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The Evaluation of Overflow and Cross Training Effect after Isometric Quadriceps Training

Choi, Jae-Cheong, P.T., Ph.D.
Department of Physical Therapy, Taejon Health Sciences College

대퇴사두근 등척성 훈련후 오버플로우와 교차훈련효과의 평가

대전보건과학대학
최 재 청

< Abstract >

The purpose of this study was to determine the overflow effect and cross training effect of isometric quadriceps training that performed in specific angle of unilateral leg. Ten healthy students with an average age of 24 years (24.1±1.3), were participated in this study. Then 5 subjects in each group were chosen at random to train using only right quadriceps muscle two time per day(group 2), five times a week and the other 5 subjects(group 1) were chosen to train one times per day, five times a week for 2 weeks at only 50 degrees (contract 6 seconds, rest 10 seconds, 3 sets). Before and after the training, isometric quadriceps muscle testing of the both leg was performed at three different angles, 60, 50 and 40 degrees respectively by KIN-COM (isokinetic dynamometer) in sitting position. The data was analyzed with paired t-test to determine significant difference between before and after training.

In this study, we have found that the isometric quadriceps muscle training on specific angle of right side produced overflow effect in healthy subjects. However, increasing the peak torque of specific angle(training angle) of trained limb did not have an effect on increasing the peak torque of contralateral limb. These results demonstrate that the cross training effect did not found in this study but a slight increase of peak torque of the untrained limb would recognized the possibility of cross training effect.

I . INTRODUCTION

Muscle strength, muscle endurance and cardiovascular endurance are very important factors to carry on normal human life as well as to the patients who injured musculoskeletal system. There are several methods to increase muscular strength and endurance. Especially, isometric training is valuable method to the patient that doesn't allows joint motion. Isometric exercise is a static form of exercise that occurs when a muscle contracts without a noticeable change in the length of the muscle or without visible joint motion and there is no physical work done as well(Lehmkuhl and Smith, 1983 : Moffroid, et al, 1969). The velocity is constant at zero so the resistance varies to match the force applied, but no functional movement is possible(Davies, 1992).

Often, we find some phenomenon that carryover of training effects from one variation of exercise to another when perform an resistance training program. We call

this phenomenon to transfer of training, overflow, or cross training. In this study, author intentionally defined the overflow as the carryover of training effects from one angle of joint range of motion to another in a isometric training program. But Carolyn et al.(1996) states that the overflow effects are substantially less than the training effects resulting from specificity of training. Lindh(1979) suggested that strength increase was mainly specific according to the angle which the knee was exercised. Davies(1992) states that isometric exercises has approximately a ≈20 degree physiological overflow through the ROM. Physiological overflow occurs a total of 20 degrees from the training angle(Knapik et al., 1983). Gains in strength will occur only at or closely adjacent to the training angle(Davies, 1992 ; Lindh, 1979).

It has also been suggested that a cross-training effect can occur from an exercised limb to a nonexercised contralateral limb in a strengthening exercise program (Devine, 1981 ; Housh and Housh 1993). Weir et al. (1994) states that the results indicated a cross-training effect and joint angle specificity for isometric torque.

However, to date insufficient research exists with regard to the overflow and cross training effects of isometric training also controversial.

The purpose of this study was to evaluate the overflow effects and cross training effects in a isometric strengthening program of quadriceps muscle.

Ⅱ. METHODS

1. Subjects

Ten healthy male students that unaccustomed to muscular strengthening program volunteered to participate in this study and gave their informed consent.

The physical characteristics of subjects were presented in Table 1.

Table 1. Physical characteristics of the subjects

age	height	weight
24.1±1.3	170.4±6.50	64.5±6.53

Mean + SD

We asked all subjects to refrain from special quadriceps training and intake of alcohl for 2 weeks that training is going on progress. This study was performed in a randomized, double-blind design.

2. Procedure and Measurement

The process and objects of experiments were explained to subjects before test. Before the training, isometric quadriceps muscle testing of the both leg was performed at three different angles, 60, 50 and 40 degrees respectively by KIN-COM(isokinetic dynamometer) in sitting position. Then 5 subjects in each group were chosen at random to train using only right quadriceps muscle two times per day(group 2), five times a week and the other 5 subjects(group 1) were chosen to train one times per day, five times a week for 2 weeks at only 50 degrees (contract 6 seconds, rest 10 seconds, 3 sets). All subjects exercised at maximal isometric torque as possible as they can. After the training period, the same measurements were made as before the training both side.

3. Data Analysis

The peak torque at each joint angle between the left and right limbs before the training, between group 1 and group 2, a paired t-test was used. The Student's t-test was also used to determine a difference of peak torque between the left and right limb in group 1 and 2. A pearson r was calculated to describe the association between peak torque at 50 degree and other joint angles after training. The statistical interpretation was based on statistical test at 0.05 significance level. SPSS WIN(ver 7. 5) software was used for the analysis.

Ⅲ. RESULTS

There was no significant difference between the peak torque of right and left leg before training. The isometric peak torque of 60 degree was greater than at 50, and 40 degree. The peak torque increased as the angle of flexion increases and more increase in left side(Table 2).

Table 2. Mean and standard deviation of peak torque (Nm) at three different angles in before and after isometric quadriceps training.

Group	Side	Angle	Peak Torque	
			Before Training	After Training
1	Right	60°	423.00± 35.15	519.58± 61.00
		50°	359.54± 37.54	452.92± 68.74
		40°	266.06± 48.99	405.46± 41.89
	Left	60°	445.60± 71.57	495.14± 46.09
		50°	402.94± 32.85	447.72± 39.98
		40°	291.26±122.30	407.90± 33.69
2	Right	60°	448.34± 98.35	617.84±153.43
		50°	383.80± 74.68	554.98±152.30
		40°	291.74± 95.18	476.78±114.11
	Left	60°	462.10± 54.87	657.65±173.82
		50°	404.93± 19.22	590.13±172.33
		40°	354.93± 27.17	499.55±135.74

pre : before training

Peak torque of group 2 increased more than group 1 but peak torque of left side(non-exercised leg) showed significant differences between group but no differences at right side(exercised leg)(Table 3).

Table 3. Summary of paired t-test between peak torque of before and after isometric quadriceps training.

Group	Side	Angle	df	SD	SE	t	p
1	Right	60°	4	44.93	20.09	-4.807	.009
		50°	4	63.79	28.53	-3.273	.031
		40°	4	46.26	20.69	-6.738	.003
	Left	60°	4	58.64	26.22	-1.889	.132
		50°	4	29.87	13.36	-3.352	.029
		40°	4	95.54	42.73	-2.730	.052
2	Right	60°	4	79.01	35.34	-4.797	.009
		50°	4	105.12	47.01	-3.641	.022
		40°	4	89.45	40.00	-4.626	.010
	Left	60°	4	146.37	73.18	-2.672	.076
		50°	4	153.24	76.62	-2.417	.094
		40°	4	147.19	73.59	-1.965	.144

Both groups of right side showed significant differences but no differences in left side without 50 degrees of group 1.

There was no significant differences between right and left after training by group but the increases of peak torque of group 2 was greater than that of group 1 in all positions(Table 4).

Table 4. Summary of paired t-test between peak torque of left and right limbs after isometric quadriceps training.

Group	Side	Angle	df	SD	SE	t	p
1	Left	60°	4	57.52	25.72	.950	.446
	Right	50°	4	79.71	35.64	.146	.993
		40°	4	50.02	22.37	-.109	.826
2	Left	60°	4	104.99	46.95	-.327	.122
	Right	50°	4	98.06	43.85	-.704	.095
		40°	4	95.25	42.59	-.038	.187

Table 5. Correlation coefficient between peak torque of exercise angle and peak torque of others after training by group.

group	side/ angle	Rt			Lt		
		post 60°	post 50°	post 40°	post 60°	post 50°	post 40°
1	Rt post 50°	.945* .015	1.000	.939* .018	.431 .469	-.006 .993	.030 .962
2	Rt post 50°	.993** .001	1.000	.971** .006	.841 .074	.813 .095	.836 .078

** : $p < .01$ * : $p < .05$

There was significant relationship between exercise angle and adjacent angles of the right side but no relationships in the left side. Especially, group 2 of the right side showed more significant correlation (Table 5).

Ⅳ. DISCUSSION

There was no critical differences of quadriceps strength of both side before training because all the subjects carry on normal daily living with balanced physical activity.

In the results of the paired t-test between frequencies after training, there was significant differences at left side

only. This is regarded as because of the subjects were right-handed person. Therefore, it is thought to be that a significant difference of left side is due to more sensitive adaptation to training than right side.

Housh et al.(1993) suggested that there was a cross-training effect, with significant increases in peak torque on the contralateral side of the body. These results indicate that unilateral velocity-specific concentric-specific concentric isokinetic training is adequate stimulus for eliciting strength gains at a wide range of velocities in both the trained and contralateral limbs.

Analysis indicated that the training resulted in increased DCER(dynamic constant external resistance) strength in both the trained (42%) and contralateral(15%) legs as well as isokinetic peak torque in the trained leg(7-19%) at velocities ranging from 1.05 to 5.24 rad. s-1. There was no cross-training effect, however, for isokinetic peak torque. Furthermore, the training-induced increases in DCER strength and isokinetic peak torque were retained across eight weeks of detraining(Housh et al. 1996).

In this study, paired t-test between before and after training by group indicated that the training resulted in increased peak torque in both side but there was no significant differences in left side. This result could construe as that there was no cross-training effect. It is stated that the result was due to difference of training method from that of the other study.

Knapik et al.(1983) stated that the physiological overflow occurs a total of 20 degrees from the training angle(10 degrees in either direction). Also, Lindh (1979) suggested that the strength increase was mainly specific according to the angle at which the knee was exercised. Gains in strength will occur only at or closely adjacent to the training angle. Marks(1994) advocated that the independent variable of maximal isometric knee extensor torque was recorded on an isokinetic dynamometer at knee angles of 90, 60, and 30 degrees respectively. These data demonstrated a progressive torque increase at all angles, with a steeper slope at the training angle. Contrary to the specificity of training concept, angle-specific strengthening an osteoarthritic knee through a wide range of motion. The results from this study were same as previous study. Therefore, this study identified increases in peak torque of right side as overflow effect.

The peak torque of training angle of right side did not correlates with the peak torque of left side but did correlates with adjacent angle of right side. These results demonstrate that overflow effect was evident but cross training was not obvious. However, we consider that the increasing in peak torque of left side would caused cross training effect by changing the training methods.

Hortobagyi et al(1999) suggested that substantial cross-education occurs after training with eccentric contractions or with contractions evoked by electromyostimulation(EMS). Shields et al(1999) reported that the regular training showed increases in cross-education, suggesting that cross-education during endurance training is no intensity-dependent. Moore (1975) stated that bilateral electromyographic recordings from the biceps brachii and brachialis demonstrated that the amount of excitation overflow in the nonactive limb is between 10 percent and 20 percent of the maximal intensity of activity measured in the exercised limb. Kannus et al(1992) reported that the purpose of this investigation was to study the effect of one-legged exercise on the strength, power and endurance of the contralateral leg. Both quadriceps and hamstring muscles of the trained subjects showed a cross-transfer effect from the trained limb to the untrained side. This concerned the strength and power, as well as endurance characteristics of these muscles. The average change in peak torque of the quadriceps muscle was +19%(p less than .001) in the trained limb, +11%(p less than .01) in the untrained limb and 0% in the control limbs. The differences of the results between this study and another study were due to the difference of training methods.

V. CONCLUSION

In this study, we have found that the isometric quadriceps muscle training on specific angle of right side produced overflow effect in healthy subjects. However, increasing the peak torque of specific angle(training

angle) of trained limb did not have an effect on increasing the peak torque of contralateral limb. These results demonstrate that the cross training effect did not found in this study but a slight increase of peak torque of the untrained limb would recognized the possibility of cross training effect.

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