Relationship Between Arm Coordination and Muscle Activation in 200-Meter Front Crawl Swimming

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Summary

This study investigated the Index of Coordination (IdC) and muscle activation in elite swimmers under varying speeds. The result from this study found that IdC and stroke frequency increased with speed, while the latissimus dorsi exhibited significant activation across all speeds. At maximum effort, latissimus dorsi activation positively correlated with IdC, highlighting its impact on stroke stability and the need for targeted training.

Introduction

The IdC is a crucial parameter in swimming biomechanics, used to evaluate the efficiency of stroke techniques. Research has shown that IdC is influenced by various factors, such as activation levels, skill proficiency, and stroke technique parameters. Moreover, previous studies have indicated that different swimming speeds significantly impact IdC.

Therefore, this study aims to explore the variations in the IdC under different speed conditions and its relationship with muscle activation among elite swimmers.

Methods

Seven male university-level elite swimmers participated in this study. Each swimmer performed three 200-meter front crawl tests at intensities corresponding to 80%, 90%, and maximum effort of their best performance record from competitions.

Stroke parameters were recorded using wireless inertial measurement units (Blue Trident, Vicon, UK) attached to the swimmers' wrists. The raw signals were low-pass filtered, and the entry, catch, push, and recovery phases of the stroke were identified. Average stroke frequency and the IdC were calculated for every 50-meter segment of the trials[1][2].

Electromyographic (EMG) signals were collected from the bilateral pectoralis major, latissimus dorsi, triceps brachii, biceps brachii, deltoid, and pronator teres muscles using waterproof surface EMG electrodes (MiniWave, Cometa, Italy). The signals were processed through a band-pass filter (20–450 Hz, fourth-order Butterworth). The median frequency of the EMG power spectrum were selected as primary outcome measures. Activation level was evaluated by analyzing changes in median frequency between strokes using Fast Fourier Transform.

Results and Discussion

Both the IdC and stroke frequency increased significantly with swimming speed (IdC: $F(2,12) = 11.74$, $p < .01$, $\eta^2 = .66$; SF: $F(2,12) = 54.38$, $p < .01$, $\eta^2 = .90$). The increase in stroke frequency reflects an adaptive strategy to meet the demands of higher speeds, while the improvement in IdC suggests that swimmers focus a greater proportion of time on the propulsion phase to maintain velocity.

EMG analysis further indicated that only the latissimus dorsi exhibited significant decreases in median frequency across all three speed conditions. This result agrees with previous findings that identify the latissimus dorsi as a primary propulsion muscle in swimming, operating near its maximal capacity even at submaximal speeds[2].

Under maximum effort conditions, a significant positive correlation was observed between the percentage decrease in the median frequency of the latissimus dorsi and the IdC (left latissimus dorsi: $R = .55$, $p < .01$; right latissimus dorsi: $R = .40$, $p < .05$). This suggests that the increased demand for force output and time proportion in the propulsion phase may directly affect the force production of the latissimus dorsi and the stability of stroke technique.

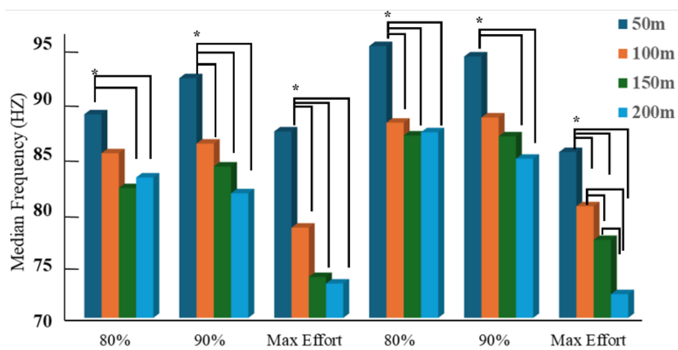

Figure 1: Segmental Changes in Median Frequency of EMG Across Different Speeds.

Conclusions

Stroke frequency and the IdC increase with speed, reflecting propulsion adaptations. Significant latissimus dorsi activation impacts stroke stability, especially under maximum effort. These findings emphasize the importance of targeted training to enhance swimming performance and mitigate the effects of muscular activation on stroke technique.

References

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[2] Huang C. (2022). Master dissertation. National Taiwan Normal University.
[3] Puce L et al. (2023). *Life-Basel*, **13**(11): 2129.