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Intrinsic Regulators of Actomyosin Contractility Engendering Pulsatile Behaviors

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ABSTRACT

Actomyosin contractility regulates various biological processes including cell migration, muscle contraction, and tissue morphogenesis. Cell cortex underlying a membrane, which is a representative actomyosin network in eukaryote cells, exhibits dynamic contractile behaviors. Interestingly, the cell cortex shows reversible aggregation of actin and myosin called pulsatile contraction in diverse cellular phenomena, such as embryogenesis and tissue morphogenesis. While contractile behaviors have been studied in several in vitro experiments and computational studies, none of them demonstrated the pulsatile contraction of actomyosin networks observed in vivo. Here, we used an agent-based computational model based on Brownian dynamics to identify factors facilitating the pulsatile contraction of actomyosin networks. We first tested effects of several important parameters on the morphology, stress generation, and dynamic properties of actomyosin networks in order to understand how they regulate contraction of actomyosin networks. We found that the pulsatile contraction only occurs when there is a subtle balance between force generation from motors, force relaxation via actin turnover, and force sustainment via network connectivity. Our study provides critical insights into understanding the mechanisms and roles of the pulsatile contraction in cells.

KEYWORDS

Actomyosin, Pulsing, Treadmilling rate, ACP, Brownian dynamics model