Core and Lower Limb Muscle Activation Symmetry in Long-Distance Athletes During a 200-Meter Swimming

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Summary

This study investigated swimming efficiency through the analysis of body mechanics and muscle activation symmetry during the 200-meter stroke. The findings reveal that Erector spinae activation significantly increased across rounds, highlighting its role in trunk stabilization under fatigue. External oblique activation also rose but was not significant, suggesting a compensatory role. Stable activation in other muscles indicates consistent neuromuscular control. These findings stress the need for core endurance training, focusing on the erector spinae and external obliques, to improve long-distance swimming performance.

Introduction

The muscles associated with the core are important for the torsion of the upper and lower limbs, and they play a role in stabilizing the torsion of the shoulder and hip [1]. The jet stroke is the fastest stroke, which requires muscular endurance, explosiveness and rhythm control, while long-distance runners need to achieve core stability through pace and technique. Kicking is essential for body roll and speed performance. Stabilizing the lower limbs can help reduce torso inclination and increase speed when sprinting [2].

Methods

6 male long-distance Front Crawl swimmers were recruited for the study with no shoulder pain and no history of muscle, bone, or nerve-related diseases, injuries, or surgeries that could have impacted their strokes in the past six months.

This study used a waterproof EMG device (2400 Hz) and six VICON Blue Trident sensors (120 Hz) to analyze motion and muscle activation. EMG electrodes were placed on Bilateral Gluteus Maximus, Quadriceps Femoris, External Obliques, Rectus Abdominis and Spinal Fasciculus. Muscle activations were recorded during 200-meters Front Crawl swimming. SPSS 23.0 was used for two-factor ANOVA to compare muscle activation percentages, followed by LSD post-hoc tests. A significance level set at $\alpha = .05$.

Results and Discussion

Muscle activation levels for the external oblique, rectus abdominis, erector spinae, gluteus, and quadriceps were analyzed across four rounds. The external oblique showed an increase from the first ($M = 0.813 \pm 0.142$) to the fourth round ($M = 0.937 \pm 0.136$), with the rounds effect approaching significance ($F = 6.883$, $p = 0.074$). The rectus abdominis showed slight fluctuations without significant differences across rounds ($F = 3.471$, $p = 0.167$), between sides ($F = 1.007$, $p = 0.362$), or in the interaction ($F = 2.511$, $p = 0.235$). The erector spinae demonstrated a significant increase in activation from the first ($M = 0.861 \pm 0.109$) to the fourth round ($M = 0.960 \pm 0.090$) ($F = 124.568$, $p = 0.008$), with no significant side ($F = 0.548$, $p = 0.500$) or interaction effects ($F = 1.249$, $p = 0.474$).

The significant increase in erector spinae activation from the first to the fourth round highlights its growing role in trunk stabilization as fatigue develops, essential for maintaining body alignment and reducing drag. Although external oblique activation also increased, it did not reach statistical significance, suggesting a potential compensatory role in rotational control under fatigue. In contrast, the rectus abdominis, gluteus, and quadriceps showed stable activation with no significant changes, indicating consistent neuromuscular control. These findings underscore the importance of core endurance training, particularly targeting the erector spinae and external obliques, to support performance in long-distance swimming.

Table 1: Maximal muscles activation during 200-meters Front Crawl Swimming. (mean ± standard deviation)

		External Oblique	Rectus Abdominis	Erector Spinae	Gluteus	Quadriceps
1 round	right	.860±.318	.512±.335	.856±.129	.898±.411	1.398±.985
	left	.767±.428	.532±.389	.866±.377	.767±.361	1.765±1.773
2 round	right	.843±.236	.478±.297	.778±.178	.815±.318	1.308±.878
	left	.713±.388	.458±.332	.812±.196	.658±.296	1.603±1.316
3 round	right	.843±.246	.445±.312	.786±.188	.758±.278	1.282±.766
	left	.770±.430	.510±.359	.898±.289	.653±.265	1.600±1.355
4 round	right	1.010±.328	.462±.290	.924±.208	.882±.333	1.447±.767
	left	.867±.445	.560±.354	.996±.286	.790±.418	1.850±1.473
F-value and *P* for L/R sides		.645/.458	1.007/.362	.548/.500	4.222/.095	1.293/.307
F-value and *P* for the rounds		6.883/.074	3.471/.167	124.568/.008	1.367/.398	3.129/.187
F-value and *P* between sides/rounds		7.262/.069	2.511/.235	1.249/.474	4.740/.117	.526/.695

Conclusions

Bilateral external oblique activation during the fourth round has significance increase. While the upper limb muscles served as the primary propulsive force, the rectus abdominis played a key role in maintaining trunk stability. Additionally, long-distance swimmers exhibited greater asymmetry in gluteal muscle activation, suggesting a higher reliance on lower limb kicking. These findings provide valuable insights for talent identification and the development of optimized training strategies.

References

[1] Andersen et al. (2020). *The Journal of Strength & Conditioning Research,* **34**(1), 20-25.

[2] Gourgoulis et al. (2014). *Journal of Sports Sciences,* **32**(3), 278-289.