Maximal and repeated muscular efforts: ergometric and physiological evaluation criteria

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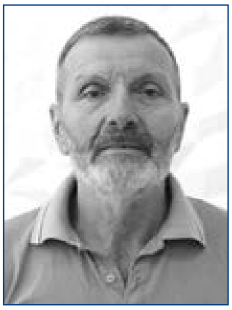

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Abstract

Objective of the study was to analyze strength control patterns for isometric contractions of the rectus femoris in a weightlifting model testing experiment by repeated 5-second maximal strength tests and 1-minute maximal strength keeping tests.

Methods and structure of the study. We sampled for the strength training system testing experiment the 18-20 years old elite sambo fighters (n=8, Candidate Masters of Sports and Masters of Sports) 174-182cm tall and 66-82 kg heavy. The tests were run in laboratory using a pressure platform.

Results and conclusion. The pre- versus post-experimental 5s maximal strength tests of the isometric contractions of rectus femoris found significant progress in the following test rates: peak force by 10.4%; maximal strength by 13.3% and force impulse by 15.5%. The pre- versus post-experimental 1min maximal strength keeping tests found significant progress in the following test rates: peak force by 11.2%; maximal strength by 15.2%; maximal strength reaching time by 14.6%; and the 97% maximal strength reaching time by 15.8%. The strength variation analysis found significant progress in the maximal strength, maximal strength reaching and keeping times with the maximal strength control and fall patterns.

Keywords: *muscular strength, isometric contractions, maximal strength reaching time, maximal strength keeping time, lactic acid, acid-base balance.*

Background. Muscular strength is largely determined by the muscular control and operation mode among the other key factors. Since muscular responses to triggers may be classified into contractions, flections (with length reductions and growths, respectively) and isometric contraction, actual performance in every of these modes depends on the operational setting [1, 3]. Modern sports give multiple examples of dynamic and isometric contractions or both at a time. It is not unusual for many sports (weightlifting, gymnastics, wrestling, etc.) that strength is applied with little or no changes in lengths of the key muscles; although such isometric tensions are commonly considered unhealthy due to the excitation in the relevant nervous centers under stress being soon responded by protective inhibition as the tense muscles squeeze blood vessels to hamper circulation and, hence, performance [1-3].

Objective of the study was to analyze strength control patterns for isometric contractions of the rectus femoris in a weightlifting model testing experiment by repeated 5-second maximal strength tests and 1-minute maximal strength keeping tests.

Methods and structure of the study. The study was designed to analyze strength control patterns for isometric contractions of the rectus femoris by the repeated 5-second maximal strength tests till meaningful strength falls with 30-second rest breaks, and the 1-minute maximal strength keeping tests. The strength variations in the tests were profiled by special software: see Fig. 1 for example. The test data were processed for analysis by the standard Statistica и Excel toolkits.

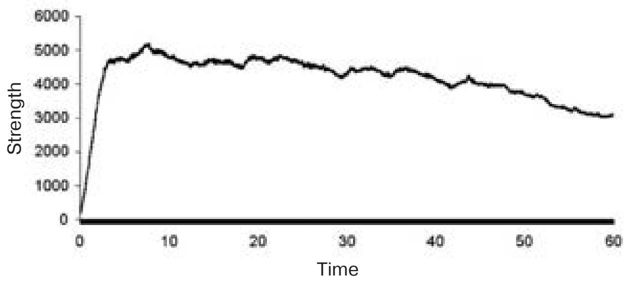
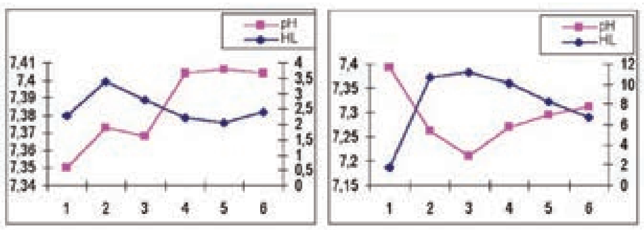


Figure 1. *Strength variation curve in one of the 1-min maximal strength keeping test*

Strength Time

We also tested the acid-base balance and lactic acid variations in the pre- and post-test blood samples on minutes 3, 5, 10, 15 and 20 after the start. The blood acid-base balance (pH) was tested by BMS-2M Microanalyzer (made by Radiometer Co., Denmark); and lactate variations (HL) were tested by Lactate-Plus Photometer (made by Nova Biomedical, USA). Blood biochemistry tracking data are given in Fig. 2. The strength variation curves were computed by a graphoanalytical method using a bi-exponential equation [4].



a b

Figure 2. *pH and HL variations for the isometric contractions of the rectus femoris in (a) repeated 5s maximal strength tests till meaningful stress falls with 30s rest breaks; and (b) 1min maximal strength keeping tests*

The strength training model included power snatches till the legs-apart squat phase for five weeks, with two trainings a week. The sample was tested by the maximal weights in training sessions 1-3, 90% maximums in trainings 4-6 and 80% maximums in trainings 7-9. In every training the athletes were tested by maximal repetitions, with the rest breaks in between the repetitions of 3min, 1min and 30s in training sessions 1, 2 and 3, respectively (9 trainings in total).

Results and discussion. Given in Table 1 hereunder are the strength variations in the repeated 5-s maximal strength pre- versus post experimental tests.

The training experiment was found to meaningfully improve the following test rates: peak force (Fpeak) by 10.4%; maximal strength (Fmax) by 13.3% and force impulse (ΣF) by 15.5%. Given in Table 2 hereunder are the strength variations in the repeated 1-min maximal strength keeping pre- versus post experimental tests.

The above data demonstrate significant progress in the following test rates: F_0 by 15.9%; peak force (Fpeak) by 11.2%; 97% maximal strength (F97%) by 15.2%; maximal strength keeping time (Tmax) by 14.6%; and 97% maximal strength reaching time maximal strength (T1) by 15.8%. We found growth in the maximal strength keeping time (Tud) by 2.2%; 97% maximal strength keeping time 2 (T2) by 7.3%; and force impulse index (ΣF) by 14.9%. Even higher improvements were found in the following test rates: pH to 7.22 from 7.37 mEq*l-1 in the 1min maximal strength keeping test; and lactate to 11.40 Mmol * l-1 from 3.45 Mmol • l-1 in the 1min maximal strength keeping and repeated 5s maximal strength tests, respectively.

Conclusion. As demonstrated by the strength variation analysis, the sample made significant progress in the maximal strength, maximal strength reaching and maximal strength keeping times with the maximal strength control and fall patterns. The experimental training system was found beneficial as verified by the significant progress in the repeated 5s maximal strength and 1min maximal strength keeping tests. The pH and HL rates were found to come back to the pretest levels in the repeated 5s maximal strength tests upon the 20min rest breaks. In the 1min maximal strength keeping tests, the pH and HL rates upon the 20min rest breaks, however, were tested still far from the pretest levels at 7.29 mEq •l–1 and 6.20 Mmol •l–1, respectively.

Table 1. *Strength variations in the repeated 5-s maximal strength pre- versus post experimental tests*

Test rates	Pre-exp.		Post-exp.		Growth, %	p
	x	σ	x	σ		
F_{peak}, H	5169,7	963,5	5710,4	941,0	10,4	< 0,05
F_{max}, H	4516,5	842,5	5119,8	932,6	13,3	< 0,05
K_1, c^{-1}	0,056	0,008	0,047	0,005	-	> 0,05
ΣF, кН	20,6	2,6	23,8	3,3	15,5	< 0,05

Table 2. *Strength variations in the repeated 1-min maximal strength keeping pre- versus post experimental tests*

Test rates	Pre-exp.		Post-exp.		Growth, %	p
	x	σ	x	σ		
F_0, H	4923,7	1070,3	5710,5	1206,7	15,9	$< 0,05$
F_{peak}, H	5275,4	933,6	5865,6	1049,6	11,2	$< 0,05$
F_{max}, H	4619,2	1081,3	5319,2	985,5	15,2	$< 0,05$
$F_{97\%}$, H	4480,7	1048,9	5159,7	955,9	15,2	$< 0,05$
T_{max}, c	6,56	2,37	5,60	2,15	14,6	$< 0,05$
T_1, c	4,18	1,73	3,52	1,59	15,8	$< 0,05$
T_2, c	11,75	1,08	12,61	1,13	7,3	$< 0,05$
$T_{уд}$, c	8,25	0,65	8,43	0,83	2,2	$< 0,05$
K_1, c^{-1}	0,008	0,002	0,007	0,002	-	$> 0,05$
K_2, c^{-1}	1,106	0,409	0,902	0,551	-	$> 0,05$
ΣF, кН	230,4	42,4	264,9	38,3	14,9	$< 0,05$

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