COMPARISON OF ISOMETRIC AND DYNAMIC METHODS OF STRENGTH TRAINING PROGRAM

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The purpose of this study was to determine the difference in the quality of muscle strength employing two methods of strength training (isometric, dynamic). Nineteen male university students volunteered to participate in the experiment, encompassing a five week strength training sessions. The dynamic method was applied to the elbow flexion and extension of the right side (load totalling 60 % of maximal performance) and the isometric method applied on the same muscle groups of the left side (maximal voluntary isometric contraction). Pre- and post-test measurements included maximal isometric strength, the angle a expressed the speed of increasing muscle strength and the number of repetitions performed for each exercise (at a of load 60 % max), as a measure of muscle endurance. No differences were found between the results of strength training when using both methods (isometric, dynamic). A five week training program improved the isometric force by about 8-14 % of pre-test values, and by about 34-54 % in repetition exercises with the load. No differences were exhibited in the rate of the speed of increasing muscle strength.

KEY WORDS: strength, training, isometric, dynamic.

INTRODUCTION: One of the popular movement activities of university students without any specific sports orientation is the basic body training pertaining to strength and fitness. Most of the different strength training methods must be applied in special training centres equipped with special devices. Contrary to this fact, the isometric training method can be applied anywhere, without special equipment, and at anytime. In addition, the application of the isometric training program is very useful in the case of segment immobilisation, as well as in reduced flexibility of body segments.
Many papers have shown interest in the assessment of different strength training methods (Abernethy and Jurimae, 1996; Hortobagyi and Katch, 1990 and others). No conspicuous differences between effects of various strength methods have been ascertained. The main reason of the strength accruing during the first phase of the training is attached to the improvement of motor skill co-ordination (Ramsay et al., 1990) and neural adaptation (Sale, 1992). Different types of muscle contractions (isometric versus dynamic) relate to the different pattern of motor unit recruitment for different types of muscle fibres (Sale, 1992).
The purpose of this study was to determine the difference in the quality of muscle strength development by using two methods of strength training (isometric, dynamic). We assumed that different patterns of motor unit activation concerning the use of two different strength training methods would be the cause of differences in the level and quality of muscle strength after completion of the training program.

METHODS: Nineteen university students (untrained males, age 19–24 years, body mass 73.79 ± 8.21 kg, body height 181.00 ± 4.52 cm) volunteered to participate in the experiment. Strength training was performed during a 5 week program (2 sessions per week, total 10 sessions, 90 min. per session). The main aim of this program was to improve the basic strength condition of the trunk and the upper and lower extremities. Eight exercises were conducted utilising standard methods of dynamic training at a load of 60% of maximum.
The research procedures were adapted during the experiment for the training on the elbow flexion and extension, both in the right and left upper extremities. The dynamic training method was applied on the right side (elbow flexion and extension) and consisted of exercises performed at 60% of maximum load, with 6 sets/10 repetitions during weeks 1-2 and 7 sets/10 repetitions during weeks 3-5, respectively.

The isometric training method was applied on the left side (elbow flexion and extension) using a program of maximum voluntary muscle contractions as follows: weeks 1-2, 6 sets/10 repetitions; weeks 3-5, 7 sets/10 repetitions. A pause of 30-35 seconds between each series in the dynamic method, and 120 seconds in the isometric method was applied. Two procedures were applied for all observed muscle groups in pre- and post-test measurements. Measurement of maximum voluntary isometric contraction provided information about the maximum strength and the angle a expressing the speed of increasing the isometric strength (Vaverka and Janura, 1994). The angle a indicates the slope of the force-time curve by maximum isometric voluntary muscle contraction performed from zero to maximum strength ($tga = F_{80}/t_{80}$, where F_{80} is 80 % of maximum force and t_{80} is the time in which F_{80} was reached). The second measurement was based on the number of repetitions (at 60% of maximum strength) completed until exhaustion as a measure of muscle endurance. The differences between the pre- and post-test were expressed in percentage of the pre-test performance. Statistical analysis was provided on the basis of the STATGRAPHIC package (basic statistics, paired t-test, correlation coefficient, one-way analysis of variance).

RESULTS: Differences between the changes in pre- and post-test measured variables are illustrated in Table 1. The maximum isometric strength (F) increased in all measured variables. The increments in the elbow flexion strength are a little bit lower (8-9% of pre-test value) in comparison to the elbow extensions (13-14% of the pre-test value). On the contrary, changes in the angles a after strength training are not significant, except in elbow extension (right). The high correlation coefficients between pre- and post-test measurement documented the positive changes in all measured variables secondary to the training. The comparison of effectiveness of the two applied methods of strength training can be assessed based on the statistics in Table 2. Differences in increments between variables measured on the right (dynamic methods) and the left (isometric methods) are very small and insignificant. Test of the differences between pre- and post-test measured variables of repeated exercises (Table 3) has shown that the performance achieved at the end of the strength training was significantly higher (on average about 34-54% of input values) than maximum post-test values of isometric strength (8-14% of input values).

Table 1 Differences between Pre- and Post-Test Measurements of Isometric Muscle Strength

Training method	Variable	Pre-test Mean	S.D.	Post-test Mean	S.D.	Post/Pre [%] Mean	S.D.	Paired t-test	$r_{(pre, post)}$
	EFRF	303.43	51.46	328.12	49.48	108.67	6.08	-5.770**	0.93**
Dynamic	EFRA	63.29	10.59	65.78	10.77	105.48	18.77	-0.990	0.48*
	EERF	188.76	34.97	212.02	31.57	113.36	11.11	-5.370**	0.86**
	EERA	56.85	13.32	63.50	11.29	114.59	17.76	-3.845**	0.82**
	EFLF	302.33	51.42	329.49	56.34	109.17	6.94	-6.080**	0.94**
Isometric	EFIA	63.45	11.76	64.96	11.41	104.16	18.29	-0.610	0.56*
	EELF	192.07	30.94	220.13	40.95	114.70	10.36	-5.568**	0.85**
	EEIA	58.52	11.66	60.82	14.12	104.83	18.29	-1.015	0.72**

EFRF (EFLF) – elbow flexion right (left), maximal isometric strength (N)
EFRA (EFIA) – elbow flexion right (left), angle a (deg)
EERF (EELF) – elbow extension right (left), maximal isometric strength (N)
EERA (EEIA) – elbow extension right (left), angle a (deg)
* $p < 0.05$ ** $p < 0.01$

Table 2 **Differences between Changes in Measured Variables on the Right and Left Upper Extremities**

	Right		Left		|Difference|	Paired
	Mean	S.D.	Mean	S.D.		t-test
EFF	108.67	6.08	109.17	6.94	0.50	-0.251
EFA	105.48	18.77	104.16	18.29	1.32	0.363
EEF	113.36	11.11	114.70	10.36	1.34	-0.449
EEA	114.59	17.76	104.83	18.29	9.76	1.490

EFF – elbow flexion, maximal strength (N); EFA – elbow flexion, angle a (deg)
EEF – elbow extension, maximal strength (N); EEA – elbow extension, angle a (deg)
* $p < 0.05$ ** $p < 0.01$

Table 3 **The Number of Exercise Repetitions Completed to Exhaustion (at load of 60% maximal performance)**

Variable	Pre-test		Post-test		|Difference|	Paired	Increment (%)
	Mean	S.D.	Mean	S.D.		t-test	Mean
EFR	11.95	3.47	16.63	3.70	4.68	-4.53**	39.16
EER	14.16	5.79	20.79	8.87	6.63	-4.26**	46.82
EFL	11.95	3.63	16.05	4.18	4.10	-4.83**	34.31
EEL	12.68	4.26	19.58	8.34	6.90	-5.37**	54.42

EFR (EFL) – elbow flexion right (left); EER (EEL) – elbow extension right (left)
* $p < 0.05$ ** $p < 0.01$

DISCUSSION: The research confirmed the positive influence of strength training in increasing the muscle strength using both methods, dynamic and isometric. Differences in strength between right and left upper extremities after training were very small. Thus, it can be inferred that both strength methods (isometric as well as dynamic) produced similar training effects. The differences in strength development between the elbow flexors and extensors is intriguing. The increase in strength of the elbow extensors after training (about 14 %) were higher in comparison to the elbow flexors (about 5-9 %). In spite of the fact that insignificant differences were documented in the above mentioned increments, these findings indicate that less trained muscle groups (the elbow extensors typically considered as a weaker group in comparison to elbow flexors due to the use of these muscles during daily activity) are more sensitive to strength training. This supports the results of Abemethy and Jurimae (1996). The comparison of the improvements measured by isometric contractions (about 8-14 %), and those obtained with repetitive exercises (about 34-54 %) has shown that the effect of improving motor skill co-ordination (Ramsay et al., 1990) could be a very important factor influencing the strength in dynamic exercises. The improvements in test scores for the dynamic training protocol were much higher (about 34-54 %) than those of the isometric group (about 8-14 %). It seems that the dynamic exercises with a lower load create better conditions for the improvement of neuromuscular co-ordination due to a better relationship between the excitory and inhibitory mechanism of one muscle for a specific movement (Schmidtbleicher, 1992). Based on differences in the muscle loads by isometric and dynamic training methods it can be suggested that improved efficacy of training could be achieved by maximum isometric muscle contraction. In a maximum voluntary contraction, all motor units being recruited and all units are firing at a rate high enough to produce the maximum possible force from their muscle fibres (Sale, 1992). The effect of recruitment of all muscle units and firing at a high rate during maximum voluntary isometric contractions (Sale, 1992) is not likely to be a predominant factor for increasing muscle strength by using isometric training methods. It seems that both methods of strength training have advantages and disadvantages and that the final result in terms of effectiveness of strength training for beginners using both methods is equal.

CONCLUSIONS: The results of this five weeks training program applied on a group of university students indicate that:

1. No differences in the applied methods of strength training have been found in the magnitude of strength increase, in the speed of increasing isometric muscle strength (angle a), or in the number of repeated exercises.
2. Higher sensitivity to the strength training process was found in the muscle groups trained less, in this case the elbow extensors. Dynamic exercises can positively influence the speed of increasing isometric muscle strength of the muscle groups with lower training level.
3. The effectiveness of the isometric training method is similar in comparison to the standard dynamic method of strength training applied to beginners.

REFERENCES

Abemethy, P. J., and Jurimae, J. (1996). Cross-sectional and longitudinal uses of isoinertial, isometric and isokinetic dynamometry. Medicine and Science in Sporfs and Exercise, **28(9)**, 1180-1187.

Hortobagyi, T., and Katch, F. I. (1990). Role of concentric force in limiting improvement in muscular strength. Joumal of Applied Physiology, **68(2)**, 650-658.

Ramsay, J. A., Blimkie, C. J., Smith, K., Gamer, S., MacDougall, J. D., & Sale, D. G. (1990). Strength training effects in prepubescent boys. Medicine and Science in Sporfs and Exercise, **22(5)**, 605-614.

Sale, D. S. (1992). Neural adaptation to strength training. In P. V. Komi (ed.), Strength and Power in Sport (pp. 249-265). Oxford: Blackwell Scientific Publications.

Schmidtbleicher, D. (1992). Training for power events. In P. V. Komi (ed.), Strength and *Power in Sport* (pp. 381-395). Oxford: Blackwell Scientific Publications.

Vaverka, F., and Janura, M. (1994). On the reduction of biomechanical data in isometrical muscle contraction test measurement. *Acta Universitatis* Palackianae Gymnica, 24, 61-65.

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