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RELATIONSHIPS AMONG SURFACE ELECTROMYOGRAPHY MEASUREMENTS AND ATHLETIC PERFORMANCE IN SWIMMERS

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Abstract: The aims of this study were to investigate the association among neuromuscular responses and athletic performance in swimmers during a training macrocycle. Thirty teenage swimmers were divided were evaluated during twenty weeks, scheduled on three stages. Besides athletic performance, surface electromyogram was realized on deltoideus medius and rectus femoris muscles. Maximal isometric strength results have showed direct correlation with jump ($p<0.01$), strengh ($p<0.05$) and power ($p<0.001$) measures for deltoideus medius and rectus femoris muscles. Maximal isometric strength was directly correlated with athletic performance in swimming.

Keywords: muscle fatigue, electromyography, muscle contraction, swimming performance.

Introduction

Changes of skeletal muscle activation sustained by disorders in strength generation as well as time to exhaustion or limit time have been associated with declined contractility, which can be also aggravated by athletic training [1]. In this aspect, muscle fatigue and athletic performance effects induced by physical training have been studied based on different biomechanical and physiological variables [1, 2].

Based on this, the present study was purposed to investigate the association among neuromuscular responses and athletic performance in swimmers during a training macrocycle.

Materials and methods

Thirty trained athletes (12-17 years old; 10 women and 20 men) were recruited from a swimming team. The prospective study was developed during a 20-week macrocycle. The collect of data was organized in four moments: initial moment (M1); End of the general preparation (M2); End of the specific preparation (M3) ; and end of the competitive period (M4). Sports performance and EMG tests were developed on all moments of evaluation. The investigation was approved by the Research and Ethics Committee of the Federal University of Mato Grosso do Sul (UFMS), approval nº 1.300.377, CAAE 46913915.3.0000.0021.

Sports performance was assessed by tests of strength [3], speed [3], power [4] and resistance [5]. With regard to the evaluation of EMG, each participant performed three maximal isometric voluntary contractions (MIVC). In order to determine maximal isometric strengh (MI) of shoulder abductors, each subject was maintained on standing position; shoulder and elbow of the dominant upper limb were positioned at 90° of abduction and flexion, respectively. Subsequently, subjects were instructed to perform MIVC by means of traction in a cable. Relative knee extensors, the strength was obtained with use of an extensor chair developed especially for the present study. On a sitting posture and with hip, knee and ankle at 90° position the volunteers were oriented to perform MIVC, as previously described [6].

After determination of MI, the subjects were also submitted to a test to induce muscle fatigue, against 50% of previous MI until task failure (exhaustion). The limit time to task failure (exhaustion time) was recorded.

Statistical analysis

RMS and MF values were obtained from successive 0.5 second packs and normalized in the time base and by highest MICV. Linear regression of RMS and MF values in function of the endurance time was calculated.

The association between variables was assessed with Pearson's correlation coefficient. Level of significance was considered to be 5%.

Results

Correlation between neuromuscular profile and athletic performance measurements in swimming is presented on Table 1. Despite of moment of evaluation, maximal isometric strength results have showed direct correlation with jump, strength, and power measures for *deltoideus medius* and *rectus femoris* muscles. Instead, significant correlations between MI and endurance were observed for both muscles, only at the first moment.

Moreover, MI was inversely correlated with speed for both muscles in almost all moments, except for *rectus femoris* at the M2. Other possible correlations were not statistically significant.

Table 1: Correlation between maximal isometric strength and measurements of athletic performance according period and peripheral muscle

Moment	Muscle	Performance variables				
		Jump r (p-value)	Strength r (p-value)	Power r (p-value)	Speed r (p-value)	Endurance r (p-value)
M1	DM	0.449 (0.013)*	0.519 (0.003)*	0.660 (0.000)*	-0.481 (0.007)*	0.445 (0.014)*
	RF	0.466 (0.009)*	0.543 (0.001)*	0.700 (0.000)*	-0.414 (0.023)*	0.474 (0.008)
M2	DM	0.584 (0.000)*	0.390 (0.033)*	0.770 (0.000)*	-0.423 (0.020)*	-0.060 (0.755)*
	RF	0.438 (0.015)*	0.403 (0.027)*	0.710 (0.000)*	-0.285 (0.127)	0.288 (0.122)
M3	DM	0.548 (0.001)*	0.481 (0.007)*	0.736 (0.000)*	-0.494 (0.005)*	0.028 (0.882)
	RF	0.579 (0.000)*	0.635 (0.000)*	0.797 (0.000)*	-0.411 (0.024)*	0.218 (0.247)*
M4	DM	0.480 (0.007)*	0.520 (0.003)*	0.613 (0.000)*	-0.532 (0.002)*	-0.007 (0.971)
	RF	0.589 (0.000)*	0.653 (0.000)*	0.617 (0.000)*	-0.544 (0.001)*	0.174 (0.358)

M1, initial period; M2, period of general preparation; M3, period of specific preparation; M4, competitive period; DM, deltoideus medius muscle; RF, rectus femoris muscle. * $p<0.05$, Pearson's correlation.

Discussion

With respect to the correlations among EMG and athletic performance parameters, maximal isometric strength has been directly correlated with jump, strength, and power results, while was inversely correlated with speed, during all training macrocycle (Table 1). In a physiological context, voluntary motor unit recruitment integrates the progressive recruitment of small, typically slow, motor units followed in order of increasing size to the larger, typically fast, motor units [7]. Although jump, strength, and power protocols have integrated a preferential recruitment of fast motor units, these fibers are also recruited in order to reach maximal isometric strength.

On the other hand, since speed test has been based on fast muscle activity in terms of excitation contraction coupling, these results have been inversely correlated with maximal isometric strength measurements. Deltoideus medius and rectus femoral muscles are constituted by higher proportion of fast fibers, contributing to improved performance during dynamic and functional tests, which request fast recruitment of muscle fibers, a diverse pattern of activity in relation to isometric contraction.

Based on this information, surface electromyogram study seems to be adequate as additional support to investigate athletic performance. However, it is noteworthy that EMG analyses have been made with specific protocols of study, and might not reproduce sports movements of swimming. Also, other muscles, as biceps brachii or pectoralis major in superior limbs are more directly associated with shoulder's movement during swimming, and they weren't investigated in the present study. Likewise, other authors have studied swimming performance from other parameters, as mean amplitude and frequency values for one stroke cycle [8, 9], during a front crawl swimming race.

However, this is the first paper to document the association between EMG and athletic performance parameters during different moments at a swimming training macrocycle.

Conclusion

Maximal isometric strength was directly correlated with athletic performance in swimming.

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