# Amoeboid swimming in a microfluidic channel

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Several microorganisms, such as bacteria, algae, or spermatozoa, use flagella or cilia to swim in a fluid. There are also many other aquatic organisms and cells of the immune system, such as {\it Eutreptiella gymnastica} (euglenids), neutropils, and leukocytes, which use rather ample shape deformation, described as {\it amoeboid motion}, to propel themselves, either crawling on a substrate or swimming in the water. Many eukaryotic cells were believed to require an underlying substratum to migrate (crawl) by using ample membrane deformation (like blebbing, or generation of lamellipodia). There is now an increasing evidence that a large variety of cells (including those of the immune system) can migrate without the assistance of focal adhesion, and can perform swimming as efficiently as crawling. We combine numerical and theoretical methods to show a detailed analysis of amoeboid swimming in a microfluidic channel, by modeling the swimmer as an inextensible membrane deploying local active forces (with zero total force and torque). Complex pictures emerge: (i) The nature of the swimmer (i.e., either pusher or puller) can be switched by confinement, thus suggesting that the nature of the swimmer is not an intrinsic property. (ii) The swimming speed might increase with increasing confinement before decreasing again for stronger confinements. (iii) Depending on the strength of confinement , the swimmer can settle into a straight trajectory in the channel for the strong stresslet, or can navigate between two walls, which happens for both pusher- and puller-type swimmers for the weak stresslet, and these excursions are symmetric. (iv) The scaling of the swimmer velocity $V$ with the force amplitude $A$ is analyzed in details and this shows that at small enough $A$, $V\sim A^2/ \eta^2$ (where $\eta$ is the viscosity of the ambient fluid), whereas at large enough $A$, $V$ is independent of the force and is only fixed by the stroke frequency and the swimmer size. This finding markedly contrasts with results known for some swimming models referring to motion based on cilia and flagella where $V\sim A/ \eta$. (v) Two types of efficiencies, put forward in the literature, are analyzed and it is found that the outcomes from each definition are quite distinct. We find that one type of efficiency has an optimum at a given confinement while the other has none.