

More males run fast A stable sex difference in competitiveness in U.S. distance runners

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Abstract

Sex differences in competitiveness are well established, but it is unknown if they originate from sociocultural conditions or evolved predispositions. Testing these hypotheses requires a quantifiable sex difference in competitiveness and the application of a powerful sociocultural manipulation to eliminate it. Study 1 reviews previous work showing that more male distance runners are motivated by competition and maintain large training volumes, suggesting that more males should run fast relative to sex-specific world-class standards. I then use two independent statistical approaches to demonstrate that, in matched populations of male and female U.S. runners, two to four times as many males as females ran relatively fast in 2003. Study 2 investigates whether the growth in opportunities and incentives for female athletes in the past 30 years is eliminating this sex difference. I first show that there was a marked increase in the number of fast female runners in the 1970s and early 1980s, a period during which female participation increased dramatically. However, I found no indication of an absolute or relative increase in the number of fast female distance runners since the mid-1980s. These findings therefore support the hypothesis that sex differences in competitiveness partly reflect evolved predispositions.

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1. Introduction

Humans show sex differences in competitiveness. Males tend to compete using direct means, such as aggression or physical displays, while females more often compete using indirect means, such as ostracizing or stigmatizing (Bjorkqvist, 1994; Buss, 2004; Campbell, 2002; Maccoby, 1998). In addition, the object of competition generally differs, as males typically compete for status, while females more frequently compete for attributions of attractiveness or sexual exclusiveness (Buss, 2004; Campbell, 2002).

The origin of these differences is debated. On one hand, the standard social science model (*sensu* Tooby & Cosmides, 1992) claims that sex differences in competitiveness and related social psychological attributes, such as dominance, independence, and egocentrism, can be ultimately traced to sociocultural conditions. These conditions differentially socialize males and females and/or direct them into sex-differentiated roles. Thus, according to the *sociocultural conditions hypothesis*, sex differences in competitiveness could be eliminated if society were altered appropriately (Cross & Madson, 1997; Eagly, 1987; Eagly & Wood, 1999; West & Zimmerman, 1987).

Evolutionary psychology, on the other hand, holds that sex differences in competitiveness and related attributes partly reflect predispositions that evolved because they were associated with enhanced fitness in the past. At the mechanistic level, these evolved predispositions are primarily due to sex-differentiated hormonal environments, especially the prenatal environment. Therefore, the *evolved predispositions hypothesis* holds that, although sociocultural conditions modulate the expression of sex-differentiated behavior, sex differences in competitiveness would occur even if society were egalitarian (Archer & Lloyd, 2002; Buss, 2004; Campbell, 2002; Daly & Wilson, 1988; Geary, 1998).

1.1. Testing the hypotheses

Beginning in the early 1960s, dramatic changes in the roles and opportunities available to girls and women have occurred in many Western societies, including the United States. Changes include increased participation and acceptance in the labor force, higher education, political office holding, and organized athletics (Browne, 2002; Shulman & Bowen, 2001; Twenge, 2001). These changes offer an opportunity to test the explanatory power of the sociocultural conditions hypothesis and the evolved predispositions hypothesis. The former predicts convergence in social psychological attributes, while the latter predicts that sex differences will remain stable.

Determining whether there has been convergence in social psychological attributes has proven difficult, however. Meta-analyses of gender stereotypes, sex typing, and personality have produced evidence of convergence (Twenge, 1997, 2001; cf. Diekmann & Eagly, 2000) but have also indicated stability or even increased differentiation (Feingold, 1994; Lueptow, Garovitch-Szabo, & Lueptow, 2001). Furthermore, the characterization of psychological attributes in these meta-analyses has relied almost exclusively on written assessments rather than behavior under real-world conditions. Thus, it is unclear whether these kinds of studies could, in principle, provide strong evidence of changes in social

psychological attributes, as opposed to changes in self-presentation (Johnson, 1981; Twenge, 1997).

Here I investigate male and female performances in distance running, an activity in which competitiveness can be assessed at the population level and that permits straightforward historical comparisons. In Study 1, I argue that the occurrence of relatively fast distance runners in matched populations should estimate a sex difference in competitiveness. I then demonstrate that in matched populations of U.S. runners, there are presently many more relatively fast males. In Study 2, I investigate whether this sex difference in the occurrence of relatively fast runners is in the process of diminishing due to the growth in opportunities and incentives for female athletes. I show that the number of fast female runners is not increasing, either absolutely or relative to males, implying that the sex difference in competitiveness is not diminishing.

2. Study 1

Studies assessing the motivational and personality profiles of distance runners with self-report questionnaires have found that individuals run for a variety of reasons, including health, affiliation, self-reflection, goal achievement, competition, and recognition. Although males and females extensively overlap in their endorsement of motives, a consistent finding is that males more often report that they run to seek competition and recognition (Callen, 1983; Johnsgard, 1985; Leedy, 2000; Ogles & Masters, 2003; Walter, Hart, McIntosh, & Sutton, 1989). This motivational profile is generally accompanied by more rigorous training habits, including larger training volumes (Ogles & Masters, 2003; Ogles, Masters, & Richardson, 1995).¹ Thus, the sex difference in competitive motivation is probably the reason that studies consistently find that males report larger training volumes (Callen, 1983; Johnsgard, 1985; Leedy, 2000; Ogles et al., 1995; Walter et al., 1989). Larger training volumes are, in turn, associated with faster performances (Marti, 1988; Ogles & Masters, 2003; Williams, 1998). These findings collectively indicate that the differential occurrence of fast runners in large populations could be used to estimate a sex difference in motivation to compete and maintain large training volumes.

Comparisons of male and female performances are complicated by the fact that, for any given level of training, males are expected to run appreciably faster than females due to hormonally regulated differences in aerobic capacity and body fat deposition (Shephard, 2000; Sparling & Cureton, 1983; Wilmore & Costill, 2004). However, because sex differences in world-class performance have stabilized at roughly 10–12% across all distances (Noakes, 2001; Seiler & Sailer, 1997; Sparling, O'Donnell, & Snow, 1998), sex-specific world records and similar standards should provide reasonable baselines for comparing performances across

¹ Numerous training approaches are recommended for achieving fast distance-running performances (e.g., Glover & Glover, 1999; Noakes, 2001). Despite the diversity of approaches, there is consensus that distance runners cannot approach their potential unless they consistently maintain moderate to large training volumes, for example, 100–200 km/week. These volumes substantially exceed those of most runners whose primary goal is finishing races, rather than achieving their fastest performance.

sexes.² In addition, population characteristics, specifically the variance among the fastest performances, can provide an independent approach for assessing the relative proportion of highly competitive runners in a population. Therefore, if there is a higher proportion of relatively fast male performers, then within a sample of top performances in corresponding male and female populations, the following predictions should hold: (1) the male performances should be closer to a relevant sex-specific world-class standard; and (2) the variance among performances should be less among males than among females.

To test these predictions, I investigated the 2003 performances of national-class high school, NCAA Division 1 collegiate, and Open (i.e., mainly professional) U.S. runners. Although a sex difference in training has been primarily documented in distance runners, sex differences in competitiveness have been reported in other athletic contexts (e.g., Gill, 1999). Thus, I tested for a sex difference across a range of race distances. Because some runners compete in several events (e.g., 100 and 200m), these tests are not fully independent. Another dependency exists because the best high school and collegiate performances can be included in the Open performance lists.

I also tested these predictions using performances from 2003 state high school cross-country championship races. Although cross-country courses are designed to be more challenging and “slower” than tracks, world-class track performances should still provide unbiased standards for comparing males and females. Examining performances across states permits multiple, fully independent tests. In addition, these analyses should reveal whether a sex difference is detectable only among elite runners or occurs more generally. A third advantage of testing state populations is that they allow rigorous consideration of the relationship between the number of participants and performance characteristics. This is important because a sex difference in the occurrence of relatively fast runners could be due to differences in participation.

2.1. *Methods*

Open data were taken from [Track & Field News \(2004\)](#); D1 collegiate data were taken from an unpublished national championships qualifiers list; national-class high school data were taken from [Shephard \(2003\)](#). High school cross-country data were gathered from state athletic association internet sites, most of which were linked from a single source ([Dyestat, 2004](#)). In most states, races were run in separate divisions (e.g., AA, AAA); times were pooled across all divisions, and the fastest 40 performances were used for analysis. The number of cross-country participants for each state was taken from the [National Federation of State High School Associations \(2004\)](#). To investigate the confound of race duration (see below), data from state championship high school outdoor track meets were taken from state athletic association internet sites ([Dyestat, 2004](#)). Comprehensive data sets for both studies are available upon request.

² The sex differences shown in this study would be greater if females' world-class standards are, in fact, still improving relative to males', as a few studies claim ([Tatem, Guerra, Atkinson, & Hay, 2004](#); [Whipp & Ward, 1992](#); but see [Holden, 2004](#); [Reinboud, 2004](#)).

World records were taken from IAAF (n.d.). The 10 fastest world performers of 2003 were taken from *Track & Field News* (2004). High school distance races are 1600 and 3200m, but these are not contested at the Open level; world records and 10-Fastest standards for these distances were estimated from world-class performances at 1500 and 3000m, following conversion guidelines from *Track & Field News* (2000).

To control for the effects of race duration on relative speed (see Section 2.2), least squares linear regression was first used to assess the relation between (log-transformed) seconds and speed relative to sex-specific world records or 10-Fastest standards. Regressions were calculated for each sex at each of the three competitive levels (national-class high school, Division 1 collegiate, and Open), using, for each point, the mean race duration and relative speed of the first 40 males and females represented in each event performance list. Regressions were similarly calculated for the 11 states that conduct “all-state” outdoor high school championship track meets; each point represented the mean race duration and relative speed of the first five finishers in each event in 2003. Although intercepts correlated with competitive levels ([competitive levels were defined as Open, D1 collegiate, national-class high school, and states, in descending order of number of participants] males: $n=14$, $r_s=.82$, $p<.001$; females: $n=14$, $r_s=.78$, $p<.001$), regression coefficients did not (males: $n=14$, $r_s=.40$, $p=.15$; females: $n=14$, $r_s=.09$, $p=.92$). The uniform decrease in ratio proximity to world-class standards as races lengthen indicates that a constant can be used to establish duration-corrected male performances at all distances and competitive levels. The constant used here was 0.043, which is the upper 95% confidence limit of the regression coefficient across all competitive levels; calculations of this constant using world records and 10-Fastest standards were identical to three decimal places. Therefore, to produce a duration-corrected male performance measure, one multiplies the individual male time by the ratio of mean female to mean male duration for that event and context (e.g., typically 1.10–1.17), log-transforms this value, and then multiplies it by the constant of 0.043. The individual’s original time is also log-transformed and multiplied by the constant; then, the latter number is then subtracted from the former. This remainder is then added to the originally computed relative performance measure (e.g., 10-Fastest ratio), and the duration-corrected relative speed measure is obtained.

Prior to calculating the variance for a sample of performances, durations were normalized by first calculating the mean duration of the 40 performances in that particular event list or race, dividing each performance by this mean and then multiplying by 100. Durations were normalized because, all else being equal, larger numbers produce larger variances. Normalized variance was computed for performances ranked 6th–40th because preliminary analyses indicated that the fastest five performances were disproportionately influential. However, the general result of male samples tending to be less variable was obtained no matter which performances were included.

Comparisons of male and female relative speed measures among the 40 performances in each event list or race were made using *t* tests with separate variance estimates. To test for sex differences in normalized variance, I calculated the ratio of male to female normalized variance (Sokal & Rolf, 1995, p. 189). All statistical modeling in both studies was conducted with Statistica 6.0 (Statsoft, Tulsa, OK). All statistical tests were two tailed and α was set at .05.

2.2. Results

2.2.1. National class runners

For each event commonly contested by national-class high school, D1 collegiate, and Open runners, I calculated the best performance of the 40 fastest males and females as a ratio of the relevant sex-specific world record (current January 1, 2004). In 20 of 21 cases, the performance of the 40 fastest males was significantly closer to the sex-specific world record than was the performance of the 40 fastest females. However, in 17 of 21 cases, the performance of the first ranked male competitor was closer to the world record than was the performance of first ranked female competitor (binomial probability $<.01$), and, in a paired t test, the first ranked males were significantly closer to world records overall [$t(20)=3.70$, $p<.01$]. These findings are consistent with the suggestion that some female world records could be anomalously fast (Seiler & Sailer, 1997).

Because world records could provide a biased standard for comparison, I repeated calculations of relative speed using an alternative world-class standard, the mean best time of the 10 fastest performers in the world in 2003 (hereafter “10-Fastest”). In 20 of 21 cases, the performances of the 40 fastest males were significantly closer to the 10-Fastest standard than were the times of the 40 fastest females (Fig. 1; Table 1). Despite this consistent sex difference across the fastest 40 competitors, there was no sex difference in the proximity of the first competitor’s performance to the 10-Fastest standard [11 events females closer; paired t test, $t(20)=0.41$, $p=.68$]. More crucially, in seven of the eight Open events, the first ranked female was closer to this standard. Thus, the 10-Fastest standard is not biased against females, and I therefore report results based on it for the rest of this study. Nevertheless, all analyses in Study 1 were also conducted with world records. Results were highly similar, except that the sex difference was generally far larger with world records.

Races that are longer in distance and duration are associated with relatively slower performances, suggesting that these results might reflect that, for any given distance, female races are longer in duration. However, even after male running performances were duration corrected, they were significantly closer to the 10-Fastest standard in 18 of 21 cases (Table 1).

The prediction of less variance among top male performances was also supported. Specifically, the ratio of female to male normalized variance was greater than 1 in 18 of 21 cases, and in all 14 cases where the variance ratio reached significance, males were less variable (Fig. 1; Table 1). Thus, not only are the performances of elite males closer to world-class standards than are the performances of corresponding females, but these males generally contend with more competitors of similar ability.

A straightforward explanation for these findings is that more males participate in competitive running. In fact, there were 9% more female teams and 2% more female participants in D1 collegiate track and field in 2003 (NCAA Research, 2004). In high school, there were 1% more male teams and 21% more male participants (National Federation of State High School Associations, 2004). This male bias in high school participation is longstanding (National Federation of State High School Associations, 1980) and might be argued to ultimately produce small but consistent sex differences at all levels.

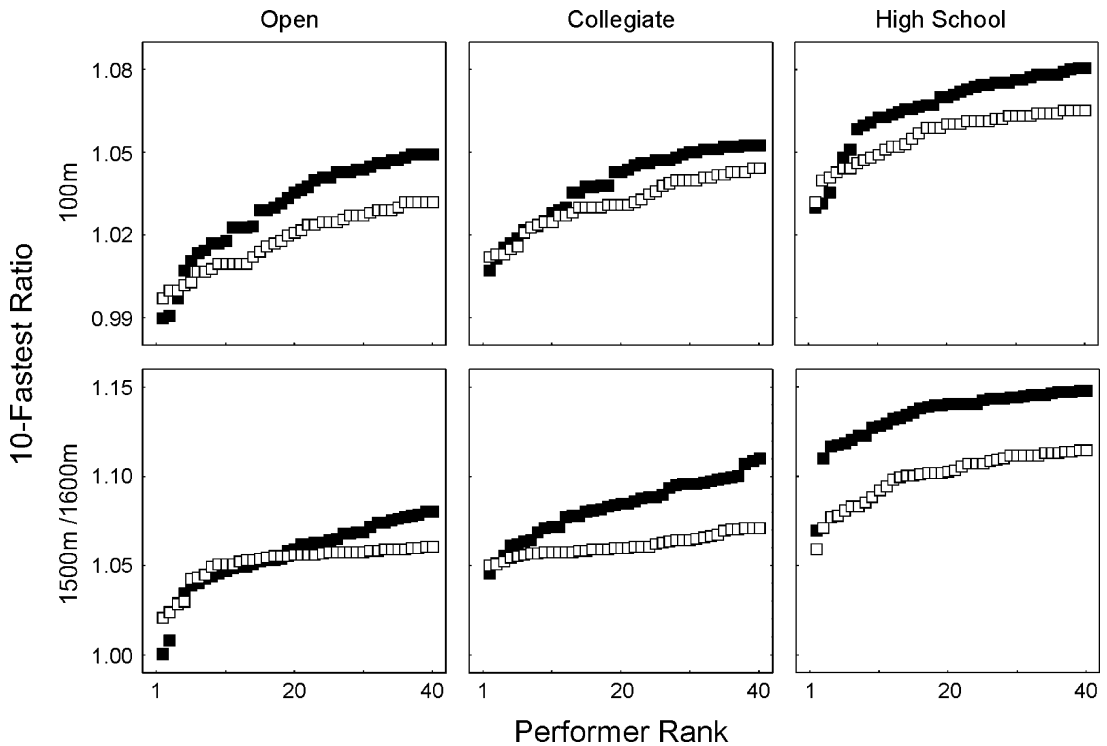


Fig. 1. Plots of performance rank and relative speed for a representative sprint and distance event, for three competitive levels. Open and collegiate runners commonly contest 1500m races, whereas high school runners generally contest 1600m races. Females are represented by filled boxes (■) and males by unfilled boxes (□). Relative speed is defined as the ratio of the performance to the event-specific, sex-specific 10-Fastest standard (see text).

One method of estimating the magnitude of the sex difference is to tabulate how many females meet or beat the relative performance of the 40th ranked male and to then calculate a bias ratio, the ratio of 40 over the number of females meeting this performance. For instance, in the Open 100m, 19 females met or exceeded the duration-corrected 10-Fastest ratio of the 40th ranked male (Fig. 1, upper left panel), resulting in a bias ratio of 2.1; this means that twice as many males as females ran relatively fast in this event. For the 21 events detailed in Table 1, the mean bias ratio was 3.5 (median=2.7). These bias ratios are far too large to be explained by slight differences in high school participation.

2.2.2. State championship cross-country runners

In the 26 states where males and females competed on the same 5000m course on the same day, the duration-corrected time of the fastest 40 male finishers was significantly closer to the 10-Fastest standard in every case. The ratio of female to male normalized variance was greater than 1 in 21 of 26 cases, and in all nine instances where normalized variance differed significantly, males were less variable. The mean bias ratio across the 26 states was 5.1 (median=3.6). Although more males than females participated in cross-country in these

Table 1

Comparison of the top 40 male and female high school, collegiate, and Open runners for commonly contested distances

Context	Distance (m)	Mean male 10-Fastest ratio	Mean female 10-Fastest ratio	p^a	Mean male duration corrected 10-Fastest ratio	p^b	Variance ratio ^c	p^d	Duration-corrected bias ratio
Open	100	1.02	1.03	<.001	1.02	<.01	1.78	<.05	2.1
Open	200	1.02	1.03	<.01	1.02	<.05	1.81	<.05	1.8
Open	400	1.02	1.04	<.001	1.02	<.001	0.95	NS	3.1
Open	800	1.04	1.05	<.001	1.04	<.01	3.89	<.001	2.7
Open	1500	1.05	1.06	NS	1.05	NS	8.32	<.001	1.7
Open	5000	1.06	1.07	<.05	1.07	NS	4.74	<.001	1.7
Open	10000	1.06	1.09	<.001	1.07	<.001	1.71	NS	2.0
Open	42195	1.09	1.13	<.001	1.10	<.001	3.59	<.001	3.6
Collegiate	100	1.03	1.04	<.01	1.03	NS	1.96	<.05	1.8
Collegiate	200	1.03	1.04	<.001	1.04	<.05	2.43	<.05	1.7
Collegiate	400	1.03	1.05	<.001	1.03	<.001	1.74	NS	2.9
Collegiate	800	1.05	1.07	<.001	1.05	<.001	3.38	<.001	2.7
Collegiate	1500	1.06	1.08	<.001	1.06	<.001	6.02	<.001	3.6
Collegiate	5000	1.08	1.11	<.001	1.09	<.001	6.87	<.001	3.6
Collegiate	10000	1.08	1.13	<.001	1.08	<.001	2.42	<.01	4.0
High School	100	1.06	1.07	<.001	1.06	<.01	1.40	NS	2.5
High School	200	1.06	1.07	<.01	1.06	<.05	1.04	NS	2.1
High School	400	1.05	1.07	<.001	1.06	<.001	1.93	<.05	3.6
High School	800	1.08	1.10	<.001	1.08	<.001	2.28	<.01	5.0
High School	1600	1.10	1.14	<.001	1.10	<.001	0.64	NS	13.3
High School	3200	1.11	1.15	<.001	1.11	<.001	0.94	NS	8.0

^a Probability of sex difference between 10-Fastest ratios.

^b Probability of sex difference between duration-corrected male and female 10-Fastest ratios.

^c Normalized variance of males divided by normalized variance of females.

^d Probability of a significant difference in variance ratio.

states (mean 25% male bias; [National Federation of State High School Associations, 2004](#)), these participation differences are much too small to account for the more than threefold difference in the number of relatively fast runners.

Another approach to estimating how many more males than females ran relatively fast in cross-country races is to examine the relationship between participation and performance across states. Although courses vary in difficulty, for both males and females, states with more participants exhibited faster relative times ([Fig. 2A](#)) and less variation ([Fig. 2B](#)) among their fastest 40 finishers. For relative speed, the regression slopes did not differ significantly between the sexes [homogeneity of slopes model, interaction Sex×Log-Participants: $F(1,48)=0.1$, $p=.90$], but the intercepts did [ANCOVA, sex: $F(1,49)=21.1$, $p<.001$]. Normalized variance exhibited different slopes for males and females [$F(1,48)=6.7$, $p<.05$], but sex remained a significant main effect in a separate slopes model [$F(1,48)=8.9$, $p<.01$]. The crucial point is that the regression equations ([Fig. 2](#)) indicate

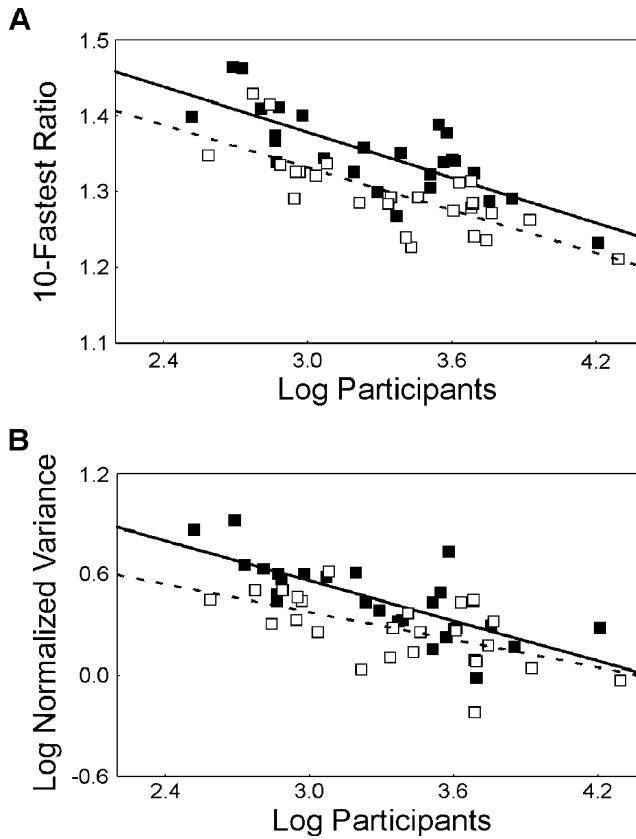


Fig. 2. Regressions of state cross-country population size on (A) mean relative speed of the fastest 40 finishers in the championship race and (B) variance among finishers 6–40. Regression equations: Female 10-Fastest = $1.678 - 0.099 \times \log\text{-participants}$; male duration-corrected 10-Fastest = $1.613 - 0.094 \times \log\text{-participants}$; female log-normalized variance = $1.753 - 0.396 \times \log\text{-participants}$; male log-normalized variance = $1.199 - 0.274 \times \log\text{-participants}$.

that, to match the characteristics of a hypothetical average-sized male population, a female population would have to be 2.3 (normalized variance) or 3.2 (10-Fastest) times as large.

2.3. Discussion

The fastest 40 male and female performances for 47 event lists or races were examined relative to a sex-specific world-class standard, the mean best time of the 10 fastest performers in the world in 2003 for that event. In all 47 cases, the mean performance of the males was closer to the 10-Fastest standard, and in 44 cases, this difference was statistically significant.

This sex difference cannot be ascribed to the 10-Fastest standard being somehow biased against females because the top-ranked U.S. female in each performance list was generally closer to this standard than was their male counterpart. Further evidence that the sex difference is not an artifact of world-class standards is that the variance among performers

was less among males than females in 39 of 47 cases, and, in all 23 cases where variance differed significantly, males were less variable. Because variance estimates are calculated completely independent of world-class standards, this sex difference cannot be attributed to them.

Bias ratios indicated that two to four times as many males as females ran relatively fast in each event list or race, a difference that is far too large to be accounted for by slight (or nonexistent) differences in the number of male and female runners. Furthermore, using a technique that fully controlled for population size, a sex difference of the same magnitude was estimated in cross-country runners.

The proportional sex difference in the number of relatively fast runners demonstrated here is both large and widespread, occurring across a range of competitive levels, events, and geographical areas. In addition, analyses of large U.S. road races indicate the same sex difference (Deaner, in preparation). To my knowledge, this sex difference has never been previously documented. Nevertheless, evidence of the phenomenon can be readily found. For instance, the qualifying time for the 2004 U.S. Olympic marathon trials of 2:48:00 for women (USATF, n.d.a) was 124% of the world record (2:15:25) and 119% of the 10-Fastest standard (2:20:55). The corresponding time for men of 2:22:00 (USATF, n.d.b) was 114% of the world record (2:04:55) and 113% of the 10-Fastest standard (2:06:12). The bias ratio shown in Table 1 indicates that if females had a qualifying standard proportionally similar to the 10-Fastest standard for males, about one third as many females as males would qualify for the Olympic trials. If females had a qualifying standard proportionally similar to the world record for males, about one fifth as many females would qualify.

2.3.1. Do more fast males really indicate a sex difference in competitiveness?

That more males run relatively fast is predicted by studies indicating that more males are motivated by competition and maintain large training volumes. Nevertheless, alternative explanations for the differential occurrence of fast runners should be considered. One possibility is that males and females might show differential responses to training, so that for a given level of training, males might generally perform closer to sex-specific world-class standards. Contrary to this hypothesis, although there is substantial individual variation in responses, when fitness-matched males and females initiate controlled aerobic training programs, their physiological responses and relative performance gains are extremely similar (Dolgener, Kolkhorst, & Whitsett, 1994; Eddy, Sparks, & Adelizi, 1977; Skinner et al., 2001; Wilmore & Costill, 2004). Furthermore, cross-sectional data show that the relationship between running volume and proximity to sex-specific world-class standards is virtually identical for both sexes (Marti, 1988; Williams, 1998). Thus, there is no evidence that more males run relatively fast because they typically can do so with less training.

Another type of alternative hypothesis recognizes that there is a sex difference in training, but claims that this reflects a sex difference in the opportunity to train, not in the motivation to do so. The most plausible version of this hypothesis is that females may be more susceptible to running injuries and so enjoy fewer opportunities to train consistently. This hypothesis is not supported because, although there is a sex difference in injury rates for some sports, such as basketball and soccer (e.g., Arendt & Dick, 1995), once running experience and

training volume are accounted for, male and female distance runners do not suffer different injury rates (Macera, 1992; van Mechelen, 1992).

In sum, alternative accounts for the sex difference in the occurrence of relatively fast runners presently enjoy no general support. It is therefore reasonable to provisionally ascribe the sex difference in the occurrence of relatively fast runners, at least in part, to a sex difference in competitiveness.

3. Study 2

Many sociocultural factors could underlie the sex difference in competitiveness indicated in Study 1, including males receiving more encouragement in athletics (Eccles & Harold, 1991), males being exposed to more same-sex athletic role models, and males receiving or anticipating receipt of greater rewards for athletic achievement, including collegiate scholarships and professional opportunities (Cahn, 1994; Lopiano, 2000; Messner, 2002; Nelson, 1994). Although the bias favoring male athletics provides a plausible account for a sex difference in competitiveness, acknowledging this bias does not differentiate the sociocultural conditions and evolved predispositions hypotheses. The crucial question for these hypotheses is whether the sex difference could be eliminated if the “playing field was leveled.” In other words, testing between these hypotheses requires a large-scale sociocultural change to substantially redress the male bias, or at least major aspects of it.

Fortunately, it is widely acknowledged that over the last 30 years in the United States, such a change has occurred (Cahn, 1994; Lopiano, 2000, Shulman & Bowen, 2001; U.S. Department of Education, 2003). During this period, female opportunities to participate in athletics have increased dramatically, both in absolute terms and relative to males (National Federation of State High School Associations, 2004; NCAA Research, 2004; United States Commission on Civil Rights, 1980). Achievement-based incentives for females have also increased sharply, including the awarding of intercollegiate athletic scholarships (NCAA Research, 2002; United States Commission on Civil Rights, 1980; Zimbalist, 1999) and the ceding of admissions advantages at non-scholarship-granting institutions (Bowen & Levin, 2003; Shulman & Bowen, 2001). These changes have extended across a broad range of sports, including cross-country and track and field. In fact, today, there are similar numbers of males and females running on high school and collegiate teams (National Federation of State High School Associations, 2004; NCAA Research, 2004) and participating in road races (Running USA, n.d.). Moreover, females compete for equal shares of prize money at professional track and field meets and road races (Road Race Management, n.d.), and female D1 collegiate runners actually receive 45% more athletic-related aid than do their male counterparts (NCAA Research, 2002).

This change in opportunities and incentives for female runners can be viewed as a historical experiment, with the contending hypotheses making competing predictions. Specifically, the sociocultural conditions hypothesis predicts that the sex difference in the occurrence of relatively fast runners should be in the process of diminishing. By contrast, the evolved predispositions hypothesis holds that, although there may be some initial response to

the sociocultural change, the sex difference should stabilize at a point where far more males than females run relatively fast.

To test these competing predictions, I analyzed historical data from Open, collegiate, and high school runners, testing both for absolute female improvement and for female improvement relative to corresponding male performances. As shown above (Fig. 2A), within matched populations, a faster mean time within a sample of top performances is an excellent indicator of a larger number of fast runners within the whole population, suggesting that mean sample times could be analyzed across years. Unfortunately, for most events, historical information was unavailable for the fastest 40 performers, precluding many of the analyses presented in Study 1. Nevertheless, the mean time of the fastest 40 performers in an event can be estimated across years by the time of almost any ranked performer. For example, the mean time of the fastest 40 female Open 1500m runners from 1985 to 2003 was significantly predicted by the time of the 1st, 5th, 10th, 20th, and 40th ranked performers in each of those years; however, the relationship was far stronger with lower ranks [1st: $r^2=.25$, $p<.05$; 5th: $r^2=.44$, $p<.01$; 10th: $r^2=.79$, $p<.001$; 20th: $r^2=.87$, $p<.001$; 40th: $r^2=.90$, $p<.001$]. Therefore, I generally used the time of the lowest ranked performer that was available across a span of years and considered improvement in this time as evidence for an increase in the number of fast females.

3.1. Methods

Historical information on Open and collegiate performances was obtained from “Track & Field News.” Open performance lists were presented in the December issue of each year or in the January or February issue of the following year. Collegiate performances were generally presented in July or August issues. Historical information on high school performances was taken from large newspapers (e.g., *L.A. Times*, *Star Ledger*, and *Boston Globe*). High school championship meets occurred in early June, and results were generally printed on the following day. Some performances from state championship high school track meets required conversions for hand timing or the use of English rather than metric distances; conversions followed “Track & Field News” (2000).

3.2. Results

3.2.1. Open runners

I first tested whether the time of the 10th best female Open performer has improved since 1976, the first year for which such data are available. In each of the eight commonly contested events, females improved significantly, both in absolute terms and relative to the corresponding male performance (all distances: least-squares linear regression, $p<.05$; Fig. 3). Visual inspection indicated, however, that most improvement occurred in the 1970s and early 1980s. I therefore repeated these analyses using only data from the last 20 years for which they were available, 1984–2003. Performance improved in the 5000m (absolutely and relatively) but worsened in the 800m (absolutely and relatively), marathon (absolutely) and 100m (relatively; Table 2). Because the 5000m marathon was rarely contested by females

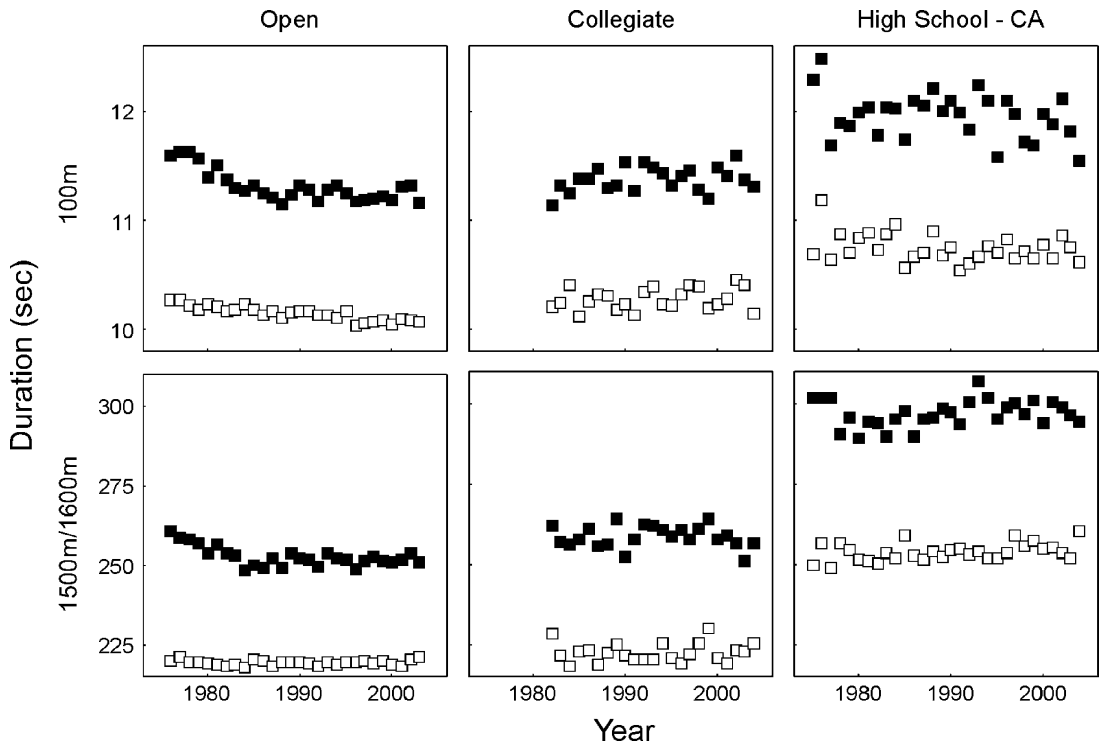


Fig. 3. Plots of year and race duration for a representative sprint and distance event, for three competitive levels. Open data represent the 10th ranked U.S. performer; collegiate data represent the fifth place finisher at the D1 Outdoor National Championship meet; high school-CA data represent the fifth place finisher at the California All-State Outdoor State Championship meet. See Table 2 for regression equations.

prior to the 1990s and was not an Olympic distance until 1996 (Runner's World, 1996; Track & Field News, 1988), improvement in this event may not reflect an increased number of fast female distance runners.

3.2.2. Collegiate runners

To test whether female collegiate performances have improved, I focused on the times of fifth place finishers at NCAA D1 outdoor national championship meets. Sanctioned championship meets, including both males and females competing in the same location, have occurred since 1982. Female performances improved relative to males in the 200m but did not show absolute improvement in this event or any other (Fig. 3; Table 2).

3.2.3. High school runners

To test for improvement in female high school runners, I analyzed the times of fifth place finishers at all-state outdoor track championships in the three most populous states that have annually held these meets: California, New Jersey, and Massachusetts. Limited information from the 1970s suggested substantial improvements during this period (Fig. 3).

Table 2

Absolute and relative changes in performance for high school, collegiate, and Open runners for commonly contested distances

Context	Distance (m)	Sample	Female			Male			Female–Male		
			β	t	p	β	t	p	β	t	p
Open	100	1984–2003	-.15	-0.63	NS	-.79	-5.41	<.001	.53	2.64	<.05
Open	200	1984–2003	-.14	-0.59	NS	-.09	-0.38	NS	-.10	-0.43	NS
Open	400	1984–2003	-.27	-1.18	NS	.04	0.16	NS	-.35	-1.59	NS
Open	800	1984–2003	.64	3.53	<.01	.11	0.46	NS	.61	3.29	<.01
Open	1500	1984–2003	.36	1.63	NS	.33	1.49	NS	.18	0.77	NS
Open	5000	1984–2003	-.52	-2.58	<.05	.33	1.48	NS	-.61	-3.28	<.01
Open	10000	1984–2003	-.18	-0.77	NS	.36	1.66	NS	-.39	-1.82	NS
Open	42195	1984–2003	.64	3.58	<.01	.77	5.11	<.001	.16	0.68	NS
Collegiate	100	1982–2004	.29	1.37	NS	.23	1.10	NS	.08	0.36	NS
Collegiate	200	1982–2004	.03	0.13	NS	.60	3.42	<.01	-.44	-2.27	<.05
Collegiate	400	1982–2004	-.23	-1.07	NS	-.33	-1.62	NS	-.04	-0.19	NS
Collegiate	800	1982–2004	-.07	-0.31	NS	-.30	-1.45	NS	.12	0.56	NS
Collegiate	1500	1982–2004	-.10	-0.48	NS	.10	0.48	NS	-.19	-0.87	NS
Collegiate	5000	1982–2004	.10	0.44	NS	-.05	-0.23	NS	.28	1.30	NS
Collegiate	10000	1982–2004	.27	1.29	NS	.17	0.81	NS	.01	0.06	NS
High school-CA	100	1980–2004	-.32	-1.61	NS	-.30	-1.51	NS	-.16	-0.77	NS
High school-CA	200	1980–2004	-.75	-5.40	<.001	-.31	-1.55	NS	-.49	-2.72	<.05
High school-CA	400	1980–2004	-.02	-0.11	NS	.13	0.63	NS	-.10	-0.46	NS
High school-CA	800	1980–2004	.41	2.18	<.05	.46	2.52	<.05	-.10	-0.46	NS
High school-CA	1600	1980–2004	.47	2.53	<.05	.47	2.56	<.05	-.02	-0.10	NS
High school-CA	3200	1980–2004	.24	1.20	NS	.38	1.98	NS	.15	0.75	NS
High school-NJ	100	1980–2004	-.82	-6.85	<.001	-.72	-4.96	<.001	-.52	-2.91	<.01
High school-NJ	200	1980–2004	-.70	-4.75	<.001	-.50	-2.76	<.05	-.34	-1.76	NS
High school-NJ	400	1980–2004	-.49	-2.67	<.05	-.17	-0.82	NS	-.36	-1.82	NS
High school-NJ	800	1980–2004	-.04	-0.20	NS	.26	1.28	NS	-.22	-1.07	NS
High school-NJ	1600	1980–2004	.46	2.49	<.05	.19	0.94	NS	.38	1.97	NS
High school-NJ	3200	1980–2004	.40	2.11	<.05	.38	1.99	NS	.19	0.91	NS
High school-MA	100	1980–2004	.00	0.02	NS	-.10	-0.49	NS	.08	0.40	NS
High school-MA	200	1980–2004	-.42	-2.20	<.05	-.21	-1.00	NS	-.38	-1.92	NS
High school-MA	400	1980–2004	-.49	-2.62	<.05	-.44	-2.29	<.05	-.03	-0.16	NS
High school-MA	800	1980–2004	-.10	-0.48	NS	-.30	-1.46	NS	.08	0.36	NS
High school-MA	1600	1980–2004	-.28	-1.34	NS	-.07	-0.34	NS	-.30	-1.48	NS
High school-MA	3200	1980–2004	-.28	-1.34	NS	-.01	-0.05	NS	-.32	-1.60	NS

However, I focused on the last 25 years, 1980–2004, during which complete data were available. Female performances absolutely improved in 6 of 18 events, all of which were sprints ($\leq 400\text{m}$), and relatively improved in 2 of these sprints (Table 2). Female performances absolutely worsened in four distance events, but there was no relative worsening in any event (Table 2). General linear models incorporating state and distance showed no main effect of year on absolute [$F(1,424)=1.2$, $p=.27$] or relative performance [$F(1,424)=0.15$, $p=.70$]. However, when only sprints were included, year showed a main effect on both measures [absolute: $F(1,211)=38.4$, $p<.001$; relative: $F(1,211)=9.6$, $p<.01$];

when only distance events were included, year was nonsignificant for either measure [absolute: $F(1,211)=2.6$, $p=.11$; relative: $F(1,211)=.01$, $p=.93$].

3.3. Discussion

With the exception of high school sprints, there is no indication of improvement among elite or sub-elite female runners since the early to mid-1980s, indicating that the number of fast female runners has not increased over this time. It might be argued that statistical power was insufficient to detect such improvement. However, the approach used here is reasonably sensitive, as is shown by the fact that improvements were detected among high school sprinters and among all Open runners when data from the late 1970s and early 1980s were included. Moreover, if the hypothesis of female improvement were true but the data too variable to reveal significant effects, one would predict that the regression coefficients would be predominantly negative. However, in terms of absolute performance, only 7 of the 18 female distance tests ($\geq 800\text{m}$) had negative regression coefficients (Table 2). Even more crucially, of the six significant regression coefficients, five were positive, indicating a decrease in the number of fast runners. Relative female performance also showed no trend towards a predominance of negative regression coefficients (only 8 of 18 coefficients negative, only 1 of 2 significant coefficients negative; Table 2). Therefore, these analyses collectively provide strong evidence that the number of elite and sub-elite female distance runners has remained stable since the early to mid-1980s.

This stability is surprising, given the well-documented gains in participation and incentives for female athletes and the celebrated accomplishments attributed to these gains (e.g., Gavora, 2002; Lopiano, 2000; Shulman & Bowen, 2001). However, distance running differs from most other sports in that widespread opportunities for female participation occurred relatively early. Specifically, in U.S. high schools in 1980, 46% of high school outdoor track and field teams were female, and the number of female participants was only 10% less than in 2003 (National Federation of State High School Associations, 2004). At the collegiate level in 1982, 38% of teams were female, and the number of female participants was only 40% less than in 2003 (NCAA Research, 2004). These data indicate that most talented female runners could have found opportunities to excel by the early 1980s. Of course, compared with their male contemporaries and females of today, these athletes almost certainly would have faced many disadvantages, including fewer scholarship opportunities, smaller travel and equipment allowances, and poorer professional prospects. Apparently, these disadvantages did not undermine the motivation of these runners.

3.3.1. Potential historical confounds

Although the change in opportunities and incentives for female runners can be viewed as a historical experiment, other factors besides this manipulation were not systematically controlled. Thus, the stable number of fast female distance runners might not indicate the ineffectiveness of the social change but might instead reflect the influence of some confound. One possibility is that prior to the initiation of randomized out-of-competition tests in the late 1980s and early 1990s (Seiler & Sailer, 1997), illegal performance-enhancing drugs were

more widely used. Because anabolic steroids may potentiate larger relative strength gains for females than males (Franke & Berendonk, 1997; Seiler & Sailer, 1997), the performances of some competitive female athletes of the 1980s might have been too good. Although a doping bias may explain the lack of historical improvement in sprint events despite an actual increase in the number of female runners training competitively, this explanation is unsatisfying for distance events where anabolic steroids are not believed to confer substantial advantages (Franke & Berendonk, 1997; Wilmore & Costill, 2004). In any event, a doping bias cannot explain the lack of improvement among female high school distance runners unless it were assumed that there was widespread doping among these runners in the early 1980s, a claim for which there is no evidence.

A second reason that the number of relatively fast female distance runners may not have increased despite a genuine change in female competitiveness is that the increased availability of other athletic opportunities has drawn many of the best female athletes away from distance running. In fact, in the past two decades, at both high school and collegiate levels, female participation in many sports, including swimming, volleyball, lacrosse, and soccer, has greatly outpaced the growth of track and field and cross-country (National Federation of State High School Associations, 2004; NCAA Research, 2004). Although male participation has also shown substantial growth in several sports, this growth is more modest.

Although this ‘competition for athletes’ hypothesis is attractive, it would be more plausible if invoked to explain the historical stability of sprinters, rather than distance runners. The reason is that the physiological characteristics of elite distance runners—high aerobic capacities and fatigue resistance and a majority of Type I muscle fibers—differ from those of elite sprinters, whose characteristics—exceptional explosiveness and muscularity and a preponderance of Type II muscle fibers—are at a greater premium in most team sports (Cometti, Maffioletti, Pousson, Chatard, & Maffuli, 2001; Fleck, Case, Puhl, & van Handle, 1985). Although these physiological characteristics can be modified with training, they are ultimately constrained by genetics (Bouchard et al., 1999; Simoneau & Bouchard, 1995). These considerations suggest that individuals with the greatest potential to become elite distance runners will generally not be able to achieve as highly in most other sports. Hence, if highly competitive, they can be expected to eventually focus on distance running.

Ultimately, the final word on the competition for athletes hypothesis will not come from plausibility arguments, but rather from empirical study. If the hypothesis is correct, then after some future period where female athletic participation in other major sports has reached an asymptote, the sex difference in the occurrence of relatively fast runners should markedly diminish. At present, however, the competition for athletes hypothesis has no support, and it is therefore reasonable to provisionally conclude that the systematic increase in opportunities and incentives for female distance runners has not enhanced their competitiveness.

4. General discussion

The present studies illustrate a new approach to addressing the long-standing question of whether sex differences in social psychological attributes are diminishing. In Study 1, I

documented a highly robust phenomenon that was previously unknown: Within matched populations of runners, far more males than females run relatively fast. Although additional studies are required to corroborate the link between competitiveness and fast running performances, the only explanation for this pattern that is currently supported is the existence of a sex difference in competitiveness. In Study 2, I tested whether the growth in opportunities and incentives for females in the past 30 years is eliminating the sex difference. Despite using a demonstrably sensitive method and conducting many tests, I found no indication of an absolute or relative increase in the number of fast female distance runners since the mid-1980s.

Together, these studies imply that the sex difference in competitiveness is not decreasing and thus support the hypothesis that sex differences in social psychological attributes partly reflect evolved predispositions (Archer & Lloyd, 2002; Buss, 2004; Campbell, 2002; Daly & Wilson, 1988; Geary, 1998). Nevertheless, it bears stressing that an evolutionary psychology perspective does not claim that sociocultural factors are irrelevant. Clearly, sociocultural factors are important, as is illustrated by the marked increase in competitive female runners during the 1970s and the pronounced variation in the popularity of sports across cultures. In the present context, the key claim of evolutionary psychology is that even if opportunities and incentives for achieving in sport are fully equitable, a sex difference in the proportion of highly competitive athletes will remain, at least in some sports.

4.1. Alternative explanations for a failure to increase competitiveness

One possibility is that, although progress in leveling the playing field has not yet increased the competitiveness of female distance runners, eventually it will. Because the growth in opportunities and incentives for female athletes first began on a large scale in the 1970s and may be still occurring today, there has been less than a generation for these altered sociocultural conditions to become effective. Thus, if the historical analyses in Study 2 were conducted in another generation, there might be evidence of an increasing number of fast female distance runners. For this reason, and because of the competition for athletes hypothesis (Section 3.3.1), historical analyses must be repeated in the future.

Another possibility is that the sex difference in competitiveness could be eliminated if the society were altered appropriately but that increased opportunities and incentives for female athletes is not an appropriate modification. Specifically, one might argue that competitiveness in athletics is dependent on receiving childhood encouragement from parents and peers (Eccles & Harold, 1991) and that the increased female athletic opportunities at high schools and colleges has not actually altered the general level of encouragement. To my knowledge, there is no cross-temporal data on childhood athletic encouragement, so this issue requires study.

Eagly's social role theory (1987; Eagly & Wood, 1999), arguably the most comprehensive version of the sociocultural conditions hypothesis, specifically holds that increased female participation in traditionally male-occupied social roles, including in athletics (Diekmann & Eagly, 2000), will ultimately lead to females developing more instrumental or agentic psychological attributes, including competitiveness. In addition, in addressing

females' lesser interest in competitive athletics, several U.S. courts have adopted a stance of "If you build it, they will come," essentially claiming that if policies would ensure that males and females participate in intercollegiate athletics at the same rate, sex differences in competitive athletics interest would disappear (Gavora, 2002). Therefore, although alternative versions of the sociocultural conditions hypothesis can be formulated, the failure of increased opportunities and incentives for female distance runners to increase their competitiveness must be considered a genuine failure for the sociocultural conditions hypothesis.

Finally, in assessing claims that the sociocultural changes occurred too recently or were not appropriate, it is notable that several social scientists have posited that sex differences in physical strength may be decreasing due to these changes (Diekmann & Eagly, 2000; Dowling, 2000; Messner, 2002). Although there is no empirical support for these suggestions (Shephard, 2000), their occurrence shows that the expectation of enhanced female competitiveness is realistic.

4.2. The generality of the sex difference in sport competitiveness

The hypothesis that males have an evolved predisposition to directly compete for status is based on a wealth of empirical observations (Browne, 2002; Buss, 2004; Campbell, 2002; Maccoby, 1998). For instance, compared with their female counterparts, young boys more frequently engage in activities with clear winners and losers (Lever, 1976), older boys compete more often in sports, particularly in informal contexts (Kirshnit, Ham, & Richards, 1989), and men typically show greater commitment to attaining high-status jobs (Browne, 2002). In this context, it is not surprising that proportionally more male distance runners are motivated to seek competition (Callen, 1983; Johnsgard, 1985; Leedy, 2000; Ogles & Masters, 2003; Walter et al., 1989) and, in fact, run relatively fast.

These observations imply that proportionally more males will be highly competitive in sports besides distance running. Study 1 provides some support for this prediction among sprinters, although Study 2 indicates that this sex difference could be shrinking. In addition, there are reasons to expect that there will be some sports with no sex difference in competitiveness or where competitive females will outnumber competitive males. For instance, Sargent, Zillman, and Weaver (1998) found that males preferred viewing sports characterized by direct competition and elements of combat, whereas female spectators were partial to stylistic sports such as gymnastics, diving, and figure skating. Thus, the generality of the sex difference in sport competitiveness requires empirical investigation.

4.3. Policy implications

These studies provide substantial evidence that there is a large sex difference in the number of competitive distance runners and that this difference is not diminishing. This stability, despite substantial growth in opportunities and incentives for female athletes, strongly suggests that a sex difference in competitiveness is not merely due to sociocultural conditions but instead partly reflects evolved psychological predispositions. These data thus provide a

powerful challenge to the assumption that all sex differences in sports interest and competitiveness should be ascribed to past or present discrimination. As this assumption lies at the heart of intercollegiate athletic policies in the United States, this policy may require revision (Gavora, 2002; Rhoads, 2004).

Recognizing that males and females may generally have different levels of interest in (some) competitive sports should not deter attempts to equalize the opportunities. As reviewed above, in the United States, opportunities and external incentives in distance running are not biased towards males. Nevertheless, biases in opportunities and incentives almost certainly remain in other sports and, when demonstrated, should be rectified.

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References

- Archer, J., & Lloyd, B. (2002). *Sex and gender* (2nd ed). New York: Cambridge University Press.
- Arendt, E., & Dick, R. (1995). Knee injury patterns among men and women in collegiate basketball and soccer. NCAA data and review of literature. *American Journal of Sports Medicine*, *23*, 694–701.
- Bjorkqvist, K. (1994). Sex differences in physical, verbal, and indirect aggression: A review of recent research. *Sex Roles*, *30*, 177–183.
- Bouchard, C., An, P., Rice, T., Skinner, J. S., Wilmore, J. H., Gagnon, J., Perusse, L., Leon, A. S., & Rao, D. C. (1999). Familial aggregation of VO₂max response to exercise training: Results from the HERITAGE Family Study. *Journal of Applied Physiology*, *87*, 1003–1008.
- Bowen, W. G., & Levin, S. A. (2003). *Reclaiming the game: College sports and educational values*. Princeton, NJ: Princeton University Press.
- Browne, K. R. (2002). *Biology at work*. New Brunswick, NJ: Rutgers University Press.
- Buss, D. M. (2004). *Evolutionary psychology: The new science of the mind* (2nd ed). Needham Heights, MA: Allyn & Bacon.
- Cahn, S. K. (1994). *Coming on strong: Gender and sexuality in twentieth-century women's sport*. New York: The Free Press.
- Callen, K. E. (1983). Mental and emotional aspects of long-distance running. *Psychosomatics*, *24*, 133–151.
- Campbell, A. (2002). *A mind of her own: The evolutionary psychology of women*. New York: Oxford University Press.
- Cometti, G., Maffiuletti, N. A., Pousson, M., Chatard, J. -C., & Maffuli, N. (2001). Isokinetic strength and anaerobic power of elite, subelite and amateur French soccer players. *International Journal of Sports Medicine*, *22*, 45–51.
- Cross, S. E., & Madson, L. (1997). Models of the self: Self-construals and gender. *Psychological Bulletin*, *122*, 5–37.
- Daly, M., & Wilson, M. (1988). *Homicide*. New York: Aldine de Gruyter.
- Deaner, R. O. (in preparation). More males run relatively fast in U.S. road races.

- Diekmann, A. B., & Eagly, A. H. (2000). Stereotypes as dynamic constructs: Women and men of the past, present, and future. *Personality and Social Psychology Bulletin*, 26, 1171–1188.
- Dolgener, F. A., Kolkhorst, F. W., & Whitsett, D. A. (1994). Long slow distance training in novice marathoners. *Research Quarterly for Exercise and Sport*, 65, 339–346.
- Dowling, C. (2000). *The frailty myth*. New York: Random House.
- Dyestat. (2004). States 2002–2004. Retrieved January 1, 2004, from Dyestat: The Internet home of high school track. Web site: <http://dyestat.com/3state/state.htm>.
- Eagly, A. H. (1987). *Sex differences in social behavior: A social role interpretation*. Hillsdale, NJ: Erlbaum.
- Eagly, A. H., & Wood, W. (1999). The origins of sex differences in human behavior: Evolved dispositions versus social roles. *American Psychologist*, 54, 408–423.
- Eccles, J. S., & Harold, R. D. (1991). Gender differences in sport involvement: Applying the Eccles' expectancy-value model. *Journal of Applied Sports Psychology*, 3, 7–35.
- Eddy, D. O., Sparks, K. L., & Adelizi, D. A. (1977). The effects of continuous and interval training in women and men. *European Journal of Applied Physiology*, 37, 83–92.
- Feingold, A. (1994). Gender differences in personality: A meta-analysis. *Psychological Bulletin*, 116, 429–456.
- Fleck, S. J., Case, S., Puhl, J., & van Handle, P. (1985). Physical and physiological characteristics of elite women volleyball players. *Canadian Journal of Applied Sport Sciences*, 10, 122–126.
- Franke, W. W., & Berendonk, B. (1997). Hormonal doping and androgenization of athletes: A secret program of German Democratic Republic government. *Clinical Chemistry*, 43, 1262–1279.
- Gavora, J. (2002). *Tilting the playing field: Schools, sports, sex and Title IX*. San Francisco: Encounter Books.
- Geary, D. C. (1998). *Male, female: The evolution of human sex differences*. Washington, DC: American Psychological Association.
- Gill, D. L. (1999). Gender and competitive motivation: From the recreation center to the Olympic arena. In D. Bernstein (Ed.), *Nebraska symposium on motivation: Gender and motivation* (Vol. 45, pp. 173–207). Lincoln, NE: University of Nebraska Press.
- Glover, B., & Glover, S. -I. (1999). *The competitive runner's handbook: The bestselling guide to running 5Ks through marathons*. New York: Penguin Books.
- Holden, C. (2004). An everlasting gender gap? *Science*, 305, 639–640.
- IAAF. (n.d.). The official records of the IAAF. Retrieved January 18, 2004 from International Association of Athletics Federations. Web site: <http://www.iaaf.org/statistics/records>.
- Johnsgard, K. (1985). The motivation of the long distance runner: I. *Journal of Sports Medicine and Physical Fitness*, 25, 135–139.
- Johnson, J. A. (1981). The “self-disclosure” and “self-presentation” views of item response dynamics and personality scale validity. *Journal of Personality and Social Psychology*, 40, 761–769.
- Kirshnit, C. E., Ham, M., & Richards, M. H. (1989). The sporting life: Athletic activities during early adolescence. *Journal of Youth and Adolescence*, 18, 601–615.
- Leedy, M. G. (2000). Commitment to distance running: Coping mechanism or addiction? *Journal of Sport Behavior*, 23, 255–270.
- Lever, J. (1976). Sex differences in the games children play. *Social Problems*, 23, 478–487.
- Lopiano, D. A. (2000). Modern history of women in sports. *Clinics in Sports Medicine*, 19, 163–173.
- Lueptow, L. B., Garovitch-Szabo, L., & Lueptow, M. B. (2001). Social change and the persistence of sex-typing: 1974–1997. *Social Forces*, 80, 1–36.
- Maccoby, E. E. (1998). *The two sexes: Growing up apart, coming together*. Cambridge, MA: The Belknap Press.
- Macara, C. A. (1992). Lower extremity injuries in runners: Advances in prediction. *Sports Medicine*, 13, 50–57.
- Marti, B. (1988). Benefits and risks of running among women: An epidemiological study. *International Journal of Sports Medicine*, 9, 92–98.
- Messner, M. A. (2002). *Taking the field: Women, men, and sports*. Minneapolis: University of Minnesota Press.
- National Federation of State High School Associations. (1980). *1979–1980 High school athletics participation survey*. Indianapolis, IN: National Federation of State High School Associations.

- National Federation of State High School Associations. (2004). *2003–04 High school athletics participation survey*. Indianapolis, IN: National Federation of State High School Associations.
- NCAA Research. (2002). *2001–02 NCAA gender-equity report*. Indianapolis, IN: National Collegiate Athletic Association.
- NCAA Research. (2004). *1981–82–2002–03 NCAA sports sponsorship and participation rates report*. Indianapolis, IN: National Collegiate Athletic Association.
- Nelson, M. B. (1994). *The stronger women get, the more men love football: Sexism and the American culture of sports*. New York: Harcourt Brace.
- Noakes, T. (2001). *Lore of running* (4th ed). Champaign, IL: Human Kinetics.
- Ogles, B. M., & Masters, K. S. (2003). A typology of marathon runners based on cluster analysis of motivations. *Journal of Sport Behavior*, 26, 69–85.
- Ogles, B. M., Masters, K. S., & Richardson, S. A. (1995). Obligatory running and gender: An analysis of participative motives and training habits. *International Journal of Sport Psychology*, 26, 233–248.
- Reinbold, W. (2004). Linear models can't keep up with sport gender gap. *Nature*, 432, 147.
- Rhoads, S. E. (2004). *Taking sex differences seriously*. San Francisco: Encounter Books.
- Road Race Management. (n.d.). Prize money. Retrieved November 1, 2004, from Road Race Management. Web site: <http://www.rrm.com/rankings/money.htm>.
- Runner's World. (1996). Stats. *Runner's World*, February, 44.
- Running USA. (n.d.). 100 largest races—All finishers timed. Retrieved March 30, 2003, from Running USA. Web site: http://www.runningusa.org/cgi/index_largest_races.pl.
- Sargent, S. L., Zillman, D., & Weaver, J. B. (1998). The gender gap in the enjoyment of televised sports. *Journal of Sport and Social Issues*, 22, 46–64.
- Seiler, S., & Sailer, S. (1997, April 17). The gender gap: Elite women are running further behind. *Sportscience News*, May–June. Retrieved January 18, 2004, from <http://www.sportsci.org/news/news9705/gengap.html>.
- Shephard, J. (2003). *High school track 2004* (46th ed). Westminster, CA: Jack Shephard.
- Shephard, R. J. (2000). Exercise and training in women: Part I. Influence of gender on exercise and training responses. *Canadian Journal of Applied Physiology*, 25, 19–34.
- Shulman, J. L., & Bowen, W. G. (2001). *The game of life: College sports and educational values*. Princeton, NJ: Princeton University Press.
- Simoneau, J. -A., & Bouchard, C. (1995). Genetic determinism of fiber type proportion in human skeletal muscle. *Federation of American Societies for Experimental Biology*, 9, 1091–1095.
- Skinner, J. S., Jaskolski, A., Jaskolski, A., Krasnoff, J., Gagnon, J., Leon, A. S., Rao, D. C., Wilmore, J. H., & Bouchard, C. (2001). Age, sex, race, initial fitness, and response to training: The HERITAGE Family Study. *Journal of Applied Physiology*, 90, 1770–1776.
- Sokal, R. R., & Rohlf, F. J. (1995). *Biometry* (3rd ed). New York: W.H. Freeman.
- Sparling, P. B., & Cureton, K. J. (1983). Biological determinants of the sex-difference in 12-min run performance. *Medicine and Science in Sports and Exercise*, 15, 218–223.
- Sparling, P. B., O'Donnell, E. M., & Snow, T. K. (1998). The gender difference in distance running has plateaued: An analysis of world rankings from 1980 to 1996. *Medicine and Science in Sports and Exercise*, 30, 1725–1729.
- Tatem, A. J., Guerra, C. A., Atkinson, P. M., & Hay, S. I. (2004). Athletics: Momentous sprint at the 2156 Olympics? *Nature*, 431, 525.
- Tooby, J., & Cosmides, L. (1992). The psychological foundations of culture. In J. Barkow, L. Cosmides, & J. Tooby (Eds.), *The adapted mind* (pp. 19–136). New York: Oxford University Press.
- Track & Field News. (1988). 5000 meters: Impossible to rank. *Track & Field News*, February, 20.
- Track & Field News. (2000). *Big green book*. Mountain View, CA: Tafnews Press.
- Track & Field News. (2004). 2003 World/U.S. Lists. *Track & Field News*, January, 37–52.
- Twenge, J. M. (1997). Changes in masculine and feminine traits over time: A meta-analysis. *Sex Roles*, 36, 305–325.

- Twenge, J. M. (2001). Changes in women's assertiveness in response to status and roles: A cross-temporal meta-analysis, 1931–1993. *Journal of Personality and Social Psychology*, 81, 133–145.
- United States Commission on Civil Rights. (1980). *More hurdles to clear: Women and girls in competitive athletics* (Clearinghouse Publication Number 63). Washington, DC: United States Commission on Civil Rights.
- USATF. (n.d.a). Qualifying Standards. Retrieved November 1, 2004 from USA Track & Field. Web site: <http://www.usatf.org/events/2004/OlympicTrials-Marathon-Women/entry/qualifyingStandards.asp>.
- USATF. (n.d.b). Qualifying Standards. Retrieved November 1, 2004 from USA Track & Field. Web site: <http://www.usatf.org/events/2004/OlympicTrials-Marathon-Men/entry/qualifyingStandards.asp>.
- U.S. Department of Education. (2003). *Open to all: Title IX at thirty*. Washington, DC: U.S. Department of Education, Secretary's commission for opportunity in athletics.
- van Mechelen, W. (1992). Running injuries: A review of the epidemiological literature. *Sports Medicine*, 14, 320–355.
- Walter, S. D., Hart, L. E., McIntosh, J. M., & Sutton, J. R. (1989). The Ontario cohort study of running related injuries. *Archives of Internal Medicine*, 149, 2561–2564.
- West, C., & Zimmerman, D. H. (1987). Doing gender. *Gender and Society*, 1, 125–151.
- Whipp, B. J., & Ward, S. A. (1992). Will women soon outrun men? *Nature*, 355, 25.
- Williams, P. T. (1998). Relationships of heart disease risk factors to exercise quantity and intensity. *Archives of Internal Medicine*, 158, 237–245.
- Wilmore, J. H., & Costill, D. L. (2004). *Physiology of sport and exercise* (3rd ed). Champaign, IL: Human Kinetics.
- Zimbalist, A. (1999). *Unpaid professionals: Commercialism and conflict in big-time college sports*. Princeton, NJ: Princeton University Press.