

Original Article

Isokinetic Training Effect of Ankle Positions on Knee Extensor Strength

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Abstract. [Purpose] The purpose of this study was to determine which ankle position most influences knee extensor strength in training programs for strengthening the knee extensors using three different active ankle positions. [Subjects] Twenty-one healthy adults (6 males and 15 females) participated in this study. [Methods] Subjects were trained isokinetically in knee extension and flexion at 70 or 80% of 1RM under three actively and naturally fixed, contracted ankle conditions: dorsiflexion, plantarflexion, and resting position. After each group successfully executed the training four times a week for three weeks, mean peak torque (PT) and total work (TW) variables were measured and compared at 60°/sec and 180°/sec among the three groups. [Results] Significant differences were revealed in knee extensor TW at 60°/sec, PT and TW at 180°/sec, with the greatest PT and TW observed with the ankle in active dorsiflexion position. [Conclusion] These results suggest that active ankle dorsiflexion in a knee strength training program may be more effective at increasing knee extensor strength than a resting or plantarflexion position.

Key words: Ankle position, Knee extensor strength, Isokinetic training

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INTRODUCTION

Isokinetic clinical training and evaluation methods are often used as a reinforcement technique for strengthening the musculature around the knee or as a muscle strength assessment for subjects with knee impairment^{1, 2)}. Isokinetic exercise for strengthening the knee extensor is also a commonly used method in rehabilitation^{3–5)}.

Isolated knee or single joint practice and testing without considering interactions of multiple joints is undesirable in some pathological conditions of the knee joint⁶⁾. Previous studies^{7, 8)} have reported that patellofemoral stresses during single joint testing are reduced by using a multi-joint leg press exercise, and the training effect of the multi-joint system is more effective than isolated joint exercise in restoring the function of patients with patellofemoral dysfunction. In addition, Tepperman et al.⁹⁾ reported that maximum isometric electromyographic activity of the quadriceps during active ankle dorsiflexion is greater than that with the ankle in a neutral position. However, all of these previous studies only assessed knee strength during the isokinetic or isometric mode of testing and did not examine the effect of ankle position during knee isokinetic exercise on knee strength. Therefore, this study was designed to investigate

whether or not fixed ankle positions (dorsiflexion, resting, plantarflexion) in the isokinetic exercise of knee flexion and extension influence knee extensor strength, and in the event of positive results, to determine which ankle position facilitated the greatest increase in strength.

SUBJECTS AND METHODS

Twenty-three healthy subjects volunteered for this study. Subjects were excluded if they had any significant neurological or cardiopulmonary diseases, lower extremity joint arthritis or fracture, or any limitation to ankle range of motion. Twenty-one subjects (6 males, 15 females; age 23±2.2 years) met the criteria. All participants had normal ankle range of motion (approximately ankle dorsiflexion 0–30 and plantarflexion 0–45) and were informed of the purpose of this study, instructed about the experimental procedure, and asked to sign an informed consent prior to their participation in this experiment. The subjects were randomly divided into three different groups each with a different ankle position: dorsiflexion, resting, and plantarflexion.

A Biodex[®] system 3 Pro isokinetic dynamometer (Biodex, Inc., Shirley, NY, USA) was used to train knee strength and measure the peak torque (PT) and total work (TW) during unilateral knee flexion and extension movements. The standardized training took place for three consecutive weeks, four days per week. The dominant leg was determined by asking each subject which leg they mostly used to kick a ball. On training days, each group successfully completed an exercise program of 5 sets of 10 repetitions of knee extension and 10 repetitions of knee flexion with

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Table 1. General characteristics of the subjects

Variable	DG (n=7)	RPG (n=7)	PG (n=7)
Sex (male/female)	2/5	3/4	3/4
Age (years)	22.7±1.9	23.9±2.3	22.9±1.9
Height (cm)	164.7±5.9	167.1±7.5	166.6±7.5
Weight (kg)	52.9±8.2	57.0±11.9	57.3±9.0
DS (right/left)	4/3	7/0	6/1

Values are expressed as frequency or mean ± SD.

DG, dorsiflexion group; RPG, resting position group; PG, plantarflexion group; DS, dominant side

Table 2. Comparison of changes in PT and TW of the knee extensors at different angular velocities

		DG (n = 7)		RPG (n = 7)		PG (n = 7)	
		Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
60°/s	PT (Nm)	64.3±11.8	78.2±14.4	73.8±29.3	69.3±27.5	82.3±32.9	82.5±37.7
	TW (Nm) ^a	314.1±88.8	407.1±83.0*	365.2±138.3	322.3±103.1	434.3±201.8	388.5±149.9
180°/s	PT (Nm) ^a	33.0±8.3	49.3±5.7*	52.1±26.7	46.0±30.7	52.6±25.2	56.5±27.1
	TW (Nm) ^a	161.4±51.0	271.8±46.2*	269.9±150.7	209.0±173.0*	274.0±177.1	283.4±167.0

DG, dorsiflexion group; RPG, resting position group; PG, plantarflexion group; PT, peak torque; TW, total work.

*Significant difference from pre-test, $p < 0.05$

^aSignificant difference in gains among three groups, $p < 0.05$

the ankle in maximal active dorsiflexion, plantarflexion, or the resting position according to the experimental group to which they were assigned. The entire training mode was planned for concentric contraction at 70~80% of 1RM¹⁰. All subjects were allowed a 2-minute rest period between each set and were instructed to abort the training if they felt any discomfort or pain.

The angular velocities used for testing were 60°/s and 180°/s. Following a five-minute sub-maximal warm-up on a stationary cycle, and 2–3 sub-maximal and maximal familiarization repetitions, each subject performed five maximal-effort reciprocal contractions of the knee extension muscle group, followed by five maximal-effort reciprocal contractions of knee flexion muscle group. To minimize the error of measurement and equalize the ankle position between pre- and post-training for the test, all the participants wore an ankle-foot stabilizer fitted in the neutral ankle position (anatomically 0°). All the testing and training began with active extension from 90 degrees of knee flexion. All post-test data acquisition was performed using the Biodex Advantage Software package for Windows®.

Before and after the three weeks of training, data for the dependent variables, PT and TW, at 60°/s and 180°/s speed were collected for the three different ankle positioning groups for analysis. After testing the normality of the data, one-way analysis of variance or the Kruskal-Wallis Htest and the Mann-Whitney Utest were performed for between-group comparisons of both demographic data and the pre- and post-training mean differences of the dependent variables among the training groups. The significance level was chosen as 0.05.

Table 3. Multiple comparisons of mean changes in PT and TW of the knee extensors at different angular velocities

60°/s	TW (Nm)	DG	–	RPG	135.9*
		DG	–	PG	138.8*
		RPG	–	PG	2.9
180°/s	PT (Nm)	DG	–	RPG	22.4*
		DG	–	PG	12.5*
	TW (Nm)	RPG	–	PG	–10.0
		DG	–	RPG	171.4*
		DG	–	PG	101.0*
		RPG	–	PG	–70.4

DG, dorsiflexion group; RPG, resting position group; PG, plantarflexion group; PT, peak torque; TW, total work

*Significant difference in gains between two groups, $p < 0.05$

RESULTS

The comparison of sex, age, height, weight, and dominant side among the three groups revealed no significant differences among the groups in their demographic characteristics (Table 1). The pre- and post-training mean differences in PT and TW at both 60°/s and 180°/s of the three different ankle-position training groups are summarized in Tables 2 and 3. The mean differences of TW at 60°/s, PT and TW at 180°/s showed significant differences among the groups. The mean differences following training with active ankle dorsiflexion of both PT and TW were greater than those of ankle active plantarflexion and the resting position ($p < 0.05$).

DISCUSSION

The purpose of this study was to analyze the effect of different ankle positions in isokinetic knee extensor strength exercises after three weeks of isokinetic training, and to determine which ankle position most effectively increased knee extensor strength.

In this study, we found that active ankle dorsiflexion during repetitive knee extension and flexion at both 60°/s and 180°/sec in the isokinetic mode had the greatest impact on increasing knee extensor strength compared to active ankle plantar flexion and the resting ankle position. TW at 60°/s, PT and TW at 180°/s increased by 30%, 50% and 69%, respectively, following knee training with the ankle in active dorsiflexion. A possible explanation of these results is that increase in knee extensor strength may balance the mechanical responses around the knee joint made by the tibialis anterior, and that active ankle dorsiflexion facilitates knee extension more than other ankle positions.

This assumption is partly supported by the results of Dimitrijevic et al.¹¹⁾ who reported that voluntary isometric contraction of the ankle dorsiflexors is accompanied by activation of the quadriceps and other muscles of the lower extremity, usually in the same leg at first, and later in the contralateral leg. In addition, our present results are consistent with those of Gough who reported that the EMGs of the vastus medialis, vastus lateralis, and rectus femoris were higher during ankle dorsiflexion¹²⁾, and are also consistent with Tepperman's⁹⁾ conclusion that the surface EMG activity of the quadriceps was facilitated more by active ankle dorsiflexion or plantarflexion than by the natural (rest) position¹¹⁾.

The present study does have limitations that require consideration when interpreting the results. First, the small sample size indicates the need for future studies with a larger number of subjects. Second, this study trained only one side and made measurements at only two angular velocities. Despite these limitations, the effect of ankle position on

knee extensor strength after three weeks of isokinetic training was demonstrated, a result which is of clinical value in the strengthening of knee extensors. Future studies should address these limitations and measure the effect of ankle position on knee strength using other tools so the results can be generalized to healthy individuals as well as individuals with knee injury.

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