Chapter 1 Introduction

Motivation

Outline of thesis

Foundations

Chapter 2 Statistical Methods for Functional Data Analysis

Basis Expansions and Smoothing

Registration

FPCA

Functional Regression

Chapter 3 The Running Injury Surveillance Centre **Dataset**

Data Collection & Extraction

Basis Representation

Landmark Registration

Chapter 4

A Multivariate Functional Mixed Model for Kinematic Data from Recreational Runners

Development of a model for the average sagittal-plane hip and knee angle functions from the RISC data

The model is used to quantify the fixed effects of scalar covariates and capture dependence among bilateral observations from the same subject

New approaches for estimation, inference, summarising and checking the model are proposed

Chapter 5

A Multivariate Multilevel **Longitudinal Functional** Model for Repeatedly-Observed Human-Movement Data

Extend the model from Chapter 4 to include the hip, knee and ankle angles from every stride in the RISC data

Development of novel multilevel longitudinal approach to capture serial correlation among adjacent strides

Fixed effects of scalar covariates and predictions of individual trajectories

Chapter 6 An Understanding of **Principal Differential Analysis**

Re-examination of PDA as a generative statistical model

Development of iterative biasreduction algorithm to improve parameter estimates

Perspective of PDA as a timevarying linearised approximation to a non-linear ODE model

Demonstrations on simulated data and kinematic data from the RISC dataset

Chapter 7 Final Remarks and **Future Work**

Summary of the Thesis

Future Work and Directions

Concluding Remarks