HEXAGON

Case study

Real-time design of 3D-printed orthopedic insoles

Laboratory of Biomechanics and Application (LBA) - Marseille, France

ODYSSEE CAE optimises insoles for real-time clinical applications.

The Laboratory of Biomechanics and Application focuses on the virtual human. The virtual human has many practical applications with the study and prevention of trauma or the improvement of diagnosis and surgical techniques. With multi-scale analysis: tissues, limbs, body sections, or complete human models can be used for virtual testing.

The Laboratory of Biomechanics and Application (LBA) is a joint research unit between the Université Gustave Eiffel's Transport, health, safety Department (formerly IFSTTAR) and the Aix-Marseille Faculty of Medicine. The multidisciplinary approach in this laboratory combines both engineering and medical science expertise focusing on human impact biomechanics. LBA is designing tools and human models for virtual testing to achieve their vision of a "Virtual Human". Their practical research has taken roots in the real world affecting the clinical and surgical settings as well as transport safety.

LBA is located in the premises of the Faculty of Medicine, in the northern Marseille Health Center in France with 39 collaborating research staff.

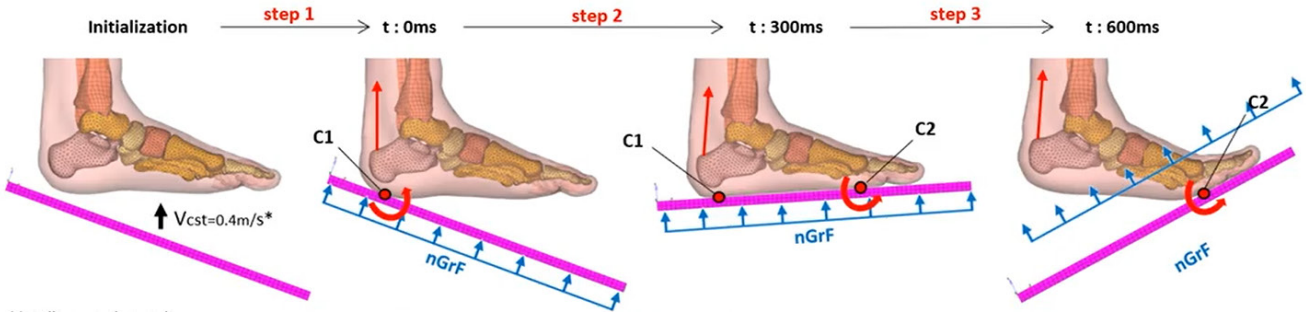

Fig 1: The four phases of the walking gait cycle (Wallace et al. 2018).

Challenge

The virtual human and limb models created by LBA has practical applications for injury prevention analyses and clinical settings. The developed foot-limb model is being used for emerging medical applications such as optimising orthopedic insoles. These optimised insoles could be 3D printed easily in the clinic. LBA uses up to seven different engineering software programs to comprehensively model the dynamics of the realistic walking gait. A digital twin model of the patient's foot could be exploited to gain insights on how to improve the insoles for the patient's specific needs. The adjusted custom insole would maximise the intended effect of the insole and the comfort of the patient. The current foot model requires significant time to accurately render the effects of the insole. LBA used ODYSSEE CAE to enable their comprehensive foot model to provide easily understandable and instantaneous feedback needed by clinical podiatrists.

Solution

The LBA's foot model provides a comprehensive analysis on the patient's walking gait. The analysis of the walking dynamics was conducted by dividing the gait into four phases and accounting for details caused by the different properties of bone, soft plantar tissue, skin tissue, ligaments, joint placement, joint stiffness, and the ground. The foot and insole models' parameters were modified to the measurements of the patient's foot. The foot model then was able to become a numerical (digital) twin of the patient, mimicking any kind of foot geometry, gait, and walking pattern. ODYSSEE CAE used thirty simulations of the original foot model to create a reduced order model that accommodates any foot geometry and accurately reproduces the dynamics of the patient's walking gait. The sensitivity studies of the reduced model showed the parameters with the largest effect on the gait. ODYSSEE CAE was able to generate near instantaneous feedback using the reduced order model, increasing the usefulness of the model to clinicians.

> **It is now actually used by podiatrists that are already clients to the company that was partly funding the study."**
>
> **Dr. Michel Behr**
> Researcher

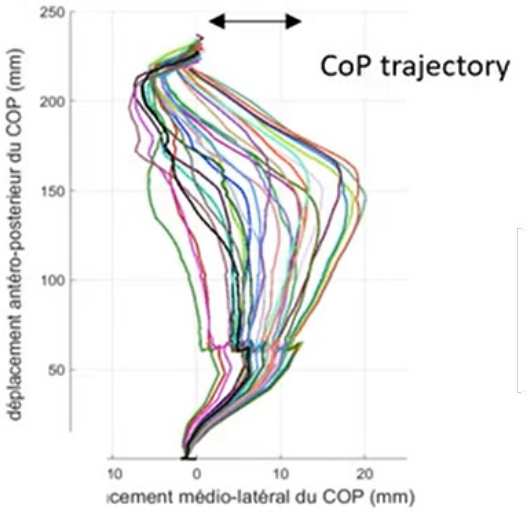

Fig 2: The plot showing how the Center of Pressure moves during the walking gait. Lines on the left show a tendency of pronation while the lines on the right show a tendency towards supination.

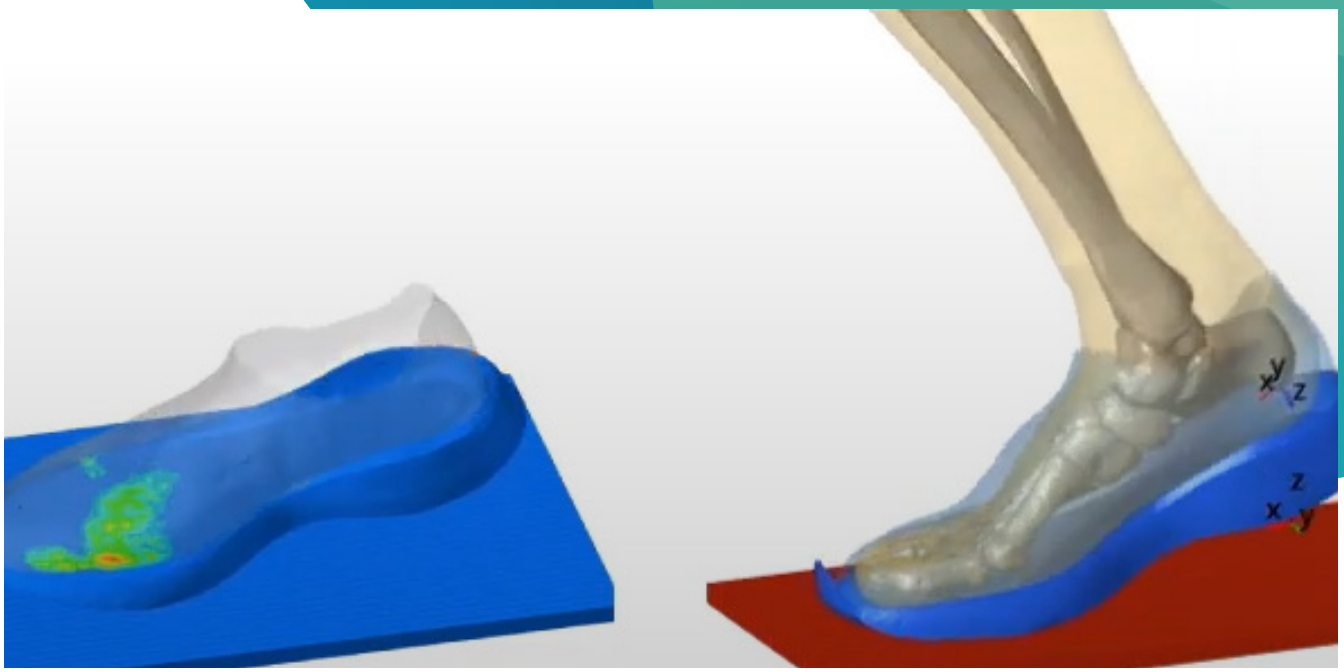

Fig 3: Models showing the pressure from the foot on the outsole during the toe-off phase of the walking gait cycle.

Results

The real time feedback supports podiatrists in providing the best possible care to their patients. The reduced foot model from ODYSSEE CAE accurately predicts the dynamic response of the comprehensive model in less than one second compared to the four hours needed to resolve the full model. The predictions of the reduced model matched very closely the Center of Pressure displacement observed in the original model. The ability to match different insole designs to the patient's foot digitally and observe the effects in real-time allows for rapid optimization of the design to maximise the intended effect. Custom insoles can be optimised with differing materials, local densities, and geometries to best meet the patient's need. The reduced model has also shown promise in optimising the outsoles of some sport shoes. One additional benefit of using the digital twin models of the foot and the insole is the ease of 3D printing the custom insole. The practical application of LBA's foot model has been accentuated through ODYSSEE's CAE real-time predictive analysis. The result of which has been successfully implemented in partnering podiatric clinics.

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Key highlights
Product: ODYSSEE CAE
Industry: Healthcare
Benefits: • ODYSSEE CAE optimises insoles for real-time clinical practice

Hexagon is a global leader in digital reality solutions, combining sensor, software and autonomous technologies. We are putting data to work to boost efficiency, productivity, quality and safety across industrial, manufacturing, infrastructure, public sector, and mobility applications.

Our technologies are shaping production and people-related ecosystems to become increasingly connected and autonomous – ensuring a scalable, sustainable future.

Hexagon's Manufacturing Intelligence division provides solutions that use data from design and engineering, production and metrology to make manufacturing smarter. For more information, visit hexagonmi.com.

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