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Overshoot intrusion forces promote robophysical bipedal walking on homogenous granular media XIAOBIN XIONG, JEFFREY AGUILAR, JENNIFER RIESER, ALLISON KIM, AARON AMES, DANIEL GOLDMAN, Georgia Inst of Tech — Bipedal walking on natural terrain such as sand and loose rubble is challenging because deformable terrains complicate foot-terrain interaction (modelled as rigid contact on hard ground). To discover how deformable ground interaction influences bipedal walking, we study constant center-of-mass height dynamic walking of a flat-footed bipedal robophysical device (40cm tall, 3 motors per leg) on homogeneous granular terrain of loosely packed poppy seeds. The planarized robot is controlled such that its zero-moment point (ZMP) stays within a stability region (termed support polygon for hard ground walking). Granular resistive force theory [Li et al, Science 2013] fails to predict this stability region despite success in predicting performance of multi-legged robots on granular media. We posit that the stability region formulation requires understanding of static reaction forces; we estimate these effects by measuring forces on a flat plate (3cmx3cm) vertically plunged (at $\approx$ 1 cm/second) into loosely packed poppy seeds with controlled pauses during the intrusion. Following a pause ($\approx$ 3 second), the force overshoots 13%-38% to that of continuous intrusion at depths from 45mm-5mm. The overshoot forces rationalize the stability regions and enable robust bipedal walking.

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