

Covariance estimation for derivatives of functional data

EcoSta 2026

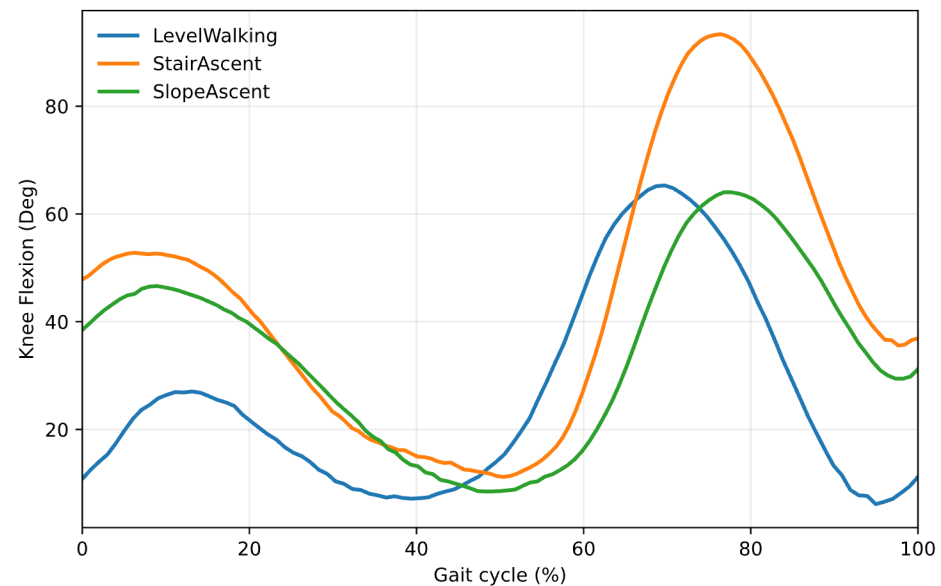
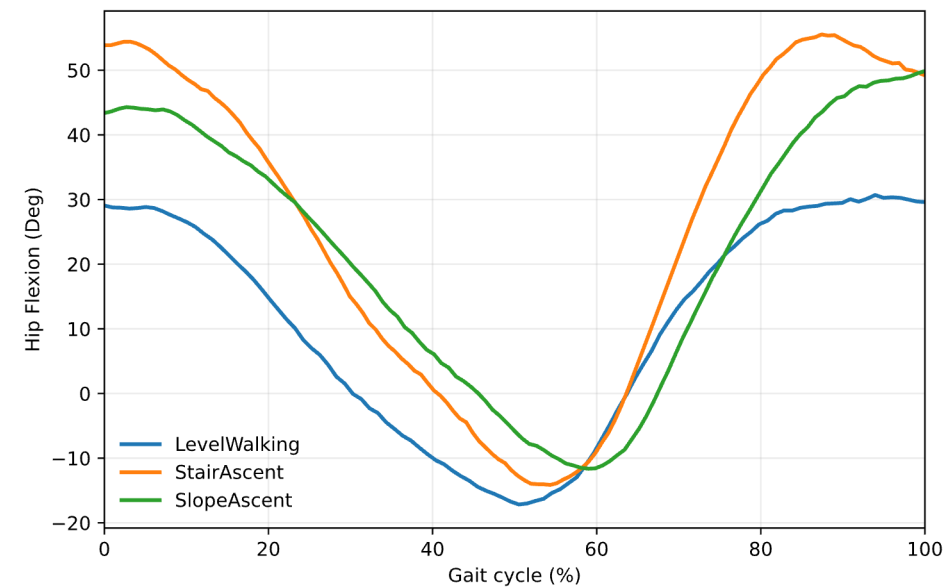
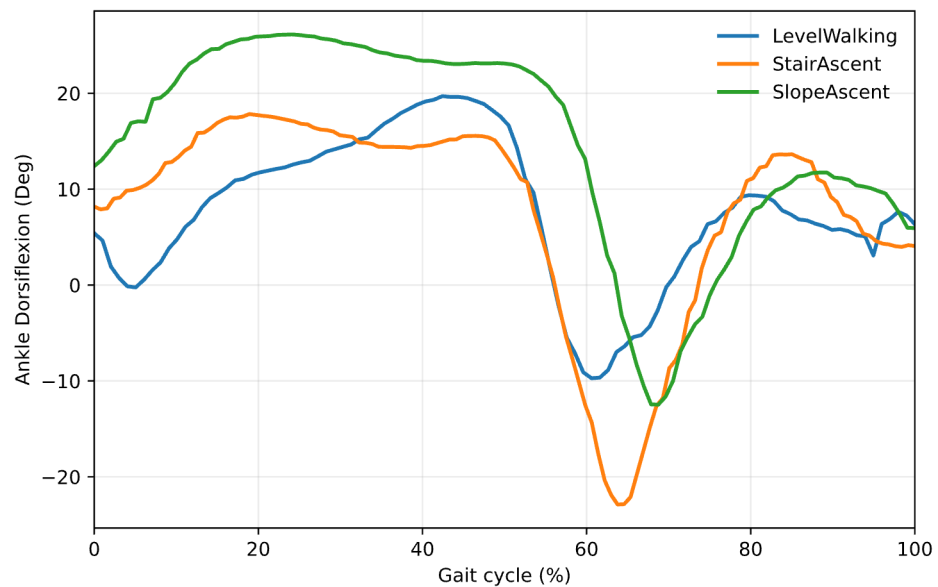
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Pictures are from the authors.

Boo, J. et al., Comprehensive human locomotion and electromyography dataset: Gait120 (2025).

The target

$$\partial_s \partial_t K(s, t) = \mathbb{E} (\partial X(s), \partial X(t))$$

FACE + additive P-spline penalty

$$\tilde{K}(s, t) = S \hat{K}(s, t) S$$

$$S = B \left(B^\top B + \lambda_1 P_1 + \lambda_2 P_2 \right)^{-1} B^\top$$

Derivative of the covariance

$$\tilde{K}(s, t) = B(s)^\top \Theta B(t)$$

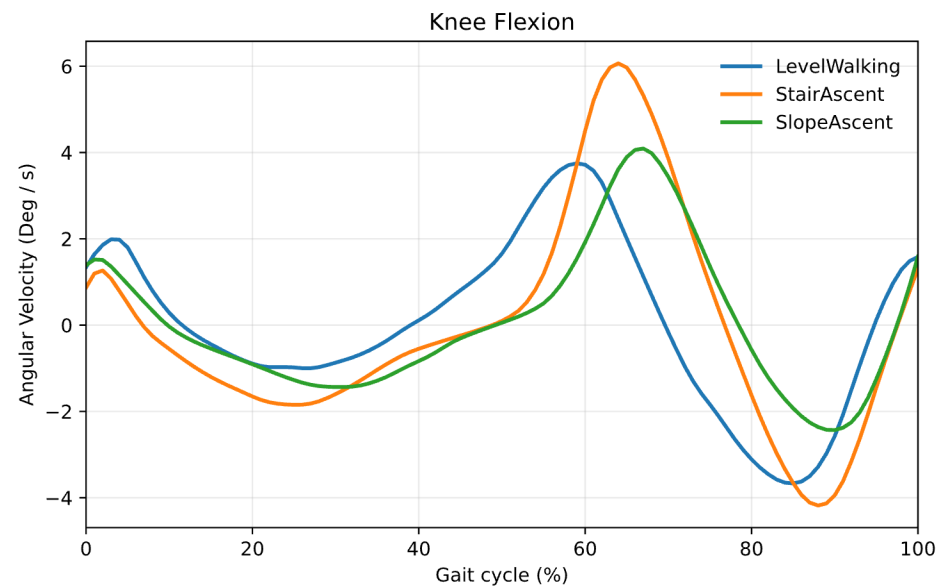
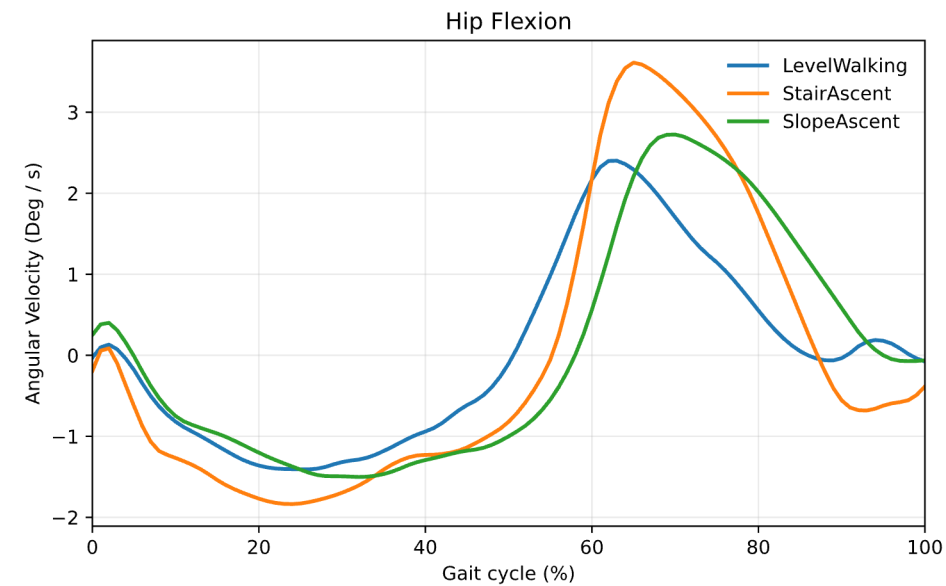
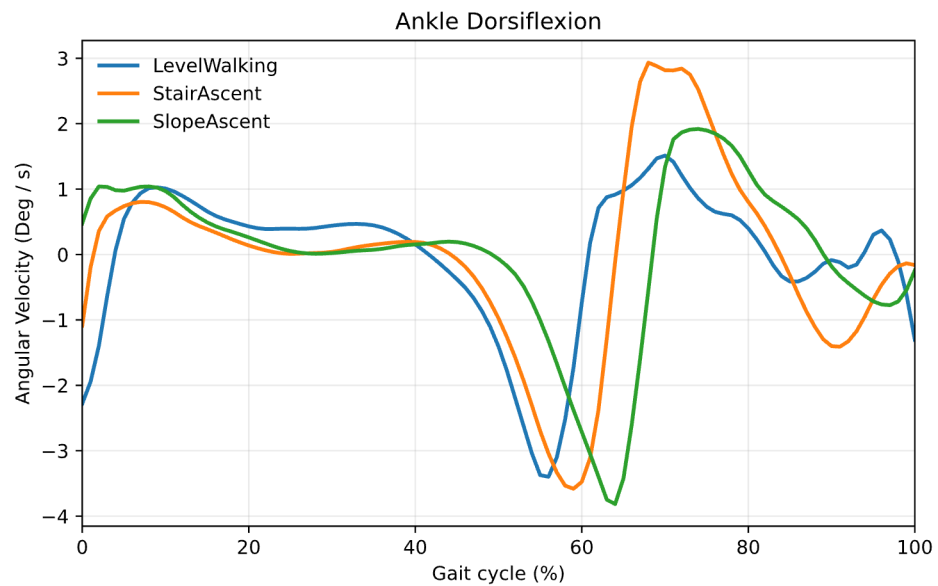
$$\partial_s \partial_t \tilde{K}(s, t) = \partial_s B(s)^\top \Theta \partial_t B(t)$$

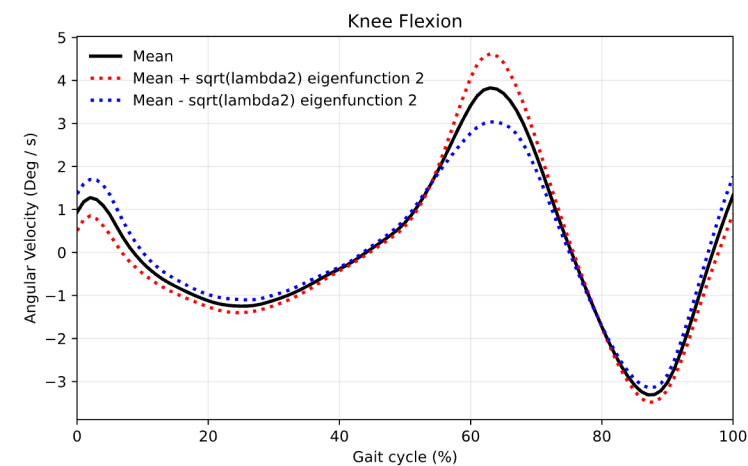
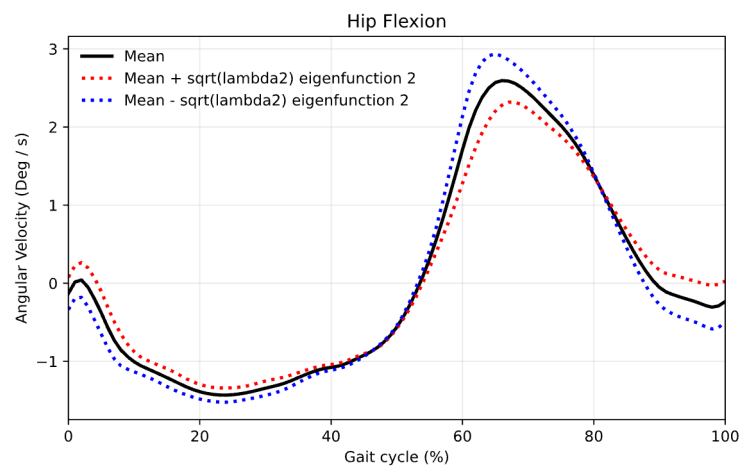
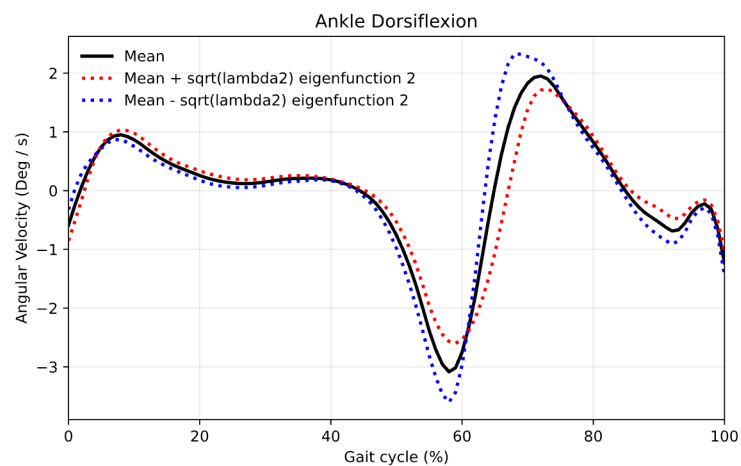
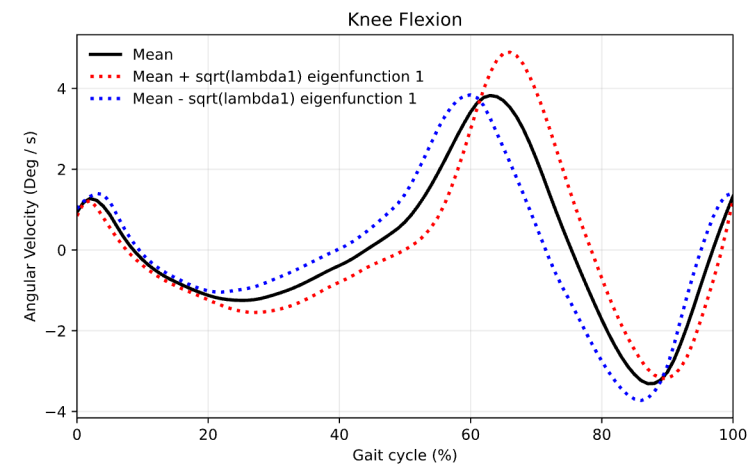
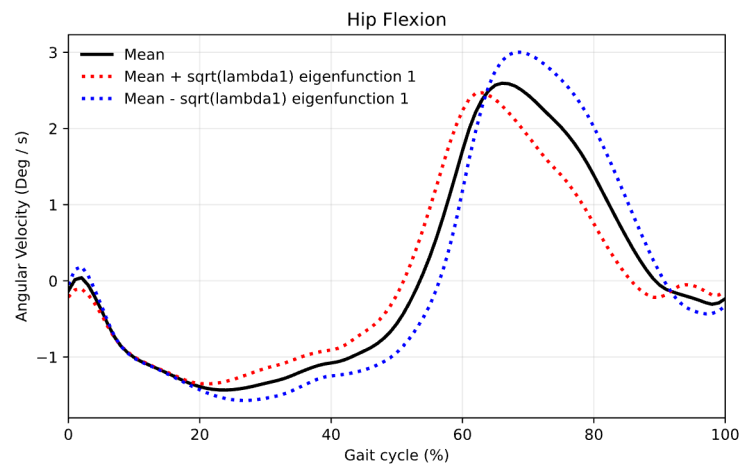
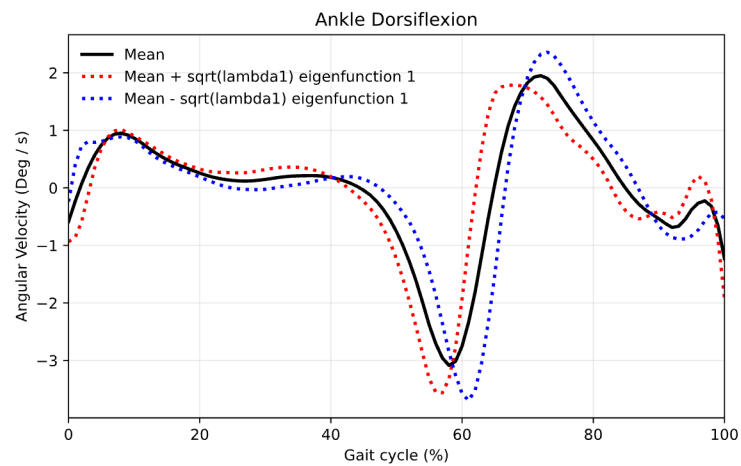
Derivative-based FPCA

$$G^{1/2}\Theta G^{1/2} = QVQ$$

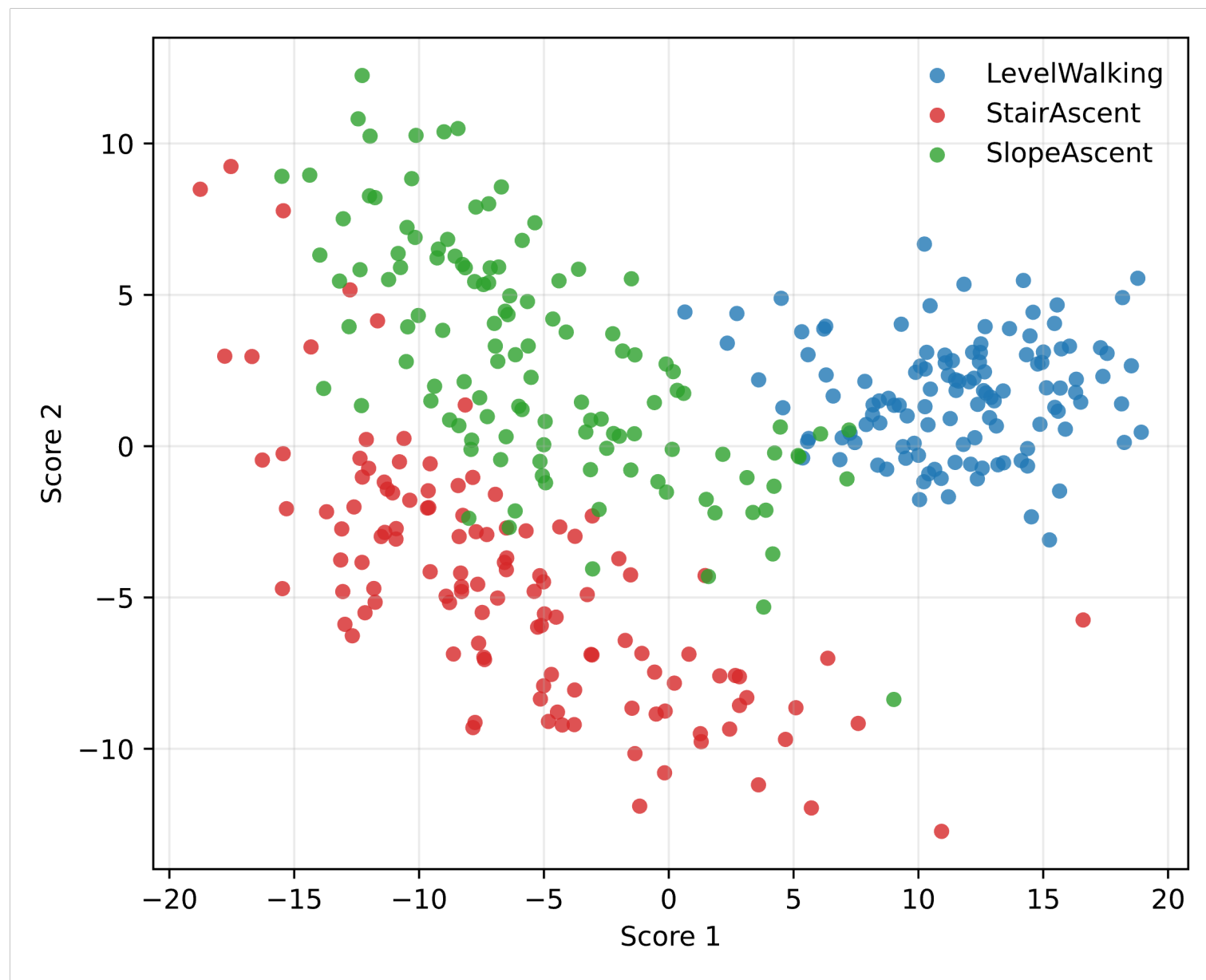
$$\Phi(t) = \partial_t B(t)^\top G^{-1/2}Q$$

$$\xi_i = \left(\Phi^\top \Phi + \sigma^2 V^{-1}\right)^{-1} \Phi^\top \partial B \Theta$$





Pictures are from the authors.



Thanks!

