

The Relationship between Drag Forces and Velocity for the Four Competitive Swimming Strokes

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Previous research has shown that the relationship between drag force (F_d) and velocity (v) in swimming freestyle can be determined using a curve of maximum power generation vs. maximum swimming velocity. Sanders et al. (2001) found the relationship for the active drag of freestyle to be a power fit $F_d=20.72v^{2.48}$. **PURPOSE:** To determine the relationships between the maximum velocity (v_{max}) and the maximum power (P_{max}) during each of the four competitive swimming strokes and to derive the velocity dependence of active drag force for each of these strokes. **METHODS:** 192 competitive swimmers (butterfly, $n=10$, 16 ± 3.2 yrs; backstroke, $n=13$, 15.9 ± 3.6 yrs; breaststroke, $n=13$, 14.8 ± 4.3 yrs; freestyle, $n=156$, 17 ± 2.3 yrs) completed tests to measure v_{max} and P_{max} . Power was calculated using the product of average velocity and resistance force from a weight and a pulley system over a 10m maximal effort swim. P_{max} was determined by progressively increasing the force of resistance until power peaked. v_{max} was determined using two 13.72m (15y) maximal effort swims. **RESULTS:** Using this type of analysis, the relationship of power to velocity was found to be $P_{max}=11.9 v_{max}^{3.67}$ ($R^2 = 0.97$), $P_{max}=11.1 v_{max}^{3.94}$ ($R^2 = 0.83$), $P_{max}=25.5 v_{max}^{3.20}$ ($R^2 = 0.96$), $P_{max}=11.4 v_{max}^{3.37}$ ($R^2 = 0.85$) for butterfly, backstroke, breaststroke, and freestyle respectively. The actual maximum power generated while swimming is approximately $2.5 \times P_{max}$ (White, 2003), thus yielding relationships between drag force and velocity of $F_d=29.0v^{2.79}$, $F_d=25.3v^{3.30}$, $F_d=64.5v^{2.20}$, $F_d=28.8v^{2.37}$ for butterfly, backstroke, breaststroke, and freestyle respectively. **CONCLUSION:** The relationships of drag force to velocity for the four competitive strokes is consistent with current empirical thinking and ranks the strokes from most to least drag as Breaststroke, Backstroke, Butterfly, and Freestyle.