Project Details	
Project Code	MRCPHS25Ex Akrami
Title	Unveiling the Biomechanics of Diabetic Foot Ulcers: Identifying Critical Foot Load Profiles for Prevention and Treatment
Research Theme	Population Health Sciences
Summary	Diabetic foot issues pose significant challenges for patients and healthcare providers. Current evaluation methods are costly, invasive, and subjective. This study aims to address these problems by analysing gait patterns in diabetic patients compared to healthy individuals. By examining how foot ulcers affect movement and using computational and experimental biomechanics simulations, we aim to understand changes in load distribution within the foot. This will enhance our knowledge of heel pad deformities, which contribute to diabetic foot ulcers.
Description	Approximately 10% of the NHS budget for England and Wales is allocated to diabetes care, costing the healthcare system more than £1.5 million every hour. This expenditure amounts to an estimated £14 billion annually, primarily spent on managing complications rather than providing direct diabetic care. The cost of diabetes medications alone has surged by nearly £500 million since 2015, underscoring the escalating financial burden on the NHS. Diabetes mellitus, a chronic illness affecting millions globally, leads to numerous complications, including diabetic foot ulcers (DFUs). DFUs result from peripheral artery disease and neuropathy, increasing the risk of infection and amputation. Preventing these catastrophic outcomes necessitates early detection and effective management of foot health issues. Traditionally, changes in diabetic foot biomechanics have been attributed to polyneuropathy, which weakens the intrinsic muscles of the foot, leading to limited joint mobility (LJM) and deformities, particularly in the forefoot. Certain deformities (i.e., small muscle wasting, hammer or claw toes, prominent metatarsal heads, and Charcot arthropathy) are associated with increased plantar pressure. These conditions can cause the displacement of the plantar fat pad and prolapse of the metatarsal heads on the plantar surface and, subsequently, are precursors of foot ulceration. A UK population study of 15,692 diabetic patients found that foot deformity, along with other risk factors such as peripheral arterial disease (PAD), peripheral neuropathy, and insulin usage, accounts for the higher number of foot ulcerations in Europeans compared with two other ethnic groups. Diabetes often impairs the body's ability to heal wounds. When combined with deformities that cause repeated pressure and friction, even minor injuries can become chronic ulcers that are difficult to treat. Early detection and management of foot deformities can prevent complications. By closely monitoring and managing foot deformities, healthcare providers can improve outcomes and quality of life for diabetic patients while reducing the risk of serious complications and associated healthcare costs. Diabetic foot problems are a significant concern for both patients and healthcare organisations. Current methods for evaluating foot health often rely on costly procedures or subjective assessments, which can be resource-intensive, time-consuming, and uncomfortable for patients.

	This study aims to address these challenges by analysing gait patterns in diabetic patients to identify differences compared to healthy subjects. This analysis will help observe how the progression of ulcers on the plantar surface of the feet impacts human locomotion patterns. Additionally, by developing computational simulations such as Finite Element Analysis (FEA), we can investigate changes in load patterns within the human foot. This will enhance our understanding of the initiation and progression of deformities and their severity within the heel pad, which contribute to the development of diabetic foot ulcers. Through such studies, different footwear and/or insoles can be prescribed to alleviate the load on diabetic feet, thereby reducing the likelihood of DFU progression. By leveraging these insights, we aim to develop a model that evaluates foot load profiles using data gathered from pressure sensors and other non-invasive devices. This approach will facilitate the early identification of abnormal pressure distributions that precede ulcer formation. The primary objectives of this study are: • To develop a comprehensive dataset of gait patterns and plantar pressure data in diabetic versus healthy patients, analysing the existing anomalies. • To create a bio-realistic finite element model of the human foot for both diabetic and healthy subjects, with a focus on those at high risk of DFU. These patient-specific models, comprising hard and soft tissues of the foot, will be developed using Magnetic Resonance Imaging (MRI) data, aiding in understanding the mechanobiology of these changes. • To design and manufacture patient-specific footwear that alleviates friction and load pressure on diabetic patients. If time permits, the project will also investigate instrumentation of the footwear to monitor pressure changes over time. To achieve a thorough understanding of diabetes-related foot complications, we will collect an extensive dataset from individuals with diabetes, including clinical outcomes, gait analysis, and foot pressure readings. Pressure sensors placed in shoes or insoles will gather data during routine activities. We will then analyse this information to identify critical elements such as distribution patterns, peak pressure sites, and pressure application duration that influence foot load profiles. Using MRI data, we will develop bio-realistic models of the human foot to study how internal segments function during different stages of the gait cycle, helping to pinpoint when and where ulcers are most likely to develop. Through these comprehensive studies, our knowledge will be significantly enhanced, facilitating the early identification and treatment of diabetic foot complications. This has the potential to reduce the frequency of DFUs and amputations, ultimately improving patient outcomes and reducing healthcare costs.
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