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# Evaluating the use of IMUs to study obstacle crossing kinematics *in situ*

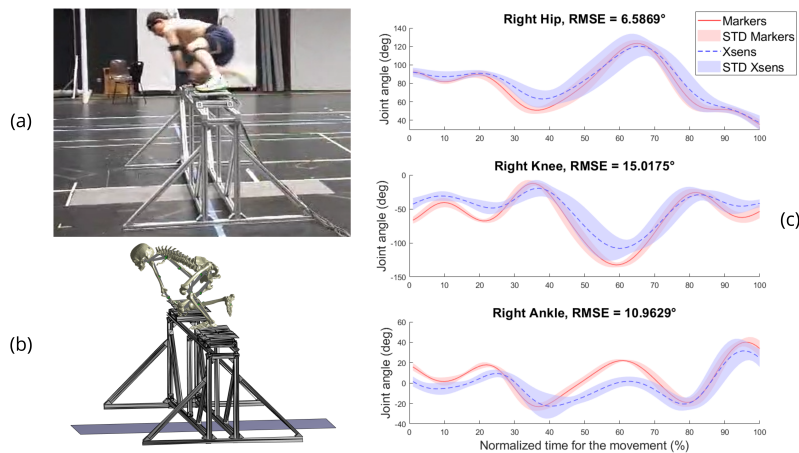
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The reference approach based on optical markers for motion capture is not suitable for outdoor activities. In this case, integrated motion capture devices such as inertial measurement units (IMUs) are used [1]. The use of IMUs data combined with biomechanical modeling has been studied previously, particularly for movements involving the lower limbs and manual handling tasks where there is little variation in body size [2]. The aim of this study is to evaluate the use of IMUs data to study the obstacle-crossing movement *In Situ* as found in obstacle races (e.g. Spartan Race®) or in disciplines such as parkour, for example.



(a) Obstacle crossing experiment ; (b) Visual representation of the biomechanical model ;  
(c) Mean +/- standard deviation of right leg flexion-extension joint angles (deg).

A single volunteer performed 10 obstacle crossings in the same way, simultaneously wearing a combination of 17 IMUs (Xsens, Movella®) and a standard set of 44 full-body optical markers, in line with ISB recommendations. A comparable virtual marker set has been generated from IMUs data using Xsens MVN 2024.2. With the CusToM toolbox [3], the geometric parameters (joint positions and orientations) of a biomechanical model containing 32 articulated segments (upper and lower limbs, thoracolumbar vertebrae) were adjusted by minimizing the squared error between experimental and model markers. Joint angles were then calculated by inverse kinematics using CusToM. Taking as a reference the segment lengths obtained from the optical marker data, we obtained a cumulative error of -1.36cm for trunk segment length, -0.81cm/-0.14cm for right/left upper limbs and -4.3cm/-4.4cm for right/left lower limbs. The highest error values were observed for tibia length (-6.4cm/-5.8cm for right/left tibia) and could be explained by uncertainties in marker placement, either experimentally or in the virtual Xsens marker set. However, the joint angles found for the lower limbs were similar with the use of the Xsens compared to the reference (c). Upper body joint angles should be investigated for further validation, with the aim of making external forces predictions based on kinematics for inverse dynamics analysis.

## References

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- [2] Mavor, M.P., Ross, G.B., Clouthier, A.L., Karakolis, T., & Graham, R.B., *Sensors*, 20(15):4280. (2020)
- [3] Muller, A, Pontonnier, C, Puchaud, P & Dumont, G, *JOSS*, 2019, 4 (33), pp.1-3.