# Effect of a Lateral Step-Up Exercise Protocol on Quadriceps Isokinetic Peak Torque Values and Thigh Girth

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*****Note: Figures may be missing for this format of the document**
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## Abstract:

Knee injury rehabilitation often includes the step-up exercise. However, the authors have been unable to locate documentation of the effect of the step-up exercise on lower extremity strength indices. The purpose of this study was to determine the effect of a six-week lateral step-up exercise protocol on quadriceps muscle group strength. Twenty female nonetheless (age 20 ± 1.5 yrs, ht 162.6 ± 4.9 cm, wt = 64.1 ± 0.5 kg) were randomly assigned to a control or experimental group. Pretest concentric and eccentric strength measures were obtained at 60°/sec on a Kin-Corn isokinetic dynamometer. Thigh girth measurements were obtained 10 and 20 cm superior to the knee joint line. An independent t-test of the difference between pre and post isokinetic strength and girth measurements between the control and experimental groups revealed no significant difference ($p > .05$). In addition, no significant difference was found for the exercised and nonexercised extremity for the experimental group ($p > .05$). These findings suggest that this lateral step-up protocol did not provide sufficient overload to increase isokinetic strength of the quadriceps muscle group or increase thigh girth in healthy subjects, In addition, open chain assessment of muscle strength may not adequately assess strength changes incurred via closed chain exercise. Clinicians should use caution in assuming that step-up exercises provide sufficient overload to increase thigh girth or isokinetic quadriceps peak torque values.

## Article:

Loss of thigh muscle strength is a major problem for individuals who have sustained an injury or undergone knee surgery (4, 11, 12). In particular, lost quadriceps strength may lead to an unstable and functionally disabled knee (2, 12). Many clinical therapeutic interventions are used to help prevent quadriceps atrophy and enhance strengthening of the quadriceps muscle. These include electrical stimulation, biofeedback, and various isometric, isotonic, and isokinetic exercises (1, 2, 5, 6, 8-11, 13). Recently, Shelbourne and Nitz (14) have recommended early, closed kinetic chain exercise during rehabilitation for anterior cruciate ligament reconstruction.

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The step-up exercise is one closed chain activity that is frequently utilized in rehabilitation protocols for the knee (1, 9).

The step-up exercise is purported to facilitate cocontraction of the quadriceps and hamstring muscles in a functional movement pattern and, more importantly, to increase quadriceps strength without anterior translation of the tibia on the femur (1, 2). Although the step- up exercise is a widely used clinical method to increase thigh strength, the authors have been unable to locate published evidence that shows the strengthening efficacy of this exercise protocol.

The purpose of this study was to determine the effect of a step-up exercise protocol on quadriceps and hamstring muscle group isokinetic strength. The research hypothesis was that a six-week lateral step-up exercise program would significantly increase thigh girth and quadriceps muscle group isokinetic peak torque of the exercised extremity.

## METHODS

### *Subjects*

Twenty healthy female university students were recruited for participation in this study (Table 1). They were free from history of' knee pathology or surgery and were not currently participating in any weight training activity. Each subject was asked to read and sign a consent

| Group | Age | Height | Weight | |
|---|---|---|---|---|
| Exercise (N = 10) | 19.40 ± .66 | 164 4.49 | 71+ ,ct | |
| Control (N = 10) | 19.90 ± 1.36 | 162.51 ± .503 | 64.54± 12.41 | |

TABLE 1. Description of subjects (means and standard deviations).

form approved by a Human Investigation Committee of the University of Virginia. Subjects were familiarized with the purpose of the study, testing procedure, instrumentation, and exercise protocol prior to initiation of the study. Subjects were randomly assigned to either a control (N = 10) or experimental group (N = 10).

### *Girth Measurement*

Girth measurements of the thigh were taken 10 and 20 cm above the knee joint line, with the subject in the supine position and the thigh musculature relaxed. An anthropometric tape was used to measure the thigh girth in centimeters.

### *Isokinetic Strength Measurement*

The Kinetic Communication® (Kin-Com) (Chattex Corp., Chattanooga, TN) isokinetic dynamometer was used to measure peak torque in Newton-meters (Nm). The dynamometer was calibrated prior to testing according to the manufacturer's guidelines (7). A threshold preload force of 50 Newtons (N) was required to initiate movement. Strength measurements were taken before and after a six-week exercise program. Concentric and eccentric quadriceps muscle group peak torques were measured at 60°/sec. Subjects were tested in the seated position with straps placed across the hips and distal thigh for stabilization. The dynamometer's axis of rotation was aligned with the anatomical axis of the knee joint, and the shin pad was placed one to 1.5 inches proximal to the lateral malleolus. Meas urements were taken through a knee range of motion of —10 to 80°. A submaximal trial contraction was used to ensure proper alignment. Each subject

was randomly assigned to begin testing with either the left or right extremity. The strength testing protocol consisted of three submaximal and two maximal warm-up repetitions followed by a 30-second rest. Following the warm- up procedure, three maximal test repetitions were performed. The highest peak torque value of the three test repetitions was used for data analysis. This protocol was followed for each test velocity. There was a two-minute rest between test speeds. This protocol was repeated for both legs, with the time required to reposition the subject for testing of the opposite extremity provided as the rest time. Standardized verbal encouragement was given during strength testing. Quadriceps concentric and eccentric peak torques were recorded for each leg.

### *Exercise Protocol*

The exercise protocol for the experimental group consisted of a lateral step-up exercise using one extremity. The exercised extremity was randomly determined for each subject at initiation of the study. The step-up exercise was performed with the foot of the exercised extremity initially placed on the step (Figure 1). Movement of the hip and knee into full extension was then initiated (Figure 2). From this position, the nonexercised leg was lowered and lightly touched to the floor with the foot in a dorsiflexed position (Figure 3). The exercised extremity remained on the step throughout the session. Exercise speed was regulated by using a count cadence of one and two and . . . over a two-second time period. Books stacked to the appropriate height were utilized as steps. The exercise was performed at progressively increasing step heights and repetitions once a day, five times a week, for a duration of six weeks (Table 2).

## Data Analysis

An independent Rest was performed on the difference between pre and post concentric and eccentric quadriceps peak torque values and girth measurements at 10 and 20 cm superior to the knee joint line. This analysis was utilized to compare the control and experimental groups. In addition, an independent t-test analysis was performed on the difference between pre and post values for isokinetic and girth measurements comparing the exercised and nonexercised extremity for the experimental group. An alpha level of .05 was accepted as being statistically significant.

## RESULTS

Mean and standard deviations for the quadriceps strength values are presented in Table 3. Means and standard deviations for the girth measurements are presented in Table 4. The results of the t-test comparing the pretest and posttest quadriceps peak torque values and girth measurements of the experimental and control groups revealed no significant difference ($p > .05$). Also, the t-test comparing pre and post quadriceps peak torque values and girth circumference values of the experimental group's exercised and nonexercised extremities revealed no significant differences ($p > .05$).

FIGURE 1. *Starting step-up position.*

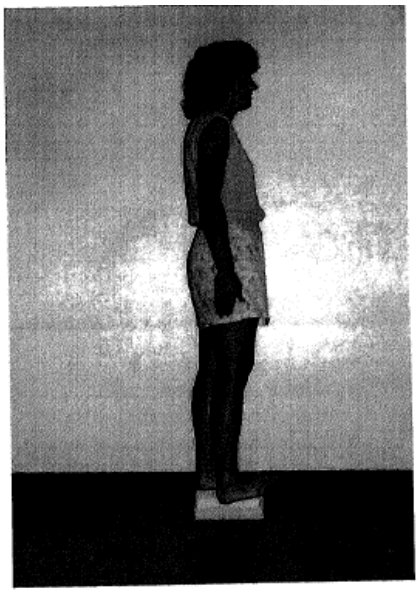

FIGURE 2. *Position at end of extension phase.*

FIGURE 3. *Position at end of flexion phase.*

DISCUSSION

The results of this study demonstrate that this clinically developed lateral step-up protocol did not provide sufficient overload stimulus for increasing quadriceps peak torque or for increasing thigh circumference in healthy female adults. There was an apparent "learning effect" on the isokinetic dynamometer, since all groups reported slight (nonsignificant) increases in posttest peak torque values.

Reexamination of this step-up protocol indicated that there was not an overall linear progression of the overload stimulus. During any given week, the number of step-up repetitions increased from 30 to 70 (133%). The total number of feet climbed also increased from week one (82.50 ft) to week six (292.5 ft) (Table 5). However, between the Friday of one week and the Monday of the following week, there was a significant decrease in cumulative vertical feet traveled (Table 6). Thus, this empirically based lateral step-up exercise protocol failed to provide sufficient overload for increasing isokinetic quadriceps peak torque values or thigh girth in a noninjured subject population. This drastic reduction in vertical feet climbed from Friday to Monday was adopted due to the clinical observation that some patients develop knee effusion and/or patellofemoral symptoms during knee rehabilitation when increasing step height. In retrospect, this reduction of vertical feet climbed from Friday to the following Monday limited the overload stimulus. Moreover, in this noninjured population, only at step-up heights of 12 and 14 inches did the subjects report muscle soreness, possibly indicating sufficient overload.

| Week | Step-Up Height | Day | Repetitions |
|---|---|---|---|
| 1 | 4" | Monday | 3 x 10 |
| 2 | 6" | Tuesday | 4 x 10 |
| 3 | 8" | Wednesday | 5 X 10 |
| 4 | 10" | Thursday | 6 X 10 |
| 5 | 12" | Friday | 7 X 10 |
| 6 | 14" | | |

TABLE 2. Lateral step-up exercise protocol.

| | Pretest Values | Posttest Values |
|---|---|---|
| *Group 1* | | |
| Exercised extremity | | |
| Concentric | 136.36 ± 17.85 | 143.55 ± 19.43 |
| Eccentric | 165.55 ± 23.65 | 171.55 ± 28.67 |
| Nonexercised extremity | | |
| Concentric | 126.20 ± 27.49 | 133.73 ± 25.86 |
| Eccentric | 153.27 ± 37.89 | 154.36 ± 45.05 |
| *Group 2* | | |
| Control extremity | | |
| Concentric | 113.00 ± 32.51 | 118.44 ± 36.31 |
| Eccentric | 132.44 ± 49.05 | 140.67 ± 49.46 |

*Group 1: Exercise group.*
*Group 2: Control group.*
**TABLE 3.** *Quadriceps muscle group peak torque values at 60°/sec (means ± standard deviations).*

| | Pretest Values | Posttest Values |
|---|---|---|
| *Group 1* | | |
| Exercised extremity | | |
| * 10 cm | 44.5 ± 5.3 | 44.6 ± 4.7 |
| † 20 cm | 53.8 ± 6.3 | 54.2 ± 5.9 |
| Nonexercised extremity | | |
| * 10 cm | 40.7 ± 13.19 | 40.5 ± 13.60 |
| † 20 cm | 49.1 ± 15.36 | 49.0 ± 15.72 |
| *Group 2* | | |
| Control extremity | | |
| * 10 cm | 42.7 ± 3.0 | 43.1 ± 3.4 |
| † 20 cm | 52.0 ± 4.3 | 52.5 ± 3.8 |

*Group 1: Exercise group.*
*Group 2: Control group.*
** 10 cm superior to knee joint line.*
*† 20 cm superior to knee joint line.*

**TABLE 4.** *Girth measurements (means + standard deviations).*

This study used healthy female subjects with no lower extremity pathology. In a patient population that has significant quadriceps weakness, this protocol may have provided sufficient overload to increase quadriceps strength. Of course, this is speculation, and further study is needed using patient populations. In addition, the possibility of a type II error exists in this study because of the small sample size (10 per group).

Brask et al (3) reported that an eight-inch step-up produced only 22 and 60.3 percent of maximal voluntary contraction (MVC) for the rectus femoris and vastus medialis, respectively. Also, these authors reported only 9.4 and 8.9 percent of MVC for the biceps femoris and semimembranosus/sernitendinosus, respectively. Brask et al (3) suggest that cocontraction of the quadriceps and hamstring muscle groups did not occur. Thus, a complete reevaluation of the lateral step-up exercise may be indicated. Perhaps increasing the overload by adding weights to the subject during the step-up exercise may provide sufficient overload to produce significant strength gains.

| Week | Vertical Feet Climbed |
|---|---|
| 1 | 82.50 |
| 2 | 125.00 |
| 3 | 165.00 |
| 4 | 207.50 |
| 5 | 250.00 |
| 6 | 292.50 |

**TABLE 5.** *Analysis of vertical feet climbed per week.*

In addition, functional closed kinetic chain assessment (pre and post) may be a more valid indicator of training changes induced by closed kinetic chain exercise than an open kinetic chain assessment, i.e. isokinetic dynamometers. Closed kinetic chain assessment for further research might include: 1) a maximal number of repetitions at a fixed step height in a fixed time interval, 2) a one-repetition maximal at a fixed step height against resistance (weights added to subjects), and 3) a one-legged hop for distance and time.

## SUMMARY

This study attempted to establish the efficacy of an empirically developed lateral step-up protocol upon quadriceps peak torque and thigh girth of healthy adult females during a six-week training period. The lack of an overall linear overload training stimulus resulted in nonsignificant changes in quadriceps muscle peak torque values and thigh girth measurements. Therefore, the authors recommend that further studies continue in order to provide scientific documentation of the empirically accepted fact that lateral step-ups increase strength of the quadriceps muscle group. Closed kinetic chain assessment of the lateral step-up exercise is recommended.

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