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The Comparative effectiveness of Isokinetic and Isotonic Strength Trainings on Quadriceps Maximum Power

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Abstract

The present study compares the effectiveness of isokinetic and Isotonic exercises on maximum power of quadriceps in 45 healthy young males. The subjects were randomly assigned into three groups (n=15): Group A- Isokinetic group, Group B- Isotonic group, Group C-Control group. Maximum power of quadriceps at velocities of 220^0/sec, 160^0/sec 100^0/sec and 40^0/sec was tested twice with a gap of 4 weeks using isokinetic dynamometer. The isokinetic protocol consisted of one set of ten repetitions at velocities of 220^0/sec, 160^0/sec, 100^0/sec, and 40^0/sec each while, the Isotonic protocol included three sets of 10 repetitions at 50% 10 RM, 75% 10 RM and 100% 10 RM. Each exercise protocol was performed thrice a week for four weeks with 1 minute rest interval. The subjects in the control group were not prescribed any kind of exercise training. Paired t-test showed significant changes at 220^0/sec ($t=7.15$, $p<0.001$), 160^0/sec ($t=7.54$, $p<0.001$), 100^0/sec ($t=9.24$, $p<0.001$) and 40^0/sec ($t=7.59$, $p<0.001$) in Group A, also at 220^0/sec ($t=8.56$, $p<0.001$), 160^0/sec ($t=8.80$, $p<0.001$), 100^0/sec ($t=10.11$, $p<0.001$) and 40^0/sec ($t=10.50$, $p<0.001$) in Group B and non-significant changes in Group C. Post-test One way ANOVA revealed significant changes at 220^0/sec ($F= 10.85$, $p<0.001$), 160^0/sec ($F=16.96$, $p<0.001$), 100^0/sec ($F=14.60$, $p<0.001$) and 40^0/sec ($F=14.00$, $p<0.001$). Isotonic exercises were found to be more effective than Isokinetic exercises in increasing the maximum power at high velocity.

Introduction

The musculature around the knee especially quadriceps is important in the prevention of injuries, as well as in the enhancement of the knee function. Isokinetic as well as isotonic exercises are commonly used methods of developing quadriceps muscle strength in both sports medicine and rehabilitation (1,2-4). During Isotonic contractions, the neuromuscular system has to overcome an initial resistance (constant throughout the movement) to move the lever arm (5). On the other hand, Isokinetic contractions provide muscle training throughout the

range of motion of the joint at a pre-set, constant speed of contractions with a constantly accommodating resistance (6).

There is an ample volume of literature regarding the comparison of both isotonic as well as isokinetic strength training programs on quadriceps muscle peak torque development (7-10). However, muscle power production has not often been the focus of attention in the previous literature.

Indeed, there is a scarcity of evidence regarding the comparison of the effect of open chain and specific training regimen types of isokinetic and isotonic exercise programs on the maximum power of quadriceps muscle. The relationship between joint torque and angular velocity is used to quantify dynamic strength; similar to the force-velocity relationship in isolated muscle since many decades (11). The ability to perform a dynamic task often depends on both torque production and the speed of contraction, the product of which is power (12). Therefore performance during dynamic muscle contractions can be examined by measuring power across a range of velocities which also depicts work performed per unit of time.

The maximum power output of quadriceps is an important factor affecting performance in sprint and power sports. Henceforth, the present study was undertaken to evaluate the comparative effectiveness of isokinetic and isotonic strength training programs on quadriceps maximum power in order to find the most appropriate method of developing maximum muscle power output amongst healthy young males. It was hypothesized that both strength training methods will enhance the quadriceps maximum power after 4 weeks. However, any of the two exercises may be better than the other.

Materials and Methods

Samples

Sixty healthy young males of 19-25 years age group were randomly taken from Maharishi Markendeshwar University, Mullana. Out of sixty, only fifty one subjects met the inclusion criteria of having normal Body mass Index (BMI) value i.e. 18.5 - 24.9 kg/m^2. Out of these fifty one subjects, six were removed as they matched the exclusion criteria of either having history or evidence of Lower extremity musculoskeletal, neurological problems, cardio-vascular, respiratory or major systemic disorders, insufficient strength to complete base line testing or participation in any type of vigorous or recreational activity, aerobic or weight training program during 6 months period prior to the study. The remaining forty five (N) were familiarized with the experimental protocol and informed about the possible risks and benefits involved with the study both verbally and in writing before obtaining written consent. The study was approved by Institutional Medical Ethics Committee.

Instrumentation

Easytech Genu 3 Isokinetic dynamometer, manufactured by Biomed-Inc, New Delhi was used for both assessment of maximum power (Newton-meter) as well as for isokinetic strength training. Quadriceps strengthening table, manufactured by Biomed-Inc, New Delhi was used for isotonic strength training. A static lower limb bicycle ergometer was used for warm-up prior to each assessment and training session. A weighing machine and an anthropometric rod were used to measure body weight and height respectively.

Procedure

Forty five subjects were randomly assigned into 3 groups of 15 subjects each (n=15): Group A - Isokinetic group, Group B - Isotonic group, Group C - Control group. All subjects were tested one day before and one day after a four week exercise protocol using isokinetic dynamometer at velocity of 220^0/sec, 160^0/sec, 100^0/sec and 40^0/sec to evaluate maximum power of quadriceps. A general body warm-up of 5 minutes easy stationary cycling followed by 5 minutes rest interval was included before each testing.

Group A (Isokinetic group)

Subjects were asked to do general body warm-up of 5 minutes easy stationary cycling followed by 5 minutes rest interval before exercise.

Isokinetic protocol:

Speed (Deg/sec)	220	160	100	40
Reps	10	10	10	10
Sets	1	1	1	1

Rest - 1 minute between each set

Duration - 3 days a week for 4 weeks

Group B (Isotonic group)

Each subject was asked to do general body warm-up of 5 minutes easy stationary cycling followed by 5 minutes rest interval before each exercise session. 1RM was estimated using Brzyncki equation (13) -

1RM= Weight lifted during n RM/ (1.0278- .0278(n))

10 RM was determined through 75% of the 1 RM (14). Each exercise session was performed three times a week for four weeks with 1 minute rest between each set.

Isotonic protocol:

10 repetitions with 50% 10 RM

10 repetitions with 75% 10 RM
10 repetitions with 100% 10 RM

Group C (Control group)
The subjects in the control group were tested twice with the gap of 4 weeks.

Statistical Analysis
All data are presented as the mean ± standard deviation (SD) and standard error (SE). The data were analyzed for statistical significance by using the statistical package for social sciences (SPSS 16.0) software. Paired student's t' test, one way ANOVA and post hoc multiple Scheffe analysis was done.

Results
The comparison of maximum power values at 220^0/sec (F=0.73, p>0.05), 160^0/sec (F=0.01, p>0.05), 100^0/sec (F=1.99, p>0.05) and 40^0/sec (F=0.17, p>0.05) at baseline with one way ANOVA showed statistically non significant differences in all the groups (Table 1). After 4 weeks of isokinetic strength training, paired t-test showed significant changes at 220^0/sec (t=7.15, p<0.001), 160^0/sec (t=7.54, p<0.001), 100^0/sec (t=9.24, p<0.001) and 40^0/sec (t=7.59, p<0.001) in Isokinetic group (Figure 1, Table 2). Isotonic strength training also yielded significant results at 220^0/sec (t=8.56, p<0.001), 160^0/sec (t=8.80, p<0.001), 100^0/sec (t=10.11, p<0.001) and 40^0/sec (t=10.50, p<0.001) (Figure 2, Table 3). On the other hand, statistically non-significant changes were observed at 220^0/sec (t=2.04, p>0.05), 160^0/sec (t=0.67, p>0.05), 100^0/sec (t=0.76, p>0.05) and 40^0/sec (t=1.81, p>0.05) in control group (Figure 3, Table 4). One way ANOVA at post training revealed statistically significant changes at 220^0/sec (F= 10.85, p<0.001), 160^0/sec (F=16.96, p<0.001), 100^0/sec (F=14.60, p<0.001) and 40^0/sec (F=14.00, p<0.001) (Table 5). Post hoc multiple Scheffe analysis showed maximum power of isotonic group to be higher than isokinetic group. The control group showed least maximum power values at post testing.

Discussion
The findings from the present study suggest that both Isokinetic and Isotonic strength training programs improved the maximum power of quadriceps. On the other hand, the non-experimental control group did not yield any significant changes on intra-group comparison.
As previously stated, there is a substantial database since decades relevant to effects of both types of strength trainings on various muscle groups throughout the body (15-18). Though, both isokinetic and isotonic contractions present

Table 1: One way ANOVA at pre test between all the groups

Variable		Sum of Squares	df	Mean Square	F
220^0/sec	Between groups	1191.24	2	595.62	0.73 NS
	Within groups	34317.87	42	817,09	
	Total	35509.11	44		
160^0/sec	Between groups	38.18	2	19.09	0.01 NS
	Within groups	81890.27	42	1949.77	
	Total	81928.44	44		
100^0/sec	Between groups	4911.24	2	2455.62	1.99 NS
	Within groups	51887.33	42	1235.41	
	Total	56798.58	44		
40^0/sec	Between groups	956.58	2	478.29	0.17 NS
	Within groups	121439.33	42	2891.41	
	Total	122395.91	44		

Table 2: Paired t-test for Isokinetic Group (** Highly Significant)

Variable	Mean	Std. dev.	Std. error	t-value
Pre 220⁰/sec	186.33	23.60	6.09	
Post 220⁰/sec	247.27	36.26	9.36	-7.15 **
Pre 160⁰/sec	266.07	48.49	12.52	
Post 160⁰/sec	327.20	52.31	13.51	-7.54 **
Pre 100⁰/sec	340.6	35.90	9.27	
Post 100⁰/sec	417.93	52.15	13.47	-9.24 **
Pre 40⁰/sec	474.53	52.46	13.55	
Post 40⁰/sec	548.47	55.82	14.41	-7.59 **

different biomechanical characteristics. Nonetheless, both load the neuromuscular system (19). Specific changes on torque-angle and torque-velocity relationship may be induced with both isotonic and isokinetic strength training (5). An increase in number and frequency of firing motor units has been observed after isotonic and isokinetic strength training (15).

Furthermore, isotonic group revealed highest power value on post-training, followed by isokinetic and control group respectively. Similar results have also been documented in the past by few researchers (8,10,19).

There may be many underlying factors responsible for such findings. Greater Motor unit activation per unit of work performed with isotonic exercise as compared to isokinetic exercises may be one of the reasons for better improvement with isotonic strength training (10). Greater strength improvement with isotonic training than with isokinetic training on maximum power of knee musculature has been

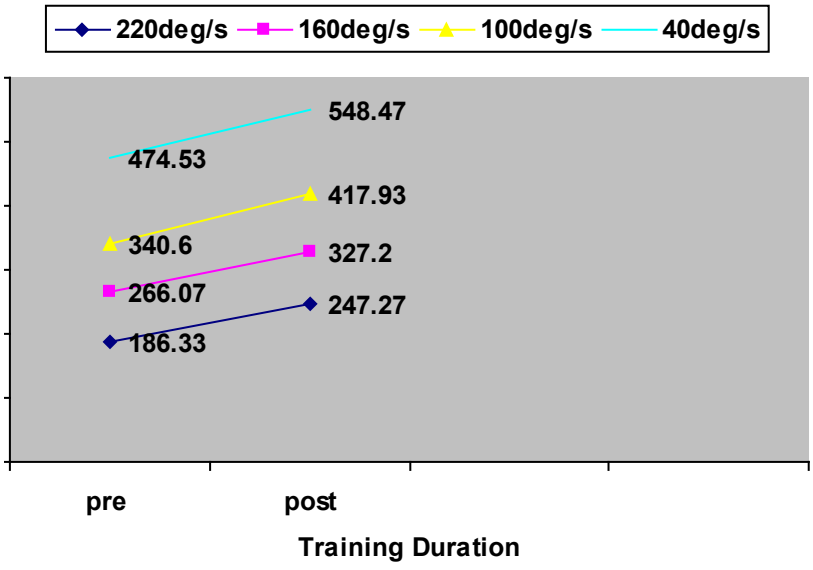

Figure 1: Intra group comparison of maximum power from pre to post training in Isokinetic Group

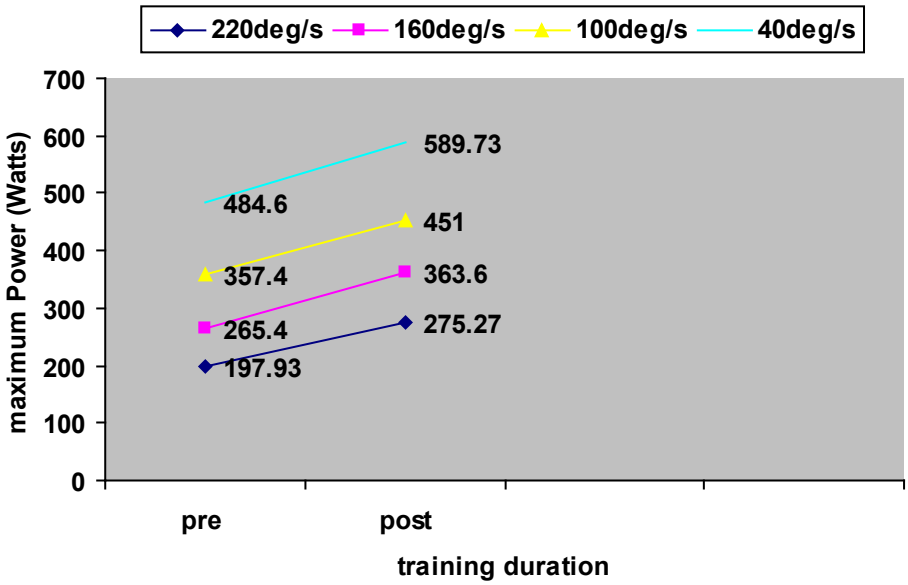

Figure 2: Intra group comparison of maximum power from pre to post training in Isotonic Group.

Table 3: Paired t-test for Isotonic Group (** Highly Significant)

Variable	Mean	Std. dev.	Std. error	t-value
Pre 220⁰/sec	197.93	30.34	7.83	
Post 220⁰/sec	275.27	54.07	13.96	-8.56 **
Pre 160⁰/sec	265.40	39.94	10.31	
Post 160⁰/sec	363.60	41.57	10.73	-8.8 **
Pre 100⁰/sec	357.40	42.17	10.89	
Post 100⁰/sec	451	36.62	9.46	-10.11 **
Pre 40⁰/sec	484.60	45.94	11.86	
Post 40⁰/sec	589.73	42.33	10.93	-10.5 **

observed on isometric tests at 10^0, 30^0, 50^0, 70^0 and 90^0 of knee flexion (8).

Isotonic exercises are the closest form of exercise to normal movement that is they are close to functional movement (20). So, it would not be surprising to find that these exercises increase muscle strength at double the speed of isometric and isokinetic exercises in the untrained population.

Another important explanation for lower maximum power values following isokinetic strength training may be that it provides constantly accommodating resistance rather than maximal resistance during the exercise because the resistance provided by the isokinetic dynamometer matches the force exerted on the attachment arm by the user through the range of motion of an exercise (21).

Moreover, Isokinetic exercise involves three phases of movement; acceleration, constant velocity, and deceleration. The acceleration phase, rate of velocity development, represents the beginning part of the motion and is performed without resistance. Constant velocity phase follows the acceleration phase of movement and corresponds to

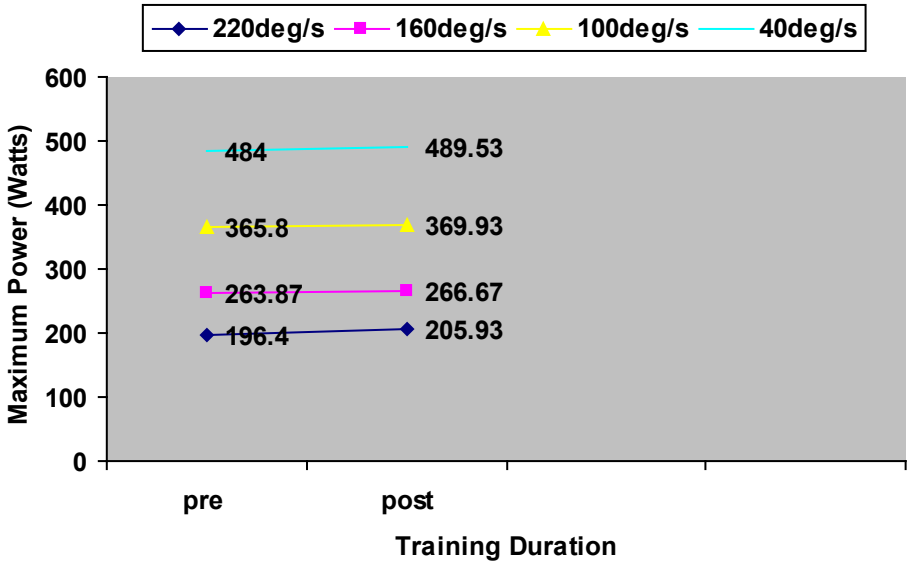

Figure 3: Intra group comparison of maximum power from pre to post training in Control Group.

Table 4: Paired t-test for Control Group (Non Significant)

Variable	Mean	Std. dev.	Std. error	t-value
Pre 220⁰/sec	196.40	31.20	8.06	
Post 220⁰/sec	205.93	28.40	7.33	2.04 NS
Pre 160⁰/sec	263.87	43.62	11.26	
Post 160⁰/sec	266.67	43.57	11.25	-0.67 NS
Pre 100⁰/sec	365.80	25.28	6.53	
Post 100⁰/sec	369.93	32.55	8.40	-0.76 NS
Pre 40⁰/sec	484.00	61.74	15.94	
Post 40⁰/sec	489.53	56.97	14.71	-1.81 NS

the matching between mechanically imposed velocity and subject's movement. The third phase of motion, deceleration phase represents slowing down of the device prior to contacting the end stop (22). By definition, only the constant velocity portion of range of motion represents load range (23). Thus, maximum loading of the neuromuscular system at a constant velocity may occur only during second phase of the isokinetic exercises when maximum power is produced.

Another important factor is co-activation of hamstring muscle during isokinetic knee extension which may have led to weaker work:repitition ratio with isokinetic strength training. Co-activation of hamstring muscle during isokinetic knee extension exercises have been reported in the literature (5,24,25).

Although lesser improvement occurred with isokinetic

Table 5: One way ANOVA at post test between all the groups

Variable		Sum of Squares	df	Mean Square	F
220^0/sec	Between groups	36497.78	2	18248.89	10.85 **
	Within groups	70634.8	42	1681.78	
	Total	107132.58	44		
160^0/sec	Between groups	71926.58	2	35963.29	16.96 **
	Within groups	89079.33	42	2120.94	
	Total	161005.91	44		
100^0/sec	Between groups	49846.04	2	24923.02	14.60 **
	Within groups	71687.87	42	1706.85	
	Total	121533.91	44		
40^0/sec	Between groups	76080.58	2	38040.29	14.00 **
	Within groups	114150.4	42	2717.87	
	Total	190230.98	44		

as compared to isotonic strength training, nonetheless, a significant improvement in maximum power output with isokinetic strength training was also observed. Velocity-spectrum training advocates have claimed that both type-I and type-II fibers may be recruited and trained by varying the velocity of movement over the course of time (7,26). The enhancement of muscle power output by high velocity training has also been documented (27).

Conclusions and Practical Applications

The findings of this study can be summarized as follows: both isokinetic and isotonic exercises are effective in increasing the quadriceps muscle power. Thus, considering the above findings, both isotonic and isokinetic strength training should be used in order to enhance strength indices and possibly in competition results in sprint and power sports requiring more quadriceps strength. However, Isotonic exercises are more effective than the Isokinetic exercises in increasing the maximum power. Future studies need to focus on other factors such as different velocities, repetitions, duration of training as well as examining the interaction of fatigue and velocity spectrum training on larger sample size . Being an easily understandable and applicable method, we recommend health professionals to add open chain isotonic training in rehabilitation program following injury.

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