framework; Age at menarche.