

INTERNSHIP PROPOSAL 2026-2027

Société HUMET et Movi-Lab
Equipe de Recherche Gepetto

Title : Laboratory and Field Validation of Wearable-Based Anteroposterior Ground Reaction Force Estimation During Running, Acceleration and Deceleration

Key words : *biomechanics, experimentations, sport performance, instrumented insoles, machine learning*

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Durée du Stage : 5 à 6 depending on availability

Level : Master or Engineer

Gratification : 4,5€/h

Project description

The anteroposterior component of the ground reaction force (AP-GRF) plays a central role in human locomotion, as it reflects the mechanical interaction responsible for propulsion and braking. During sprint acceleration, the ability to orient force effectively in the horizontal direction is strongly related to performance, whereas during deceleration athletes must generate substantial braking forces to reduce forward velocity. However, direct measurement of AP-GRF generally requires force platforms or instrumented treadmills, which limits its assessment in field-based sport settings.

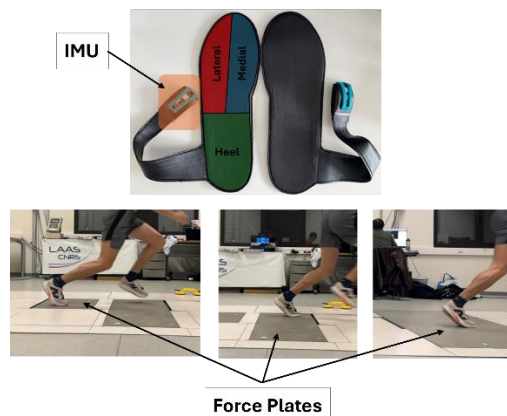


Figure 1

A wearable approach combining bilateral instrumented insoles and foot-worn inertial measurement units (IMUs) has been developed to estimate continuous AP-GRF outside

conventional force-platform laboratories (Figure 1). Initial work focused on maximal sprint acceleration and demonstrated promising participant-independent estimation performance. The next step is to determine whether this approach can be extended to **deceleration**, where the magnitude and direction of the anteroposterior force might differ substantially from those observed during acceleration.

The internship will therefore comprise two complementary experimental components.

Firstly, experiments will be conducted on an instrumented treadmill at IBHGC Paris (the student will have to go to Paris for 1 week to collect the data). Participants will perform running trials under controlled conditions, including different running speeds and controlled acceleration and deceleration tasks. The instrumented treadmill will provide the reference AP-GRF against which the wearable measurements can be compared. The primary objective will be to characterize AP-GRF during braking and to adapt and validate the existing deep-learning framework for continuous AP-GRF estimation during deceleration. Model performance will be assessed using participant-independent validation and metrics such as the coefficient of determination, RMSE and MAE.



Figure 2

Secondly, a new dataset will be collected from professional male and female rugby players in a motion-capture laboratory in Toulouse, using the same general experimental approach as in the previous sprint study. Athletes will perform maximal sprint accelerations over ground while bilateral instrumented insoles and foot-worn IMUs are recorded simultaneously with ground-embedded force plates, providing a direct laboratory reference. This second study will enable an external validation of the existing sprint-acceleration model in an expert population, and will allow the robustness of the approach to be assessed across sex and performance level.

Together, the two studies will evaluate whether wearable-based AP-GRF estimation can be extended both to a different mechanical task, deceleration, and to a new, high-level athletic population under laboratory reference conditions.

The candidate will acquire skills in experimental biomechanics, wearable sensing, ground-reaction-force analysis, multimodal signal synchronization, machine learning, sprint and deceleration mechanics, statistical model validation, data visualization and scientific programming in Python. The internship will also provide experience in translating laboratory-based biomechanical methods towards practical applications in elite sport.



The research question to answer is if a wearable system combining instrumented insoles and foot-worn IMUs can accurately estimate anteroposterior ground reaction force during acceleration and deceleration, compared with an instrumented treadmill in elite sport athletes.

Internship setup

This 5- to 6-month internship will take place at LAAS-CNRS and at HUMET and MOVI-LAB in Toulouse, with one week of data collection in Paris. The internship will be supervised by Bruno Watier and Galo Maldonado.

Required Skills

The candidate, with an engineering or master's background in mechanics, biomechanics, or related, should be able to carry out experimental work, implement numerical algorithms, and be proficient in Python programming. A good command of English (minimum B2 level) is required. Proven skills in biomechanics and machine learning, and strong interest in sport performance will be considered strong assets.

To apply

Send a motivation letter to :

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