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# Bending energy in pole vaulting using motion capture and Kirchhoff-Cosserat's rod theory

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Pole vaulting is a demanding Olympic sport requiring a combination of speed, strength and technical skills. Performance in pole vaulting strongly relies on the efficient transfer of energy throughout the vaulting phase [1]. In order to study the energy transfer within the pole, this study proposes a mechanical model of the deformable pole. Data were collected from two decathletes (1.81m, 84.1kg and 1.78m, 72,4kg). For each athlete, four successful trials were selected for analysis. 3D kinematics was collected using an optoelectronic motion capture system [2] sampled at 120 Hz. They were equipped with 38 reflective markers according to ISB recommendations [2],[3], while the pole was equipped with 21 circular markers at 20 cm intervals. The pole was modeled using a 3D Cosserat formalism using Kirchhoff's assumptions. We assumed inextensibility without internal shearing of the cross section during the jump. Under such hypotheses, we considered our pole in pure bending and we calculated time histories of the bending energy of the pole [5].

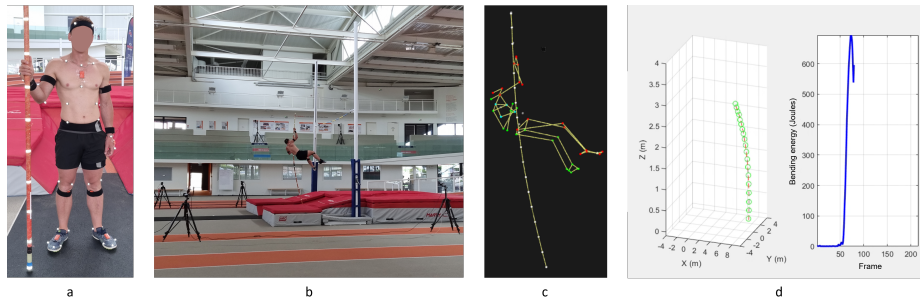


Figure 1: a) athlete and pole equipped with reflective markers b) experimental setup c) rebuilding of the pole and the vaulter d) bending energy of the pole over the time.

We applied our model to the different trials and were able to reconstruct the curvature associated with the pole bending. A mean maximum bending energy of 726J and 452J was calculated for the first and second decathlete respectively. Combining experimental data and this first mechanical model, we are able to calculate bending energy of the pole during the complete vault. It led to a new way to analyze the interactions between the pole and the pole vaulter for numbers of vaults.

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