STEEPLECHASE MECHANICS

Iain Hunter & James Tracy
Brigham Young University, Provo, UT

Hurdles

- Due to the positioning of the legs, it is desirable to have the high point of the center of mass of the athlete before the barrier (Horz pos of high point in Image 1).
- Most athletes need to accelerate into the barrier to reach the optimal combination of speed and economy. The faster a runner is, the less they need to adjust their speed.
- The faster a runner goes, the lower he or she needs to jump since less time is required above the barrier.

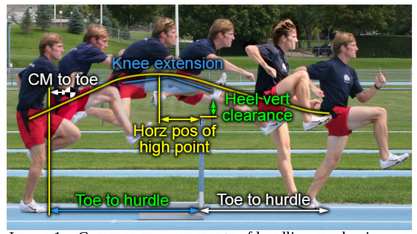


Image 1 – Common measurements of hurdling mechanics.

- During **TAKEOFF**, horizontal velocity is lost due to:
  - Large vertical forces
  - A short takeoff distance (Toe to hurdle in Image 1)
  - Large braking forces (friction from the ground)
- During **LANDING**, horizontal velocity is either gained or lost. Gains come from:
  - Landing close to the barrier (Toe to hurdle in Image 1)
  - The center of mass being horizontally close to the touchdown toe at initial impact with the ground

Men & Women

- Women lose more horizontal velocity through the water jump than men.
- Men lose more horizontal velocity through the barriers mostly due to the takeoff.

"The steeplechase is a race for animals!" – Kip Keino

Water Jump

The forces from the ground in landing from the water jump are up to two times greater than regular running (7 times body weight upon landing compared with about 3 times body weight in running).

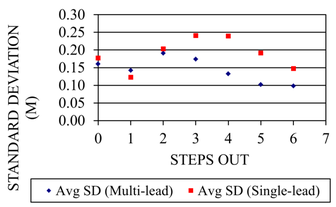
- Use a gradual progression using drills and water jumps in practice to strengthen the body to handle these forces.

The most important performance factor in a successful water jump is approach velocity.

- A high approach velocity allows for a greater landing distance and smaller loss of velocity.
- Sighting in the barrier is critical to avoid stuttering and losing velocity during the approach.
- Avoid jumping too high off the barrier. This causes losses in horizontal velocity at landing and a greater impact force.

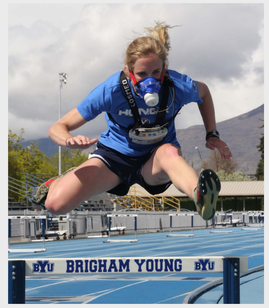
Ambidexterity

The ability to lead with either leg can make seconds of difference over the course of a race. When someone forces one lead leg for a preferred leg, extra energy is used and more horizontal velocity is lost during the takeoff.



Graph 1 – Variability of the steps approaching the barriers with forcing the same lead leg every time versus allowing either leg.

Energy Cost of Obstacles



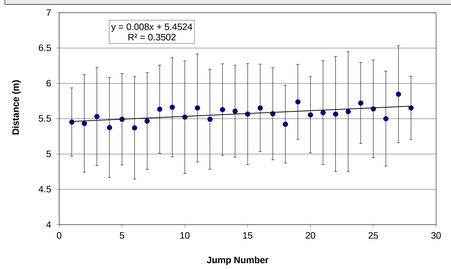
Running at race pace with the water jump and barriers costs 2.5% more energy than running without any obstacles. That explains some of why a 3000m steeplechase race is slower than an open 3000m race. However, along with the greater energy cost of the steeplechase, the energy use is not constant due to the obstacles. So, a steeplechaser needs to have the ability (naturally or through training) of adjusting effort back and forth throughout the race. They must:

- Include hurdling and water jumping during interval training near race pace.
- Avoid sudden changes in training that might lead to injury.
- Work through a gradual adaptation to stress to handle the required training.

Changes through Race

There is a gradual increase in distance through the range of steps shown in Image 3 as the race progresses (Graph 2). Most of this is due to changes in pace. However, some of this is due to mechanics changing slightly with fatigue. These runners tend to "float" over the barrier landing further from it.

Image 3 – Step definitions for hurdling



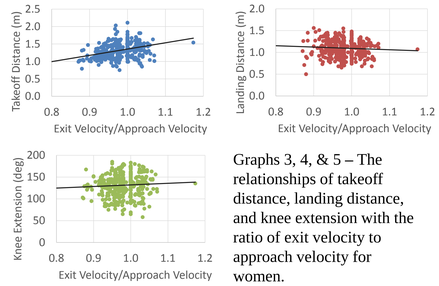
Graph 2-Distance from toe-off from penultimate step to foot contact of the step following landing versus jump number.

Trends in Hurdling

A greater exit velocity relative to approach velocity in hurdling is accomplished through:

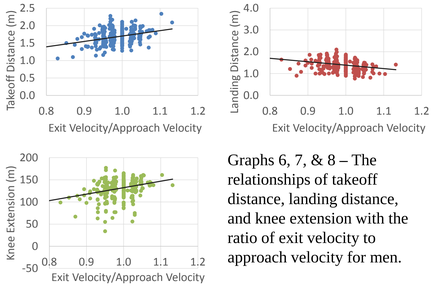
- Taking off farther back (Women - Graph 3, Men – Graph 6)
- Landing closer to the hurdle (Women – Graph 4, Men – Graph 7)
- Greater lead knee extension above the barrier (Women – Graph 5, Men – Graph 8)

WOMEN



Graphs 3, 4, & 5 – The relationships of takeoff distance, landing distance, and knee extension with the ratio of exit velocity to approach velocity for women.

MEN



Graphs 6, 7, & 8 – The relationships of takeoff distance, landing distance, and knee extension with the ratio of exit velocity to approach velocity for men.

Care should be taken in how to interpret these results since there is clearly a lot of variability around the best fitting lines. This is because 1) factors related to hurdling technique interact with other factors and 2) anatomy and flexibility varies from athlete to athlete, so different optimal positions are required.

Since men must clear a greater height, the trends become more apparent. Knee extension for women is less critical since they do not need to raise their foot as high.

Key Points / Coaching Cues

Water Jump

- A high approach velocity is critical.
- Jump forwards rather than upwards.
- Utilize a smooth steady step rhythm in the final steps.
- Use a high approach velocity to get a good landing distance rather than a large push off the barrier.
- Find an optimal crouch above the barrier for you. We all have different positions that generate the best power around our hip and knee. It is possible to be too high or too low.

Hurdling

- At 9:30 pace, women should take off around 1.65m (5' 3") from the hurdles.
- At 8:23 pace, men should take off around 1.95m (6' 3") from the hurdles.
- Minimal vertical force at takeoff is a good thing, but make sure you get enough to safely clear the barrier.
- Men and women should land as close to the barrier as reasonable.
- Knee extension should be around 150 deg (30 deg from straight) while clearing the barriers. This is less important for women.
- The slower a runners race pace is, the more they should accelerate into the barriers.
- Focus on trail leg flexibility to avoid needing a higher jump than is necessary.
- Hit your high point prior to clearing the barrier to land closer to the barrier and get horizontal velocity back.
- Land with your foot underneath you to avoid excessive braking upon landing.

References

- Earl S, Hunter I, Mack GW, Seeley M. (2015) The relationship between steeplechase hurdle economy, mechanics, and performance, Journal of Sport and Health Science, 4(4), 353-356.
- Hunter I, Lindsay BK, Andersen KR. (2008) Gender differences and biomechanics in the 3000m steeplechase water jump, Journal of Sports Science and Medicine, 7(2), 218-222.
- Hunter I & Bushnell TD. (2006). Steeplechase barriers affect women less than men, Journal of Sports Science and Medicine, 5, 318-322.
- Kipp S, Taboga P, Kram R. (2016) Ground reaction forces during steeplechase hurdling and waterjumps, Sports Biomechanics, 1-14.