RESISTIVE FORCES AND TECHNIQUE ANALYSIS IN FRONT CRAWL SPRINT SWIMMING

By

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Abstract

Free swimming is the main component of a swim performance and is the most complex to understand. Using the Assisted Towing Method (ATM), developed at the Australian Institute of Sport, this thesis was designed to investigate resistive forces (active drag) and how this method could be integrated into the assessment of free swimming technique. Four investigations were conducted to assess the ATM protocol for integration as an objective assessment tool for coaches, scientists and athletes in front crawl sprint swimming. The aim of study 1 was to examine the reliability of the mean active drag values collected using the ATM. Results indicated that towing the swimmers whilst permitting intra-stroke fluctuations (ICC = 0.94, 0.88-0.97) allowed the swimmer to produce a higher level of reliability values than when being towed with a constant velocity (ICC = 0.83, 0.57-0.94). A considerably lower amount of percentage error was found in the fluctuating trials (CV_{TE} % = 12.6) than the constant trials (CV_{TE} % = 35.0). The aim of study 2 was to compare the stroke mechanics (stroke lengths and rates) of a free swim and an assisted tow trial to determine whether the ATM protocols alter stroke mechanics. Results indicated a significant increase in stroke lengths and rates occurred when swimmers completed the ATM protocol. However, the ratio of stroke length and stroke rate in the assisted condition was found to significantly predict ratios of stroke mechanics in free swimming (r = 0.95). It was concluded that when using the ATM protocol it is possible to transfer technique critiques found in assisted swimming and apply them to free swimming. The aim of study 3 was to investigate instantaneous active drag force-time profiles and deconstruct them into stroke phases. The total sample was split into groups to identify differences between male and female, and elite and sub-elite swimmers. A consistent biphasic curve was found between all elite swimmers and stroke phases could be identified within a profile. The sub-elite group, however,

produced multiphasic curves which could be linked to anthropometric differences, slower velocities, or inconsistent propulsion generation during the propulsive stroke phases. The aim of the final study, study 4, was to quantify technique through the use of a coach feedback survey and identify whether a relationship existed between coach ratings of technique and active drag force-time profiles. Eight coaches were provided with a survey which included still images and video clips of thirty swimmers. Coaches were asked to rate technique on a simplified Likert scale. The coach ratings were then correlated against force data at the same time points. Findings revealed a range of low to moderate internal consistencies between coach ratings in all swimmers, thus indicating a major limitation of using the coach feedback survey in its current form. Alternatively, these low consistencies were maybe a direct result of coaches not being able to quantitatively assess swim technique as the norm is to assess qualitatively whilst on pool deck. The results found in this study should be interpreted with caution as only weak correlations were found between coach ratings and force-time profiles. Four main additions to the area of swimming biomechanics were concluded from this thesis: 1) the ATM protocol is a reliable tool to capture kinetic information for the assessment of free swimming; 2) a consistent increase was observed in stroke length and stroke rate between free swim and assisted towed trials which could enable the transfer of technical assumptions from assisted tow trial outputs to free swimming; 3) the ATM active drag force-time profiles revealed the possibility of an optimal profile being established within the elite sprint swimmers thus enabling the ATM to be used in the future as an objective assessment of technique; and 4) a novel tool was presented which has potential to quantify technique proficiency with further investigation.

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List of Abbreviations

3D	Three Dimensional
A	Frontal Surface Area
AIS	Australian Institute of Sport
ANOVA	Analysis of Variance
ATM	Assisted Towing Method
C_D	Drag Coefficient
CFD	Computational Fluid Dynamics
CI	Confidence Intervals
CI_U	Confidence Intervals Upper
CI_L	Confidence Intervals Lower
CV	Coefficient of Variation
$CV_{TE}\%$	Typical Error Coefficient of Variation Percentage
$\frac{d}{dt}$	Derivative
D	Swimming Drag
D_A	Active Drag
D_{AE}	Active Drag Event
D_b	Drag Force with added resistance
D_F	Drag Force
F_b	Drag Force with added assistance
FINA	The Federation Internationale de Natation Amateur
FS	Free Swimming
ICC	Interclass Correlations

IdC	Index of Coordination
K	Constant value
MAD-System	Measuring Active Drag System
m	Mass
m/s	metres per second
N	Newtons
η_P	Propelling efficiency
P	Propulsion
ρ	Density of fluid
PB	Personal Best
P_d	Useful Power
P_o	Mechanical Power Output
SD	Standard Deviation
SL	Stroke Length
SR	Stroke Rate
TE	Typical Error
TS	Towed Swimming
v	Swim Velocity
v_1	Swim Velocity
v_2	Assisted Swim Velocity
v_b	Resisted Swim Velocity
VO_{2net}	Net Maximal Oxygen Consumption
VPM	Velocity Perturbation Method

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Publications from Doctoral Thesis

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