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Energetics of World Running Records: Lloyd's Equations Revisited for the Millennium

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Introduction: Analysis of the energetics of world running records has been intriguing to scientists since R. M. Sargent (1) and A. V. Hill (2) evaluated the physiological basis of these records in the 1920's. An extensive analysis of world running records was conducted in the mid 1960's by B. B. Lloyd (3, 4) of Oxford University in England for distances between 50yd and 623 miles and records attained in 1965. A relationship between distance run and run time was reported which corresponded to the equation: $y=S/B+t(R-A)/B$, where intercepts equate to energy stores and slopes to rates of energy supply. For shorter distances *S* (a runner's energy store) is small, while *R* (the rate of energy expenditure) is large, whereas for longer distances *S* is larger and *R* smaller. *A* was defined as the non-running metabolism and *B* represents average calories/meter for a 72 kg adult male. Furthermore, Lloyd's equations revealed that: *log meters run=1.11+0.9 log seconds run time*. Since limited data was available at that time for adult female runners (i.e., times were recorded for distances through 880yd for females) a comparison for males and females was less feasible than today. The purpose of this abstract is to present an analysis of current world and American records for both males and females based on Lloyd's equations. **Methods:** World and American adult, as well as junior, male and female records set by the Spring 1999 were utilized in the analysis. Records included in the analysis were for 10 events: 100m, 200m, 400m, 800m, 1500m, Mile, 3000m, 5000m, 10,000m, and the marathon (5). **Statistics:** Run distance and time data was compared by linear regression analysis using log transformations of the run time data. **Results:** Regression equations generated from current world and American record data for both males and females were comparable to Lloyd's findings from the 1960's:

Population	*World Records*	*American Records*
Adult Males	y=1.12+(0.896)log seconds	y=1.13+(0.891)log seconds
Junior Males	y=1.11+(0.897)log seconds	y=1.13+(0.885)log seconds
Adult Females	y=1.09+(0.889)log seconds	y=1.09+(0.887)log seconds
Junior Females	y=1.09+(0.887)log seconds	y=1.09+(0.878)log seconds

Discussion: This analysis revealed that Lloyd's equations remain valid for current world and American running records for both males and females. Minor variations in intercepts and slopes were noted for males and females, as well as between world and American record categories. All American record times in distance events, between 800m and the marathon are slower than world records. This is most evident for the 800m, 1500m, 3000m, 5000m, and 10,000m events. Previous research confirmed that Lloyd's model was valid at the 1500m distance for healthy male runners, and that run time was inversely correlated with increased VO_2max (6). In summary, Lloyd's model remains applicable for contemporary running records, and supports his concept that the energetic relationship between event distance and run time can be accurately represented as a function independent of running velocity. The effects of altitude on the predictive value of the model remain to be studied. Finally, in 1966 Lloyd predicted men's world record running times for the year 2000. In general, his predictions are close but the times are slightly faster than the actual 1999 records (e.g., in the mile, 10,000m, and marathon events). As run distance increases, physiologic variation in metabolic transition zones (i.e., anaerobic to aerobic) may account for minor overestimates of predicted times offered by Lloyd 34 years ago. **References:**

1. Sargent RM. *Proc Roy Soc* [Biol]. 100:10-22, 1926. **2.** Hill AV. *Proc Roy Soc* [Biol]. 102:380-385, 1928. **3.** Lloyd BB. *Advance Sci*. 22:515-530, 1966. **4.** Lloyd BB. *Circ Res* 20-21, S1:I-218:226., 1967. **5**. USA Track and Field Association, World and American Records, 1999. Indianapolis, IN: Online. Available: http://www.USATF.org. **6**. Camus G. et al. *J Physiol*., Paris. 80:3-7, 1985.