Appendix S2: Patterns of second- and third-trimester growth and discordance in twin pregnancy: analysis of the Southwest Thames Obstetric Research Collaborative (STORK) multiple pregnancy cohort

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1 Structure of fitted models for estimated fetal weight

Estimated fetal weight (EFW) was modelled after logarithmic transformation with base 10. In both DCDA and MCDA twin pregnancies, following the initial 'random intercept' model, highly statistically significant improvements in model fit were achieved by a 'random slope' model and subsequently a quadratic model for the relationship with gestational age. The latter model included both a quadratic 'fixed effects' function for the mean and quadratic fetus-level 'random effects' in terms of gestational age in each case, with these correlated between Twin A and Twin B in each pregnancy. Model-fitting was attempted including cubic components for both the fixed and random effects, but convergence was not achieved.

Unlike the individual biometric variables, for the fitted quadratic models, plotting of the examination-specific standardized residuals against the fixed part prediction (wholly dependent on gestational age) did not reveal any trend in the magnitude of the residuals.

The structure of the fitted model can be expressed in the following form, in which Y_{Ajk} and Y_{Bjk} represent the Log_{10}(EFW) for 'Twin A' and 'Twin B' in the k$^{\text{th}}$ pregnancy at j$^{\text{th}}$ time point t_{jk} (in weeks centred at 14), the β-coefficients represent the fixed effects estimates for the overall relationship with gestational age, $\boldsymbol{\Omega_u} + \boldsymbol{\Omega_v}$ represents the fetus-level covariance matrix of random effects (inclusive of pregnancy-level variation), $\boldsymbol{\Omega_v}$ represents the between-twin covariance matrix (interpretable as equivalent to a pregnancy-level random effects matrix) and $\boldsymbol{\Sigma}$ is the covariance matrix for examination-specific random effects:

$$
\begin{aligned}
Y_{Ajk} &= \beta_0 + U_{0Ak} + (\beta_1 + U_{1Ak})\, t_{jk} + (\beta_2 + U_{2Ak})\, t_{jk}^2 + E_{Ajk} \qquad (1)\\
Y_{Bjk} &= \beta_0 + U_{0Bk} + (\beta_1 + U_{1Bk})\, t_{jk} + (\beta_2 + U_{2Bk})\, t_{jk}^2 + E_{Bjk}\\
&\begin{pmatrix} U_{0Ak} \\ U_{1Ak} \\ U_{2Ak} \\ U_{0Bk} \\ U_{1Bk} \\ U_{2Bk} \end{pmatrix} \sim MVN(\mathbf{0}, \mathbf{\Psi}), \text{ where } \mathbf{\Psi} = \begin{pmatrix} \mathbf{\Omega_u} + \mathbf{\Omega_v} & \mathbf{\Omega_v} \\ \mathbf{\Omega_v} & \mathbf{\Omega_u} + \mathbf{\Omega_v} \end{pmatrix}\\
&\begin{pmatrix} E_{Ajk} \\ E_{Bjk} \end{pmatrix} \sim MVN(\mathbf{0}, \mathbf{\Sigma}), \text{ where } \mathbf{\Sigma} = \begin{pmatrix} \sigma^2 & \sigma_{AB} \\ \sigma_{AB} & \sigma^2 \end{pmatrix}
\end{aligned}
$$

2 Parameter estimates for fitted models

The tables below give a summary of parameter estimates for the final fitted models for DCDA and MCDA pregnancies. Following earlier notation:

$$
\mathbf{\Omega_v} = \begin{pmatrix} \varphi_{00} & \varphi_{01} & \varphi_{02} \\ \varphi_{01} & \varphi_{11} & \varphi_{12} \\ \varphi_{02} & \varphi_{12} & \varphi_{22} \end{pmatrix} \qquad \mathbf{\Omega_u} + \mathbf{\Omega_v} = \begin{pmatrix} \tau_{00} + \varphi_{00} & \tau_{01} + \varphi_{01} & \tau_{02} + \varphi_{02} \\ \tau_{01} + \varphi_{01} & \tau_{11} + \varphi_{11} & \tau_{12} + \varphi_{12} \\ \tau_{02} + \varphi_{02} & \tau_{12} + \varphi_{12} & \tau_{22} + \varphi_{22} \end{pmatrix}
$$

Although we have retained the notation $\mathbf{\Omega_u} + \mathbf{\Omega_v}$, because conceptually this represents the sum of fetus-level and pregnancy-level variation, the terms that comprise this matrix have been estimated directly by MLwiN. Estimated standard errors are given in parentheses.

2.1 Log_{10}(EFW)

	DCDA	**MCDA**
Fixed		
β_0	1.95808 (0.00153)	1.93965 (0.00287)
β_1	0.10191 (0.00024)	0.10194 (0.00046)
β_2	-0.001647 (0.00001)	-0.001651 (0.000020)
Random		
Level 3		
$\tau_{00}+\varphi_{00}$	0.00152 (0.00013)	0.00232 (0.00023)
$\tau_{01}+\varphi_{01}$	-6.77e-5 (1.89e-5)	-0.00012 (3.03e-5)
$\tau_{11}+\varphi_{11}$	2.23e-5 (3.43e-6)	3.44e-5 (5.75e-6)
$\tau_{02}+\varphi_{02}$	1e-6 (6.92e-7)	3.38e-6 (1.24e-6)
$\tau_{12}+\varphi_{12}$	-6.7e-7 (1.28e-7)	-1.21e-6 (2.35e-7)
$\tau_{22}+\varphi_{22}$	2.9e-8 (5e-9)	5.56e-8 (1.02e-8)
φ_{00}	0.000892 (0.000133)	0.000998 (0.000226)
φ_{01}	-3.1e-5 (1.9e-5)	-4.48e-5 (3.04e-5)
φ_{11}	9.71e-6 (3.45e-6)	1.63e-5 (5.79e-6)
φ_{02}	-3.46e-8 (6.97e-7)	3.79e-7 (1.24e-6)
φ_{12}	-2.58e-7 (1.29e-7)	-5.51e-7 (2.37e-7)
φ_{22}	1.03e-8 (5.06e-9)	2.66e-8 (1.03e-8)
Level 2		
σ^2	0.000596 (1.08e-5)	0.000601 (1.88e-5)
σ_{AB}	0.000157 (1.1e-5)	0.000125 (1.91e-5)