

## Research article

# STEEPLECHASE BARRIERS AFFECT WOMEN LESS THAN MEN

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### ABSTRACT

Women began contesting the 3000 m steeplechase during the 1990's using barriers of different dimensions than men. Whenever a new event is introduced for women, consideration should be taken as to whether different technique or training methods should be utilized. This study investigated three aspects of hurdling technique: 1) Differences in the ratio of the landing step to the penultimate step between men and women around each non-water jump steeplechase barrier, 2) differences in step lengths between the four non-water jump barriers, and 3) changes in the step lengths around the barrier throughout the race. The step lengths around the 28 non-water jump barriers of the top seven men and women at the 2003 USA Track and Field Championships were measured using a two-dimensional analysis. A *t*-test determined any differences between men and women for the ratio of the landing to penultimate steps. A 2x4 repeated measures ANOVA tested for differences between the four non-water jump barriers. Linear regression tested for changes in step lengths throughout the race. Men exhibited a smaller ratio between the lengths of the landing to penultimate steps than women ( $0.73 \pm 0.09$  and  $0.77 \pm 0.10$  for men and women respectively,  $p = 0.002$ ). No step length differences were observed between the four barriers in the step lengths around each barrier ( $p = 0.192$  and  $p = 0.105$  for men and women respectively). Athletes gradually increased the total length of all steps around the barriers throughout the race ( $R^2 = 0.021$ ,  $p = 0.048$  and  $R^2 = 0.137$ ,  $p < 0.001$  for men and women respectively). The smaller ratio between landing to penultimate steps shows that the barriers affect women less than men. There may be a need to train men and women differently for the non-water jump barriers in the steeplechase or slightly alter racing strategy.

**KEY WORDS:** Gender, physical endurance, running, track.

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### INTRODUCTION

The steeplechase race has been contested for over 150 years. The event evolved into a track event of 3000 m where athletes hurdle 28 barriers and negotiate a barrier followed by a water pit seven times during the race. Strength, endurance, coordination, and flexibility are all important factors for a good performance in this event.

Over the years, coaches have determined many cues for men for improved performance over steeplechase barriers (Benson, 1993; Dyson, 1967; Griak, 1982; Hislop, 1985; Popov, 1983). Steeplechasers should accelerate as they approach

the barriers. A lower jump height is required when a faster approach is used since the athlete does not need to be above the barrier for as long. Men should leave the ground between 1.2 m and 1.5 m prior to the barrier depending upon their approach speed and body height. The landing should be about 1 m past the barrier (Griak, 1982; Hislop, 1985). Some of these cues may need to be adjusted for women. As the gender differences among elite steeplechasers are observed, coaches and researchers will better be able to train the unique aspects of each event.

All hurdling events in track and field use different heights between genders. While the gender gap in race times has been narrowed over the years,

no changes have been made in hurdle heights. For the steeplechase, barrier heights between genders are disproportionate in comparison with typical body heights. Women are typically 92% of men's height (Ogden, 2004). The barriers are 0.91 m for men and 0.76 m (83% of the men's height) for women, seemingly giving the women an advantage over the men. In comparison with the typical speeds between men and women in a 3000 m race, the barrier heights are proportionally greater for men than women. For example, the qualifying times for international 3000 m events are 7:54 and 9:05 for men and women respectively, leading to women running about 87% of the men's pace (IAAF, 2006). While not yet tested experimentally, steeplechase barriers may affect men more than women due to the differences between speed and barrier height. If there are differences between men and women in how much the barriers affect race pace, there may be a need to train each gender differently. This follows gender differences among sprint hurdlers where women have a longer landing step than men even though they are running at a slower speed (McDonald and Dapena, 1991).

The water-jump is considered a fatiguing obstacle. It must be negotiated seven times during the race. Among both genders, it may be of interest to know whether the water jump leads to a different approach to the barrier immediately following the water jump compared with the other barriers. As a runner approaches a barrier in a more fatigued state, they may need to find ways to modify their hurdling technique.

Throughout a race, runners become increasingly fatigued showing changes in running mechanics even when race pace remains relatively constant (Candau et al., 1998; Dutto and Smith, 2002; Place et al., 2004). As runners approach each of the 28 barriers and 7 water jumps, their form may progressively change. There may be slightly different needs in training for various barriers throughout the race.

This study investigated: 1) Differences in the ratio of the landing step to the penultimate step between men and women around each non-water jump steeplechase barrier, 2) differences in step lengths between the four non-water jump barriers, and 3) changes in the step lengths around the barrier throughout the progression of a race.

## METHODS

### *Subjects*

Fourteen men and 15 women were filmed at the 2003 USA Track and Field National Championships during the 3000m steeplechase finals. The study was approved by the university institutional review board and determined to be exempt from a need for informed consent since the video was considered public domain.

### *Instrumentation*

Four cameras were placed perpendicular to each barrier with the tripods (Manfrotto, Venice, Italy) extended to 1.68 m. The ground plane around each barrier was calibrated using rods of known length. The distances of the penultimate, flight, and landing steps were measured for the top seven men and women on all 28 jumps (Figure 1). Since some athletes were running closer to the camera than others, the projective scaling method found in Peak Motus 8 (Colorado Springs, CO) was used to determine foot positions on the ground. This allowed us to measure position accurately as long as the digitized points were at ground level. Knowing the foot positions for each step, the average speed from touchdown of the penultimate step to touchdown of the end of the landing step was calculated. The slower an athlete is around each barrier compared with their race pace, the greater effect the barrier has on their race. We calculated the ratio of speed around the barrier to race pace to indicate how the barriers affected each athlete.



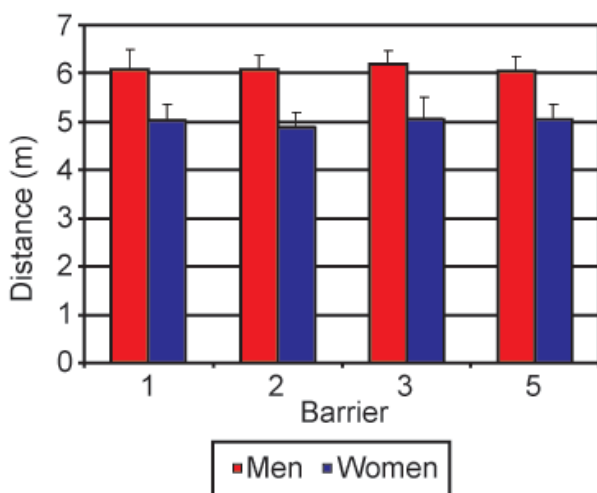
**Figure 1.** Description of the three step lengths investigated.

### Statistical analysis

To account for varying speeds throughout the race, lap splits for each runner were taken from video of the race. Three analyses were completed to answer three different questions. A *t*-test was used to determine any gender differences (independent variable) between ratios of the landing step to the penultimate step around each barrier (dependent variable). A 2x4 ANOVA with repeated measures on barrier, due to the seven times laps of the race, was used to detect differences in distances around each barrier among men and women. The independent variable was barrier with the four levels being barrier number. The barriers are numbered one through five with barrier four being the water jump (which was not analyzed in this study). Linear regression was used to determine how each step length (dependent variables) changed with barrier number (dependent variable). All analyses were completed using an alpha-level of 0.05 using SAS 9.1 for Windows (SAS Institute Inc., Cary, NC).

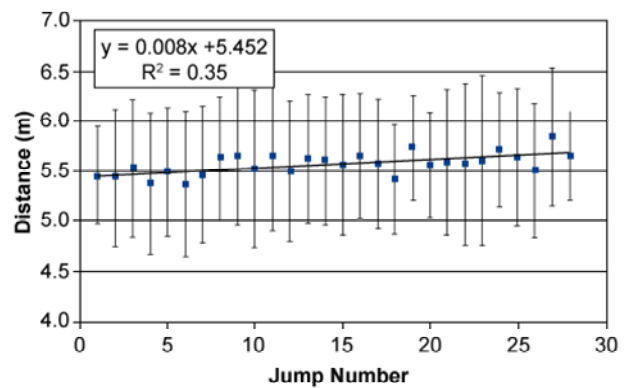
## RESULTS

After accounting for differences in running speed, men have a smaller ratio of the landing to penultimate steps than women ( $0.73 \pm 0.09$  and  $0.77 \pm 0.10$  for men and women respectively,  $p = 0.002$ ). No step length differences were observed between the four barriers in the steps around each barrier (Figure 2,  $p = 0.192$  and  $p = 0.105$  for men and women respectively).



**Figure 2.** Average length from the beginning of the penultimate step to the end of the landing step for each of the four non-water jumps found in each lap for men and women. No differences were found between barriers for men or women ( $p = 0.192$  and  $0.105$  respectively).

A consistent, yet subtle, trend was observed throughout the race. Multiple linear regression showed athletes gradually increased the total length of all steps around the barriers (Distance =  $0.008 \times \text{Jump Number} + 5.452$ ,  $R^2 = 0.356$ ,  $p = 0.020$ , Figure 3). Individual *p*-values for each beta from the regression analysis showed that for men, the penultimate accounted for the overall increase ( $p = 0.001$ ). No significant difference was found for the flight or the landing steps ( $p = 0.695$ ). For women, the penultimate and flight accounted for the overall increase ( $p = 0.029$  and  $p = 0.005$  respectively). No significant difference was found for the landing step ( $p = 0.361$ ). Although some step lengths were increasing throughout the race, lap pace remained unchanged from start to finish ( $p = 0.380$ ). The increase was  $0.006$  m for each barrier for men and  $0.016$  m for women.



**Figure 3.** The gradual increase in the distance from the beginning of the penultimate step to the end of the landing step for all non-water jumps throughout the race (men and women combined,  $R^2 = 0.35$ ,  $p = 0.020$ ).

## DISCUSSION

### Gender Differences

The results of the ratio of landing to penultimate step lengths were smaller for men. A possible cause may be the barriers altered the stride of men more than women due to the women's barriers being only  $0.76$  m high while the men's are  $0.91$  m. The lower barrier height for women should help them not lose speed through the obstacle, but their lower race pace requires a higher jump since runners would need to be above the barrier for a longer time (McDonald and Dapena, 1991). The technique used by women in clearing the barriers seems to have a smaller effect on their running stride than men since the ratio of landing to penultimate steps is smaller for women. Since 1999, the women's world record has

dropped 47 s and been broken 9 times. The men's record has only dropped 2 s and been broken two times (World Record Progressions, 2006). With best times improving more rapidly for women than men in the steeplechase, the difference in the ratio between men and women may favor women even more in the future.

### ***Step lengths between barriers***

While it has never been measured, the water jump likely requires more energy than other barriers since they are jumping higher and further. Even with the expected increased effort at the water-jump, the lengths of steps in the barriers prior to or following the water were similar. Therefore, there is no need to train differently for any of the non-water jump barriers.

### ***Changes throughout the race***

Men and women both completed the barriers with greater step lengths and speeds as the race progressed. While the flight remained unchanged, the penultimate step and, for women, the landing step gradually increased. It may be thought of as unusual that lap pace remained unchanged while the speed around the barriers increased. Since speed was increasing around the barriers, but average lap speed was unchanged, the athletes must be running slower in between barriers as the race progressed. Typically, in distance running, a relatively steady pace results in faster overall speeds (Billat et al., 2001). The increasing differences in speed around the barriers and race pace may need to be considered in overall race strategy. One should also consider that while jump number was a significant predictor of the steps around each barrier for men and women, the variance explained was very small. Thus, there are more detriments of step length.

## **CONCLUSION**

Men and women were affected by steeplechase barriers differently. The non-water jump barriers did not disrupt the stride of women as much as men, thus more attention to hurdling technique should be given to men than women in training for the steeplechase event. There was no difference in how athletes completed one barrier compared with another, so there is not a need to train differently for any given barrier. Since stride lengths increased throughout the race, while race pace was maintained, coaches and athletes should realize that among the best steeplechasers in the US, hurdling technique gradually changes as the race progresses.

With these ideas in mind, coaches and athletes will be able to train more appropriately as they

attempt to attain the technique level of elite US steeplechasers.

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**KEY POINTS**

- Non-water jump barriers disrupt the stride of men more than women.
- There is no difference between any of the four non-water jump barriers in the step lengths used around each barrier.
- Stride length gradually increases throughout a 3000m steeplechase race even if race pace is maintain.

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