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Cilia beating patterns are not hydrodynamically optimal HANLIANG GUO, University of Southern California, JANNA NAWROTH, Harvard University, YANG DING, EVA KANSO, University of Southern California — We examine the hydrodynamic performance of two cilia beating patterns reconstructed from experimental data. In their respective natural systems, the two beating patterns correspond to: (A) pumping-specialized cilia, and (B) swimming-specialized cilia. We compare the performance of these two cilia beating patterns as a function of the metachronal coordination in the context of two model systems: the swimming of a ciliated cylinder and the fluid pumping by a ciliated carpet. Three performance measures are used for this comparison: (i) average swimming speed/pumping flow rate; (ii) maximum internal moments generated by the cilia; and (iii) swimming/pumping efficiencies. We found that, in both models, pattern (B) outperforms pattern (A) in almost all three measures, including hydrodynamic efficiency. These results challenge the notion that hydrodynamic efficiency dictates the cilia beating kinematics, and suggest that other biological functions and constraints play a role in explaining the wide variety of cilia beating patterns observed in biological systems.

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