Myosin II and Movement: The effect of Myosin II Concentration on Cellular Functions

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- Title: Myosin II Adjusts Properties and Regulates Force Production Based on Motor Environment
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If you are reading this article right now, then there is a 100 percent chance that there are bio molecules in your body undergoing biochemical processes that allow for necessary bodily functions. Among these bio molecules is myosin, which is crucial for creating movement. Myosin is most known for its role in muscle contraction. Myosin binds (connects) with actin, a "protein roadway" of sorts, as part of a chemomechanical cycle (a cycle that converts chemical energy to mechanical energy) that results in muscle contraction. In Figure 1, actin is represented as the green lines. These are the "roads" for myosin. In this same figure, myosin is represented as the blue shapes. Adenosine Triphosphate, or ATP, is another biomolecule in the body that serves as an energy source in your cells. ATP binds to myosin, allowing it to move along actin (on the order of a few nm). As myosin moves along actin, tension in the system increases, which results in muscle contraction [1]. This process happens continuously in the body, and it is amazing that these small molecules are able to achieve such large scale functions!

Myosin is a very interesting molecular motor to study because of its ability to transfer chemical energy from ATP into mechanical energy (movement). One aspect of myosin's chemomechanical cycle that has been closely studied by scientists and biophysicists is the force dependence of myosin and its motility (movement). A lab at the University of Mississippi specifically studies myosin II, a motor that is heavily studied, but was found to have a gap in existing research. They found that there had been a lot of research on single molecule myosin II, but not on how myosin II motility and force production differ when these motors work together in different concentrations [2]. Myosin II is also a favorable protein to experiment with because it spends most of its time unbound from actin. You will find out why this matters later in this article! In the *in vitro* study (an *in vitro* study refers to studying a protein outside of the cell [3]) at the University of Mississippi, the researchers studied myosin motility using actin bundles (essentially multiple strings of actin) and different concentrations of myosin II motor. They used an experimental tool called an optical trap to carry out their experiments. An optical trap contains a focused laser that allows molecules to be held in place in order to measure their position [4]. They studied how applying forces in backward or forward directions affected motility and force production. The researchers also measured the amount of time that myosin remained unattached from actin during each step of the chemomechanical cycle (they referred to this as the detachment time) [2]. This is why using a myosin motor that spends most of its time unbound from actin is important. It makes detachment time data more substantial and easier to measure!

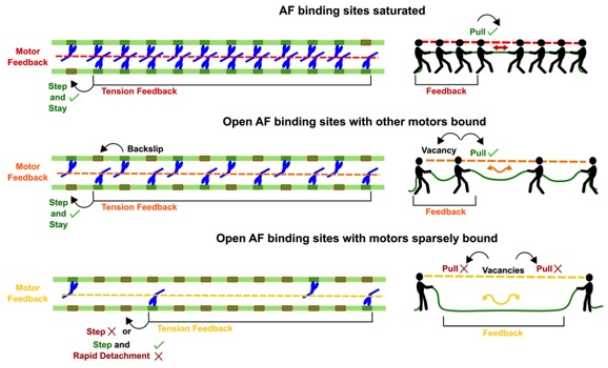

FIG. 1. A visual representation of three general myosin concentrations (saturated, half saturated, sparse). Motility and force generation increase with more saturated binding sites.[2].

The researchers made several interesting conclusions from their data. Lower myosin concentration was found to be associated with longer detachment time and a greater step size, while higher myosin concentrations were found to have shorter detachment times and smaller step sizes. However, at myosin concentrations greater than 0.1 μM, detachment time, step size, and force dependence stayed constant. This was determined to be due to the saturation of actin binding sites at high myosin concentrations. The saturated system is thought to have more efficient motor communication since the system is stiffer with more bound myosin holding everything in place. This is shown in Figure 1 as a depiction of a tug of war, where a decrease in myosin is associated with less tension and therefore a lower efficiency of the system [2]. Practically, a lower efficiency would mean that our muscles would contract slower, and we don't want that!

These exciting results tell us that myosin II motors do indeed work together in the cell in order to carry out their functions in the most efficient way. Lower force production for higher myosin concentrations justifies this, since the more efficient system is not moving around as much (which produces more force). In addition, cellular environment is an important indicator towards efficiency and force production [2]. These conclusions give us a better understanding of how myosin II likely behaves inside of our bodies, but these are also some of the first data comparing single molecule myosin data to high myosin concentration data. Future work will bring us closer to understanding even more about the actin-myosin chemomechanical cycle, and this is an exciting step forward!

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[1] G. M. Cooper, *The Cell, A Molecular Approach* (Sinauer Associates, 2000).

[2] J. E. R. J. E. D. D. N. R. Omayma Y. Al Azzam, Janie C. Watts, Myosin ii adjusts properties and regulates force production based on motor environment, BMES. **15**, 451 (2022).

[3] What is the difference between in vivo and in vitro?, `https://www.medicalnewstoday.com/articles/in-vivo-vs-in-vitro`, accessed: 2024-03-12.

[4] Optical trapping, `https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1523313/`, accessed: 2024-03-20.