EM9201: **Nature 355,** 25, January 2, 1992 [DC Library call number: PER Q1.N2].

REGRESSION: Will women soon outrun men?

The average running velocity ($\overline{v}$) is a crucial determinant of the metabolic demands imposed by competitive running events.[1,2] Its historical progression, therefore, is likely to be important in understanding the physiological determinants of the seemingly inexorable progression of record performances.

We therefore established $\overline{v}$ as a function of historical time (t) for the world records at all the standard Olympic events from the 200 m to the marathon (42,195 m) for men, decade-by-decade, throughout this century.[3,4] We were able to establish this relationship only for events up to 1,500 m since the 1920s for women; data were inadequate for the 5,000 and 10,000 m, although we judged there to be sufficient for the marathon.

In men, the progression of $\overline{v}$ appears to be a linear function of t, with slopes for the different events being remarkably similar (left-hand digram below) – in agreement with the results of Ryder *et al.*[5] These ranged from 5.69 to 7.57 m min^{-1} decade, with no systematic variation with increasing race distance. The marathon slope, however, was appreciably greater (9.18 m min^{-1} decade).

For women, there were also no significant differences in the slopes among the different events up to the 1,500 m (middle diagram below). The slope, however, was approximately double that for the men, ranging from 14.04 to 17.86 m min^{-1} decade. As for men, the rate at which $\overline{v}$ increased in the marathon was appreciably greater (37.75 m min^{-1} decade). Despite the potential pitfalls, we could not resist extrapolating these record progressions into the future.

Unless the progression rate of men's records increases relative to that of women, then $\overline{v}$ for these events will be no different for men and women within the first half of the twenty-first century (right-hand diagram below). Beyond that time, current progression rates imply superior performance by women. The projected intersection for the marathon is 1998.

The suggestion that women could, so soon, be running these races as fast as men seems improbable at first appearance. None of the current women's world record holders at these events could even meet the men's qualifying standard to compete in the 1992 Olympic games. However, it is the *rates* of improvement that are so strikingly different – the gap is progressively closing.[6]

Although it is difficult to establish a precise metabolic energy equivalent of these rates of improvement, one may estimate from the data of Margaria *et al.*[7] and Wyndham *et al.*[8] that, for the events up to 10,000 m, the progression requires a rate of increase in O_2 consumption of about 10 ml min^{-1} yr for men and more than double that for women.

It is unlikely that we will learn when, and how rapidly, the current high rate of improvement was established, owing to the lack of reliable times over reliable distances in the past. Some world records are available, however, as far back as the 1860s (reference 4); they are consistent with the values 'expected' from the current progression rates. Whether the world record progression rate will begin to slow, either relatively abruptly or more progressively, will only become apparent in the future.

In any event, these results pose four challenging questions to physiologists. Why is:

- the world record progression in the various events so linear over an interval of approximately a century;
- the slope of the record progression so similar from the sprints to the 10,000 m;
- the record progression in the marathon appreciably greater;
- the record progressions for women increasing at such a rapid rate relative to men?

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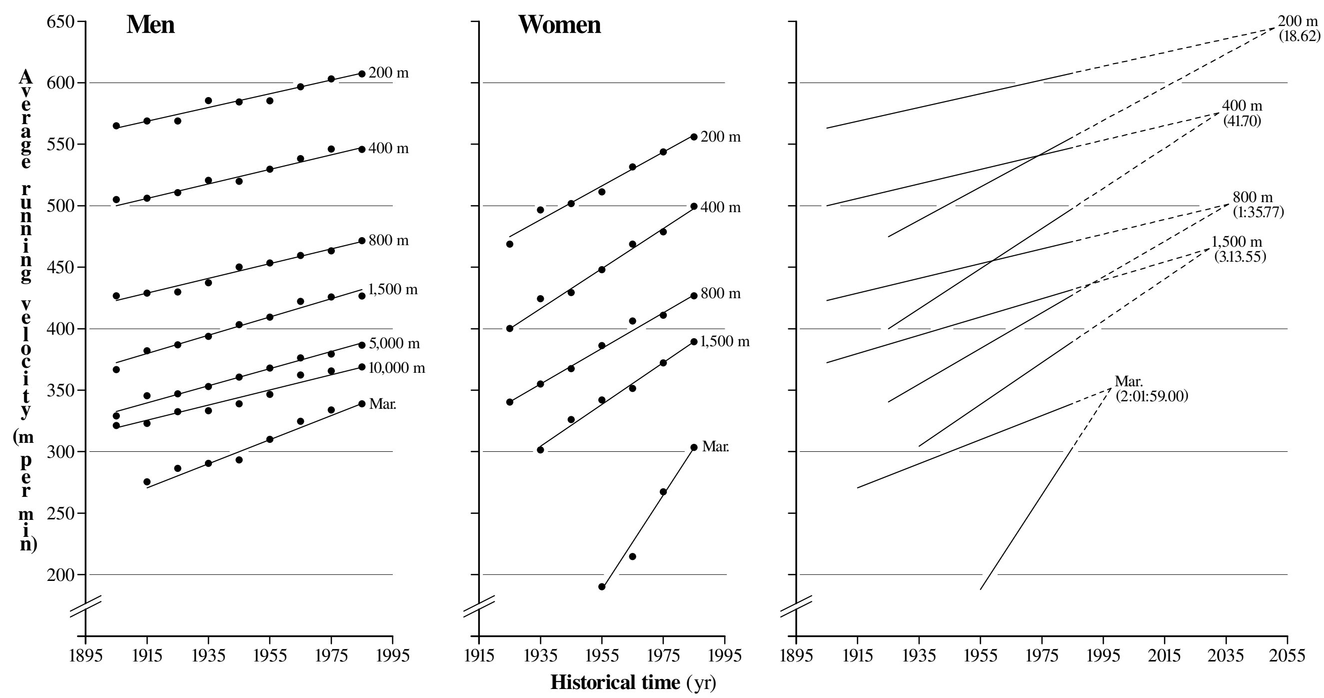

World record progression, expressed as average running velocity versus historical time, for men and women, with best-fit linear regressions (solid lines) superimposed. In the right-hand diagram, the regression lines for the common events for men and women (solid lines) are extrapolated (dashed lines) to their points of intersection; the predicted world record times at these intersection points are shown in parentheses (h:min:s).

(*continued overleaf*)

1. Lloyd, B.B. *Circ. Res.* **XX** & **XXI** (suppl. 1), 218-226 (1967).
2. Di Prampero, P. E. *Revista di Cultura Sportiva* **3**, 3-7 (1984).
3. Matthews, P. *Track and Field Athletics: The Records* (Guinness, Enfield, 1986).
4. *Progression of World's Best Performances and Official I.A.A.F. Records* (International Athletic Foundation, Monaco, 1987).
5. Ryder, H.W. Carr, H.J. & Herget, P. *Sci. Am.* **234** (#6), 109-119 (1976).
6. Dyer, K.J. *J. Biosocial Sci.* **9**, 325-338 (1977).
7. Margaria, R., Cerretelli, P., Aghemo, P. & Sassi, G. *J. appl. Physiol.* **18**, 367-371 (1963).
8. Wyndham, C.H., Strydom, N.B., Van Rensburg, A.J. & Benade, A.J.S. *S. Afr. Med. J.* **43**, 996-1002 (1969).

The article EM9201 reprinted overleaf on page HL56.1 and above is of statistical interest because its main Answer is based on *extrapolating* regression lines.

A December, 2020, Google search yields the world record data given in the table below. The race times at the extrapolated crossing points in the right-hand diagram overleaf are shown in **bold** type in the central column; adjacent to them in smaller type are the ratios of men's records to these extrapolations and the ratios of the women's to the men's records. Three matters seem inhospitable to the implications of the article reprinted overleaf and above and its title.

- the relatively long standing of some records;
- differences of still at least 10% between the men's and women's world records;
- except for the marathon, the differences of about 3% to about 6½% that remain between the men's records and the values at the extrapolated crossing points.

RACE	**MEN** Time	Name	Year				**WOMEN** Time	Name	Year
200 m	19.19	Usain Bolt	2009	1.0306	**18.62**	1.1120	21.34	Florence Griffith-Joyner	1988
400 m	43.03	Wayde van Niekerk	2016	1.0319	**41.70**	1.1062	47.60	Marita Koch	2006
800 m	1:40.91	David Rudisha	2012	1.0537	**1:35.77**	1.1226	1:53.28	Jarmila Kratochvilová	1983
1,500 m	3:26.00	Hicham El Guerrou	1998	1.0643	**3:13.55**	1.1168	3:50.07	Genzebe Dibaba	2015
Marathon	2:01:39	Eliud Kipchoge	2018	0.9973	**2:01:59**	1.1021	2:14:04	Brigid Kosgei	2019

The article EM9201 is also used in Figure 13.1 of the STAT 221 Course Materials and it is cited at the end of Figure 16.1 of the STAT 231 Course Materials.

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