### 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

Used to quantify fixed effects of scalar covariates and predict and describe 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