RUNNING AND SWIMMING WORLD RECORDS

This paper is dedicated to Professor Archibald Vivian Hill on the occasion of his 90th birthday.

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"In the data of athletic records we have a store of information available for physiological study."

A. V. Hill in "The Physiological Basis of Athletic Records", The Scientific Monthly, 1925.

TABLE I
RUNNING AND SWIMMING WORLD RECORDS AFTER MONTREAL 1976

	DISTANCE METERS	MEN			WOMEN		
		NAME-YEAR	RECORD TIME	% MAXIMUM VELOCITY	NAME-YEAR	RECORD TIME	% MAXIMUM VELOCITY
RUN	100	J. HINES (1968)	9.95	100.00	A. RICHTER (1976)	11.01	100.00
	200	T. SMITH (1968)	19.80	100.51	I. SZEWINSKA (1974)	22.21	99.14
	400	L. EVANS (1968)	43.86	90.74	I. SZEWINSKA (1976)	49.29	89.35
	800	A. JUANTORENA (1976)	1:43.50	76.91	F. KAZANKINA (1976)	1:54.90	76.66
	1500	F. BAYI (1974)	3:32.20	70.33	F. KAZANKINA (1976)	3:56.00	69.98
	3000	B. FOSTER (1974)	7:35.20	65.58	L. BRAGINA (1975)	8:27.12	65.13
	5000	E. PUTTEMANS (1972)	13:13.00	62.74			
	10000	D. BEDFORD (1973)	27:30.80	60.27	C. VAHLENSIECK (1975)	34:01.40	53.93
	42000	D. CLAYTON (1969)	2:08:34.	54.17	J. HANSEN (1975)	2:38:19.	48.68
SWIM	100	J. MONTGOMERY (1976)	49.99	100.00	K. ENDER (1976)	55.65	100.00
	200	B. FURNISS (1976)	1:50.29	90.65	K. ENDER (1976)	1:59.26	93.33
	400	B. GOODELL (1976)	3:51.93	90.10	P. THUMER (1976)	4:09.89	89.08
	800	S. HOLLAND (1976)	8:02.91	82.81	P. THUMER (1976)	8:37.14	86.09
	1500	B. GOODELL (1976)	15:02.40	83.10	J. TURALL (1974)	16:33.94	83.98

Analyses of current world records (Table I) show that the decline of speed with distance is greater in running than in swimming. Figs. 1 and 2 indicate the magnitude of the decline expressed for each world record (WR) as percentage of velocity of the 100 m speed.¹ In terms of their duration, the 1,500 m running and the 400 m free style swimming events are comparable: Within less than 4 minutes runners lose about 30% velocity, swimmers only 10%;² within about ¼ of an hour runners lose 37% (see Putteman's 5000 m WR), swimmers only 17% (see Goodell's 1500 m WR).

TABLE II

EVENT	DISTANCE	TIME			
		MEN		WOMEN	
Running	100 m	9.95 sec.		11.01 sec.	
Swimming	100 m	49.99 sec.		55.65 sec.	
(New record by J. SKINNER of 49.44 pending.)					
		min.	sec.	min.	sec.
Running	1,500 m	3	: 32.2	3	: 56.0
Swimming	400 m	3	: 51.93	4	: 09.89

Fig. 3. Roentgenometric demonstration of the change of heart size in relation to posture and immersion in a bath (Subject W.J.). The lines to calculate heart volume from the postero-anterior (left) and the lateral projection (right) have been drawn. Note the increase in curvature of the contour of right atrial silhouette with increasing heart volume indicating a preferential volume uptake and distension of the atrium

Photograph — Otto Gauer

Fig. 1

The differences in rates of decline of velocity become greater with increasing distances. On the whole runners lose speed at rates almost three times greater than swimmers.

What are the causes of this discrepancy? The answer has come from recent investigations into the state of weightlessness, a problem of major importance for space medicine. During immersion of the body in water which simulates the state of weightlessness, the heart enlarges and expels more blood with each systole. Since the swimmer lies in the water horizontally his heart's ability to expel blood forward is further enhanced. Also, the cool environment causes blood to be diverted from the skin to the central circulation.

The roentgenograms in figure 3 were obtained by Professor Otto Gauer of Berlin. Cardiac volume of the person standing was 698 ml; after adoption of the supine position, 771 ml; and following immersion, 922 ml.

Thus the heart of swimmers enjoys three advantages: weightlessness, the horizontal body position, and the cooling effect of the water.

"That people think to some degree in logarithms, although unconsciously, is shown by the fact that the records which men have thought worthwhile to make are distributed approximately uniformly if thus plotted."

A. V. Hill, 1925

Fig. 2

The progressive limitation of speed with increasing distances reveals a biological law whose determining influence is expressed by the parallelism of the two lines in figs. 4a and b, plotted on double logarithmic scales using the pre-Montreal World Records. One line depicts the decrease of running velocities from 100 to 5,000 m; the

Men's World Records
in Running (100m-5000m) and Swimming (100m-1500m)
June 1976
Double Logarithmic Scales

Fig. 4a

Women's World Records in Running (100 m - 3000 m) and Swimming (100 m - 1500 m)

June 1976
Double Logarithmic Scales

Fig. 4b

Comparison of Men's and Women's World Records in Running (100 m - 42200 m)

June 1976
Double Logarithmic Scales

Fig. 5

other that of swimming velocities from 100 m to 1,500 m. The law thus identified pertains to rates of production of kinetic energy. Irrespective of the physiological differences between swimming and running, the time relation of the two clusters of world records is modified by a common metabolic determinant, a fact recognised 50 years ago by A. V. Hill. The time relations of running and swimming are the same for the post-Montreal records shown in Table I, also in respect of the computations for Figs. 5-7.

In figs. 5 and 6, swimming and running records for men and women are plotted in relation to distances,

Comparison of Men's and Women's World Records in Swimming (100 m - 1500 m)

June 1976
Double Logarithmic Scales

Fig. 6

Percentage Values of Maximal Velocities of Men and Women in Running (100 m - 42200 m), Computed from World Records

June 1976
100 m World Record = 100% Maximal Velocity

Fig. 7

again on double logarithmic scales. Surprisingly the mathematical progression demonstrated with the data presented in fig. 4, applies to races up to 42,000 m. Percentage rates of velocities assessed from women's WRs are slightly lower than those assessed from men's world records. (Fig. 7).

Hill was the first to ponder the fact that the decrease of speed with increasing time occurs in accordance with mathematically identifiable laws. The latter he deduced

Fig. 8

Fig. 9

from the world records of the early twenties which were of course very different from what they are today; at the 1920 Olympic Games at Antwerp Charlie Paddock won the 100 m sprint in 10.8 sec, and Duke Kahanamoku came first in the 100 m free style swimming race in 1 : 01.4. The women's gold medal in the same event went to Ethelda Bleibtren who clocked 1 : 13.6. The 100 m race

for women was introduced into the Olympic programme at Amsterdam in 1928: Elizabeth Robinson won in 12.2 sec.

The mathematical relationship between velocity and distance computed from world records was of the same order in 1925 as it is now. To exemplify the growth of

% Deviation of Mexico City Winning Times
from World Records 1968
Men

Fig. 10a

% Deviation of Munich Winning Times
from World Records 1972
Men

Fig. 10b

% Deviation of Montreal Winning Times
from World Records 1976
Men

Fig. 10c

performances during the past decades we present fig. 8. Petra Thumer's world record time of 4 : 09.89 surpasses Don Scholander's world record of 1964.

Jenny Turrell's 1974 1,500 m world record-time of 16: 33.9 is better than that of all winners of the men's races at Olympic Games prior to 1972. It will soon be improved further.

As regards running performances today we refer to Jackie Hansen's 1975 Marathon world record of 2 : 38.10 which would have sufficed to beat Olympic Gold Medalists Spiridon Louis (Athens 1896), Michel Theato (Paris 1900), John Hayes (London 1908), Kenneth MacArthur (Stockholm 1912), and Albin Stenroos (Paris 1924).

Most world records are likely to be improved but at different rates. In a few athletic disciplines, e.g. the long jump, the limits of records seem to have been reached; in others, e.g. the sprints their outlines are in sight, Fig. 10a, b, c; while some sports e.g. swimming are still *in statu nascendi* and an estimate of records is as yet not possible, Fig. 11.

1500m FREE STYLE SWIMMING (MEN)

Fig. 11