CUTTING SEX-PERFORMANCE DIFFERENCES DOWN TO SIZE:

ARE FEMALES CLOSER TO MALES IN SHORTER SPRINT RACES?

Emily L. McClelland and Peter G. Weyand

Locomotor Performance Laboratory, Southern Methodist University, Dallas, Texas, Unites States

The body size and composition differences between men and women are set by genetic factors with relatively constant offsets, particularly in homogeneous athletic populations. However, performance differences between the sexes appear to be more variable, potentially due to the mechanical demands of different events. Here, we set out to analyse the sex performance differences across sprint running events that differ in mechanical demands due to race length. Based on the scaling of tissue areas in relation to body mass, shorter, smaller athletes should be more forceful per kg body mass than larger ones. Greater force per kg body mass capabilities should be most advantageous during the acceleration portion of any race. Therefore, we hypothesized that the shorter sex, would fare relatively better in shorter vs longer races. We tested this by gathering performance, height and mass data from open sources on the top 40 performers in the 60, 100, 200 and 400 meter races over a 15 year period. As hypothesized, the shorter the sprint race, the smaller the male-female performance difference. These differences ranged from 8.6% at 60 m to 10.9% at 400 m. We conclude that male-female performance differences appear to be smaller for accelerated vs. steady-speed running.

KEYWORDS: sprint running, scaling, biomechanics, locomotion.

INTRODUCTION: Basic differences in athletic performance between men and women have attracted interest since formal participation of women began many decades ago. Running performance differences have received the most attention, particularly in the early decades of participation from the 1950s to the 1980s when female performances improved rapidly. Early trends led to speculative analyses suggesting that female running performance might match or possibly surpass that of males at some point (Whipp & Ward, 1992). However, in subsequent decades (or since the 1980s), male-female performance differences have been stable (Cheuvront et al, 2005, Seiler et al, 2007). On average, regardless of event distances from 100 meter to the marathon, men run just over 11% faster than women with little variability across different events.

The biological differences between the sexes in aerobic power successfully explain the performance gap for endurance races (Sparling & Cureton, 1980). The greater sex-specific fat and slightly lower haemoglobin levels in females result in less aerobic power to fuel endurance races. However, sprint races are limited by mechanical factors (Weyand et al, 2000) that could introduce variability in the sex performance gaps present across different sprint events.

Though differences between males and females in human biology are well established, the influence of size, and potential performance advantages of being smaller have received little attention. We recognized that differing mechanical demands of short vs. long sprints could conceivably interact with body size to result in smaller sex performance differences in shorter sprint running events. Here, we addressed the question; does the sex difference in sprint performance, race speed, vary with event distance?

Sprinting includes a distinct acceleration phase at the beginning of each race and a constant speed phase for the remainder. The shorter the sprint, the greater the proportion of the total event that is comprised of acceleration. Sprint accelerations conform to Newton's 2nd law in being determined by the magnitude of the ground force applied relative to body mass (a=F/m). Work by Ford and colleagues (2000) nicely demonstrated the greater mass-specific strength of smaller individuals in weight-lifting competition. Their results support the view that smaller athletes may be capable of applying greater ground forces in relation to body mass to accelerate more rapidly. Therefore, we hypothesized that because females are the smaller sex their performances would be relatively closer to males, for shorter racing distances. On this basis, we predicted that sex-performance differences would be smaller in shorter vs. longer sprint races.

METHODS: In order to analyse the sex performance differences across event distance we gathered race times from the World Athletics' Top list of the top 40 performances for the 60, 100, 200 and 400 meter races (N=160 men, N=160 women), from the years 2003 to 2018. The range of times for each sex in each event was narrow. [60 meter: males = 6.34 - 6.51s females = 6.97- 7.11 s; 100 meter: males= 9.58 - 9.92, females = 10.64 – 10.96 s; 200 meter: males = 19.19 – 19.97, females = 21.63 – 22.27 s; 400: males = 44.03 – 44.48, females = 48.7 – 50.08 s] We then analysed the sex difference in average race speed using equation 1. The varying height and mass for the specific athletes in the sample was also gathered from public sources.

$$\left(\frac{\text{male performance} - \text{female performance}}{\text{male performance}}\right) *100 \qquad \text{(Equation 1)}$$

Independent sample t-tests were performed for race velocities in each event to analyse performance differences between the sexes. Simple linear regression was performed to determine the relationship between the sex performance difference and event distance. Separate simple linear regressions were also performed for each sex to determine the relationship between athlete height and event distance. All statistics were completed using IBM SPSS Statistics (Version 25) predictive analytics software, a priori alpha level was set at 0.05.

RESULTS: The average heights, and masses for all performers in each event appear in Table 1. The race speeds of males and females at each of the sprint distances are illustrated in Figure 1A. The percent differences in race speed were small, but statistically significant [60: 8.6%, t(78) = 66.375, p<.001; 100: 9.2%, t(78) = 55.312, P<.001; 200: 10.4%, t(78) = 56.814, p<.001; 400: 10.9%, t(78) = 71.761, p<.001]. The difference in performance between males and females increased in relation to event distance from 60 to 400 meters as illustrated in Figure 1B.

Within each sex, there was a significant positive relationship between athlete height and race distance. The trend showed athletes specializing in shorter distances to be shorter in stature for both males, y=.0001x+1.79, (F(1,158)=10.805, p =.001, R^2 =.253), and females, y=.0002x + 1.65, (F(1,158)= 36.415, p<.001, R^2 =.433). Men were on average 7.1% taller than females in the same event.

Table 1: Mean (SD) performance, height, & mass for each event.

	Height (m)		Mass (kg)	
Event	men	Women	men	women
60 meter	1.79 (0.06)	1.66 (0.07)	77.82 (7.35)	59.15 (5.23)
100 meter	1.81 (0.08)	1.67 (0.06)	78.10 (7.86)	58.53 (4.32)
200 meter	1.84 (0.06)	1.69 (0.07)	77.53 (6.12)	59.05 (4.71)
400 meter	1.84 (0.07)	1.74 (0.05)	75.75 (6.99)	61.1 (5.10)

N=40 males & N=40 females per event.

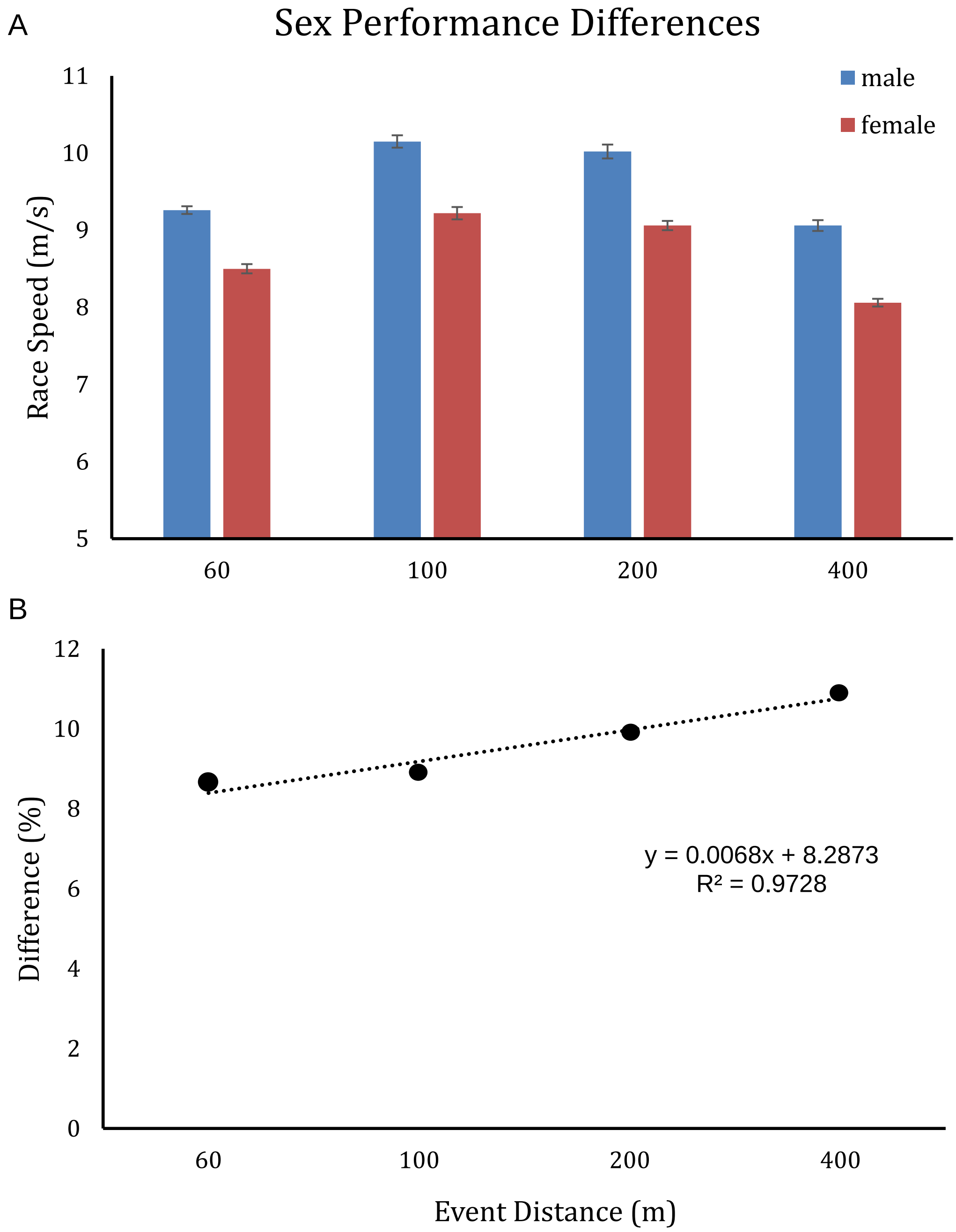

Figure 1: A) Male and female mean race speeds for the 60, 100, 200, & 400 meter races. B) Percent difference between males and females as calculated using equation 1 for the same events. (Note: the X-axis above is not continuous for illustrative purposes only. The slope of the best fit equation is % difference per meter)

DISCUSSION: As hypothesized, male-female differences were smaller for shorter vs. longer sprinting events, whereas, the sex differences are relatively constant across distances in the endurance races. Our results indicate that the magnitude of the sex-based performance difference varies with event specific mechanical requirements.

The range of the sex performance differences quantified was narrow (8.6-10.9%), but the relationship to event distance was consistent (R^2=0.97). In particular, the expectation that the greater percentage of the race devoted to accelerating, the smaller the sex performance difference is well supported.

The relationship between smaller body size and specialization for sprint races with greater percentage of the race devoted to acceleration was supported by the trends observed in average height of the top performers in relation to event distance. Within each sex, there was a positive relationship between athlete height and race distance. Athletes of the shortest stature specialized in the shortest event distances. Although our findings have been established using open source data, that has limitations, the large sample size for both sexes in all four sprint running events (N=40) provide for robust relationships.

CONCLUSION: Although intrinsic biological differences between elite male and female athletes are relatively constant due to genetic factors, performance differences between the sexes in sprint events vary in accordance with event-specific mechanical demands. These findings appear likely to generalize beyond sprint events to other performances determined by differing mechanical factors such as specific types of jumping, for which sex performance differences are greater (Castagna & Castellini, 2013, Laffaye et al, 2014). Finally, our results raise the question of whether females might perform relatively closer to males in events and activities that require running shorter distances.

REFERENCES

Castagna, C., & Castellini, E. (2013). Vertical jump performance in Italian male and female national team soccer players. *The Journal of Strength & Conditioning Research*, *27*(4), 1156-1161.

Cheuvront, S. N., Carter, R., DeRuisseau, K. C., & Moffatt, R. J. (2005). Running performance differences between men and women. *Sports Medicine*, *35*(12), 1017-1024.

Cureton, K. J., & Sparling, P. B. (1980). Distance running performance and metabolic responses to running in men and women with excess weight experimentally equated. *Medicine and science in sports and exercise*, *12*(4), 288-294.

Ford, L. E., Detterline, A. J., Ho, K. K., & Cao, W. (2000). Gender-and height-related limits of muscle strength in world weightlifting champions. *Journal of Applied Physiology*, *89*(3), 1061-1064.

Laffaye, G., Wagner, P. P., & Tombleson, T. I. (2014). Countermovement jump height: Gender and sport-specific differences in the force-time variables. *The Journal of Strength & Conditioning Research*, *28*(4), 1096-1105.

Seiler, S., De Koning, J. J., & Foster, C. (2007). The fall and rise of the gender difference in elite anaerobic performance 1952-2006. *Medicine & Science in Sports & Exercise*, *39*(3), 534-540.

Stat zone all time toplist. https://www.worldathletics.org/records/all-time-toplists.

Weyand, P. G., Sternlight, D. B., Bellizzi, M. J., & Wright, S. (2000). Faster top running speeds are achieved with greater ground forces not more rapid leg movements. *Journal of applied physiology*, *89*(5), 1991-1999.

Whipp, B. J., & Ward, S. (1992). Will women soon outrun men?. *Nature*, *355*(6355), 25.

ACKNOWLEDGEMENTS: The authors would like to thank World Athletics for their impeccable record keeping of all track and field events worldwide.