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Biochemical evaluation of muscle function during long distance fin swimming

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Introduction: Fin swimming is a new sport characterised by the fact that the feet of the swimmer are placed in a single large fin. Its dimensions are not specified by regulations except for third class championship, where they are 60 cm × 60 cm. The arms are stretched forward while the athlete maintains the head underwater, breathing through a respirator. Propulsion is achieved by an oscillatory motion closely resembling the movement of the trunk and legs in butterfly swimming.

Little is known about the biochemical and functional changes accompanying fin swimming [1, 2]. We have therefore taken advantage of the second world championship of long distance fin swimming to examine certain biochemical parameters of skeletal muscle function of participating athletes. These are plasma lactate concentration, which indicates the degree of anaerobic metabolism in exercising muscles, and plasma creatine kinase and aldolase activity, whose elevation has been associated with muscle fibre damage (rhabdomyolysis).

Materials and methods: Nine male and six female elite endurance fin swimmers consented to participate in the study. Males swam a distance of 8,000 m and females, 6,000 m in the open sea. Water temperature was 20–22°C. A brief history and physical examination was performed on each subject.

Three blood samples were drawn from their antecubital vein: one before the event, one 5–10 min after the finish for lactate determination, and another 6–7 h after the event for the assay of creatine kinase (EC 2.7.3.2) and aldolase (fructose bisphosphate aldolase, EC 4.1.2.13) activity. All three determinations were performed in plasma using reagent kits from Boehringer-Mannhein (catalogue numbers 149 993 for lactate, 1 087 533 for N-acetylcysteine-activated creatine kinase and 123 838 for aldolase).

Results were expressed as means ± SD, and statistical analysis was performed using signed rank tests. The level of significance was set at $p = 0.05$.

Results and discussion: Anthropometric and performance data of participating swimmers are recorded on Table 1. Table 2 presents values for the three biochemical parameters determined. In all three cases an increase was observed after the event. The percentage increases, along with the level of statistical significance of each change, are also shown.

The mean plasma lactate concentration in males rose to a moderate 3.5 mmol L^{-1} after finish. Although this was almost twice the resting value, the difference was not significant. The increase in lactate concentration was higher and statistically significant in females, indicating that there was a more intense shift toward anaerobic glucose catabolism in both relative and absolute terms. Since the blood was drawn 5–10 min after the finish, to allow for equilibration with the intramuscular lactate concentration, the values obtained correspond mainly to the intensity of the final sprint. Taking into account this and the fact that the final values are below what is considered [4] to mark the anaerobic threshold (4 mmol L^{-1}), we infer that muscle metabolism during the contest was predominantly aerobic, as might have been expected for an endurance sport.

Table 1: Characteristics of subjects in study (means ± SD).

	Males (n = 9)	Females (n = 6)
Age (yr)	19.2 ± 3.2	17.5 ± 1.9
Height (m)	1.82 ± 0.09	1.63 ± 0.03
Mass (kg)	73.2 ± 8.7	55.7 ± 4.6
Lean body mass (kg)[a]	64.8 ± 5.8	47.8 ± 3.7
Time to finish (min)	101.81 ± 4.48	83.73 ± 5.68
Average speed (m s^{-1})	1.323 ± 0.071	1.198 ± 0.074

[a] *Calculated as described [3].*

Significant increases were observed in the plasma activities of creatine kinase and aldolase. Such changes have been attributed to increased permeability of the sarcolemma after intense muscle work and to consequent leakage of sarcoplasmic enzymes into the bloodstream [5]. The increases correspond directly to the intensity of exercise [6]. Significant changes in creatine kinase activity have been observed as early as 5 h after exercise [7]. Peak enzyme levels have been reported most often 1 day post-exercise [6, 8, 9], while other investigators [10–13] have found maximal activities somewhat earlier. Apparently different exercises and different training programmes influence not only the magnitude of changes in the activity of enzymes but also the kinetics of their appearance in the blood and clearance from it.

In our study the latest possible time when we could obtain the third sample from the athletes was 6–7 h after competition. At this point muscle enzyme accumulation in blood is probably on the rising phase. Nevertheless, the increases we found are among the highest recorded in the literature, pointing to considerable muscle fibre damage. This is even more noteworthy in view of the fact that prolonged traditional swimming has been reported to have at most moderate effects on the blood activities of muscle enzymes [5, 14]. On the other hand, it has been suggested that the intensity of muscle mass effort in fin swimming is much higher than that in traditional swimming on the grounds of blood lactate and heart rate measurements [1]. Our results support this view.

The changes in creatine kinase activity were higher than the corresponding alterations in aldolase activity, showing that the former is a more sensitive index of rhabdomyolysis. This is in accordance with reports by other investigators who have examined blood creatine kinase and aldolase [14] or other enzymes [6, 8, 10, 11, 15] after intense exercise.

The changes in both creatine kinase and aldolase activity were more profound in females than in males, although an opposite result on creatine kinase has been reported [6]. The different exercise protocol employed and the fact that that

Table 2: Plasma lactate concentration, creatine kinase (CK) activity and aldolase activity before and after long distance fin swimming (means ± SD).

	Males (n = 9)			Females (n = 6)		
	Before	After	% Increase	Before	After	% Increase
Lactate (mmol L^{-1})	1.8 ± 0.7	3.5 ± 1.8	94 NS	1.2 ± 0.9	3.9 ± 2.8	225*
CK (U L^{-1}, 30°C)	113 ± 63	355 ± 173	214*	104 ± 48	475 ± 381	357*
Aldolase (U L^{-1}, 37°C)	8.9 ± 0.9	14.1 ± 3.8	58**	3.4 ± 0.8	11.6 ± 2.1	241**

*After as compared with before swimming, * $p < 0.05$; ** $p < 0.001$; NS = not significant.*

study involved untrained individuals may account for the discrepancy. Finally, no significant correlation was found between performance in the race and any of the three biochemical parameters measured.

In conclusion, our data indicate that muscle contraction during long distance fin swimming is fuelled mainly by aerobic catabolic processes. This sport is particularly strenuous, as evidenced by the dramatic elevation of the activities on muscle enzymes in plasma. Based on the higher relative increases of all three biochemical indices in females than in males, the toll of the musculature of the former appears to have been heavier than on that of the latter, despite the shorter distance they swam.

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