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ORIGINAL PAPER

Changes in the Muscle Strength of the Elbow Flexors Following a Six-week Experimental Procedure in Adolescents Monitored Through Isokinetic and Motor Tests

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ABSTRACT
A group of 7 subjects underwent an experimental procedure which studied the potential changes in the maximal strength of the non-dominant arm elbow flexors. The programme duration was limited to 6 weeks during which the subjects practiced exercises 3 times a week, 3 series, on a Scott bench. Individual approach was applied to the external load and it was designed so that the weight being lifted would increase if the number of lifts in one series would exceed 3. The subjects were monitored through the one-repetition maximum 1 RM motor test and the isokinetic tests performed on biodex system, tested in 3 time periods (at the beginning, after 3 weeks, and after the 6th week). Of the 6 isokinetic tests, only the test for the maximum torque and the time for achieving the maximum torque have shown statistically important changes in terms of reduction in values, which was not expected. The one-repetition maximum test, unlike the isokinetic tests, has shown statistically important increase of the maximal muscle strength of 32.1% after the third week of exercising, and 46.8% after the six weeks of exercising. The statistical test for the correlation between the two variables has shown low correlation between these two tests. The values of the data of the two test types have not shown any correspondence among the subjects possibly due to the type of performance of the maximal muscle load during exercises, performed in conditions identical to the one-repetition maximum test, with similar and yet different conditions in the case of isokinetic tests. Most probably, due to the conditions in which the exercises and the tests took place, there is difference in the obtained results.
Key words: isokinetic tests, 1 RM, 6 weeks, elbow flexors

1. INTRODUCTION

Isokinetic tests are performed on isokinetic machines. These machines enable the performance of movements (in the specific elbow of the human body), where the speed for performance of movements is fixed and the muscle load is variable in order to maintain speed consistency. The isokinetic test manner is being used for about 30 years. The first published papers date from the 60' of the last century (1-5). This type of testing is recommended as the best way to assess the muscle tissue capacities while presenting the strength capacities (6-10). Isokinetic tests (and isokinetic exercises) have considerable application in the medical rehabilitation for assessment as well as for recovery from injuries of the muscle tissue and the elbow elements (1-3). The indicators that could be obtained from the isokinetic tests pertain to the torque of the strength, muscle acceleration and stopping. In addition, one could obtain indicators on the angle in which the muscle produces the greatest strength, the agonists/antagonists ratio, and similar. This study has used the Biodex system for assessment of the isokinetic indicators, as well as the motor test 1RM for assessment of the maximal strength component.

2. WORK PROGRAMME

The experimental procedure was with duration of 6 weeks (3). The subjects (N=7) practised by performing muscle contractions (in whole movement amplitude conditions) on Scott bench, with the non-dominant arm with one-arm weight, 3 times a week, 3 series per training (4). The load intensity was given in percentages and amounted 90% of the indicator for the one-repetition maximum 1RM test. The individual exercise approach for all subjects was the programme objective, so the load intensity was a variable factor "from series to series" during one training (5). The imperative for each subject was to lift a sufficiently heavy one-arm weight by not exceeding the number of 3 repetitions in single series (6). In that manner, the continuous increase in steps of the muscle load was secured, which was always within the zone of 90% of 1 RM. The break between series was limited to 3-5 minutes (7, 8).

The isokinetic tests were performed on the Biodex Multi-Joint System (#900-550). Each subject was tested 3 times (initial, control, and final test) and each of these tests consisted of 5 performed repetitions on the biodex system, with speed of 60 degrees/second. The tests were carried out in PZU Kineticus in Skopje: a) Maximum torque of elbow flexors strength–BIPTRQ [Nm]; b) Time for achieving maximum torque strength of elbow flexor muscles –BI*TIME* [sec]; c) Elbow angle under which the maximum torque strength of elbow flexor muscles is achieved–BIANGL [rad]; d) Power of the strength of the elbow muscle flexors – total work against time–BIPOW [W]; e) Muscle acceleration, time during which the elbow flexor muscles reach isokinetic speed from relaxed condition to isokinetic speed–BI-ACCE [sec]; f) Muscle acceleration, elapsed time during which the elbow flexor muscles progress from reached isokinetic speed to zero speed – BIDECE [sec]. The subjects were also tested with the one-repetition maximum test (1RM) on Scott bench, the results of which were used in this study to compare the changes with the values of the isokinetic tests. The statistic data analysis was carried out through the Friedman ANOVA, and Wilcoxon Post Hoc test.

	%		
test	ini-kon %	kon-fin%	ini-fin%
1RM	32.1	11.2	46.8
BIPTRQ	-9.3	1.5	-8.0
BITIME	-36.6	18.2	-25.0
BIANGL	-21.0	18.4	-6.4
BIPOW	2.6	-5.1	-2.6
BIACCE	-3.5	-3.6	-7.0
BIDECE	-44.3	17.9	-34.3

Table 1. *Percentage differences for 1RM and biodex indicators in case of elbow flexion between initial, control and final testing.*

Friedman ANOVA ini-kon-fin				
тест	Chi Sqr.	N	df	p-level
1RMBI	11.31	7	2	0.004
BIPTRQ	8.00	7	2	0.018
BITIME	8.24	7	2	0.016
BIANGL	3.00	7	2	0.223
BIPOW	1.14	7	2	0.565
BIACCE	0.70	7	2	0.705
BIDECE	2.89	7	2	0.236

Table 2. *Analysis of the variance of values of the 1RM and biodex indicators for elbow flexors, for the three time periods (initial, control, final)*

3. RESULTS AND DISCUSSION

At the control testing, the Biodex indicators for elbow flexors, in the group, noted relatively small changes. The value of the maximum torque–BIPTRQ (X=50,83; Sd=7,44) after 3-week exercises was reduced by 9,3% although positive change after exercise was expected to be noticed. This decline is statistically important at the level of p= 0,018.

These reductions could be a result of the learning of movements occurring during exercising. The manner in which the test is conducted (although it mostly simulates the movements performed during the exercising) maximally limits the movements (the subject is fixed on the biodex machine in a seating position). Whereas during exercising, the subject is not fixed, but is in a standing position. It is possible that the increase of the lifted weight (tested with one-repetition maximum) is based on a "learned movement" during exercising, which slightly differs from the movements being performed during the biodex system testing.

For the biodex indicator on the value of the angle that presents the highest torque (BIANGL), (initial: X= 77,57 ; Sd=32,19) although there is still reduction of the mean value of the angle of the control (by 21,0%) and of the final testing (by 6,4%), there are still no statistically important differences shown at neither of the programme control tests (after 3 and after 6 weeks).

After the 6-week treatment of the experimental procedure, the angle in which the subjects of group E1 have shown greatest strength remains relatively unchanged, throughout the entire procedure.

One can conclude that the programme according to which the subjects of this group have exercised, performing an entire elbow flexion amplitude, has not resulted into any significant changes of the angle in which the flexor muscles have exhibited maximum strength. The time necessary for the flexor muscles to exhibit maximum strength, assessed through the biodex measure BITIME, has changed significantly throughout the programme. The arithmetic mean (X=1668,57; Sd=419,34) for this measure was reduced after the 3-week treatment by 36,6%, as a result of the exercises , which means that the speed for lifting the weight has increased (significantly at level p=0,028,). From week three to week six, the experimental procedure has resulted into decline in the speed of lifting the weight by 18,2%. This decline is statistically significant at the level of p=0,043 and is potentially a result of the nervous system saturation for rapid electric impulses release. The decline after a certain training period was also noted by Gandevia SC, Rube N, and Secher NH (9, 10). However, following the six weeks of exercising, the total improvement of the speed of the elbow flexor muscles, for the subjects performing an entire amplitude was increased by 25% compared to the pre-programme testing. This speed increase for achieving maximum force is not statistically significant. The arithmetic means of the measures for: power of the

Wilcoxon Matched Pairs Test (phdv5ka.sta)				
1RMBI	N	T	Z	p-level
initial/control	**7**	**0**	**2.20**	**0.028**
initial/final	**7**	**0**	**2.37**	**0.018**
control/final	7	3	1.57	0.116
BIPTRQ	N	T	Z	p-level
initial/control	**7**	**0**	**2.37**	**0.018**
initial/final	7	3	1.86	0.063
control/final	7	11	0.51	0.612
BITIME	N	T	Z	p-level
initial/control	**7**	**0**	**2.20**	**0.028**
initial/final	7	5	1.52	0.128
control/final	7	0	2.02	0.043

Table 3. *Wilcoxon (Post Hoc) test*

Spearman Rank Order Correlations (korelac.sta)				
	Valid	Spearman		
	N	R	t(N-2)	p-level
1RM & BIPTRQ	21	0.321	1.475	0.157

Table 4. *Spirman correlation*

flexor muscles estimated through the BIPOW measure, the neuromuscular capacity of the flexors in case of concentric contraction (BIACCE), as well as the neuromuscular capacity of the flexors in case of eccentric contraction (BIDECE), although percentage fluctuations of the control tests can be observed, are still not statistically important. In addition, the speed of muscle fibre excitation (BIACCE) and their relaxation, according to the statistical analysis, have not experienced any changes. That indicates that conclusions are to be sought regarding the positive changes occurring during the procedure in the patterns at the CNS level for performance of strong movements (through learning the movements, as well as getting used the CNS to high level of stimulations).

Unlike the isokinetic tests, the one-repetition maximum test, tested in 3 time periods like the biodex tests, has shown statistically significant changes between the tested time sequences, but not in the same order as the biodex tests. The analysis of the variance on the maximal strength of the elbow flexors in the group has shown statistically significant difference for the values of the three time periods at the level of p=0,004 (Chi Sqr.=11,31). The Post Hoc test for the test 1RMBI is statistically significant (p=0,028) between the values obtained at the pilot and control testing, as well as between the pilot and the final testing (p=0.018). The maximal strength of the elbow flexors in the E1 group has no significant statistical increase in the second part of the experimental programme (from week 3 to week 6, p=0,116) although there is real increase of the maximal strength of the subjects of 11,2% in terms of the average value of the lifted weight. As a result of the logical connection of the 1RM and BIPTRQ variables, an analysis was made on the potential correlation between the tests. The same is with value R=0.321 and is not statistically important (p=0.157).

4. CONCLUSION

Presented analysis shows that the experimental procedure had a positive impact on the changes of the maximum strength of the elbow flexors (test 1RM). For the isokinetic tests, this effect of the six-week programme was presented (statistically significant) from the test for the maximum torque of the muscle flexors (BIPTRQ). However, the test on the relationship of both variables has shown low correlation between these two tests. This fact is interesting since these are tests that assess the maximal strength component, and yet they provide different joint values in both control periods (control and final testing). It should be pointed out that the subjects during the six-week experimental procedure have performed the exercises for the flexor muscles in conditions identical to the one-repetition maximum test, with similar and yet different conditions in the case of isokinetic testing. Most probably, due to the conditions in which both the exercises and the tests took place, there is a low correlation between the two tests (1R*M u* BIPTRQ).

Moreover, another statistically significant change occurs in the time necessary for the subjects to oppose the external load imposed by the isokinetic machine. So, in the first part (3 weeks), the subjects have, simultaneously, by developing the maximum strength component also advanced the elbow flexion speed, which can be used as a recommendation for development of these two motor capacities (although in the second part, significant decline of the speed can be noted, in cumulative terms, there is percentage speed increase after six weeks of exercises). The other variables of the isokinetic tests have not shown any significant changes even though the percentage variations are present; hence no deeper analysis of the same was carried out.

This research can be used as a starting point in the creation of experimental procedures (and their assessment by the means of tests) that touch upon the segment of strength capacities.

CONFLICT OF INTEREST: NONE DECLARED.

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