Effects of Isokinetic Velocity Spectrum Exercise on Average Power and Total Work

John E. Kovaleski, PhD, ATC
Robert J. Heitman, EdD
Frederick M. Scaffidi, PhD
Frank B. Fondren III, MD

ABSTRACT: In this study we compared the influence that the order of the performance of different velocity exercise progressions has on average muscle power and total work production during a velocity spectrum isokinetic training session. Twenty-two college students were assigned randomly to four exercise trials, each containing an isokinetic exercise training session involving dominant knee extensors and flexors. Each exercise trial consisted of two sets of ten repetitions at speeds of 30°, 90°, 150°, and 210°/sec. The pretest, posttest, and experimental session muscle function measurements were assessed. Selected measurements of average power (joules/sec) and total work (joules) were used to make comparisons between the protocols. There was no training effect (change in peak torque) during the study for either extension or flexion at any of the four speeds. Total work was similar across the four protocols. There was a difference in average power for both extension and flexion among the protocols. We conclude that when performing velocity spectrum type training, performing faster speed sets early in the exercise session will produce a greater average power.

John Kovaleski is an assistant professor in the Department of Health, Physical Education, and Leisure Services (H, PE, & LS) and director of the South Alabama Sports Medicine Center at the University of South Alabama, Mobile, AL.

Robert Heitman is a professor in the Department of H, PE, & LS at the University of South Alabama.

Frederick Scaffidi is an associate professor and chairman of the Department of H, PE, & LS at the University of South Alabama.

Frank Fondren is a clinical assistant professor in the Department of Orthopedic Surgery at the University of South Alabama.

Isokinetic exercise is used to test and train functional characteristics of skeletal muscle. Isokinetic training studies have shown wide variations in intensity, frequency, duration, and effect on muscle strength (8,12,14,17), endurance (5), and power (3,4,11,18,20). These studies that examined velocity-specific effects during concentric exercise have produced conflicting results. In an early study, Moffroid and Whipple (12) reported that the effects of training at a specific velocity are limited to that velocity or to lower velocities, while more recent studies (3,11,18) using high velocity isokinetic training have reported that the overflow training effects reach higher velocities. In contrast, Vitti (20) concluded that increases in average leg power resulting from variable training speeds were not great enough to differentiate in favor of low, high, or low/high speed isokinetic training.

More recently, velocity spectrum training advocates have claimed that patients can recruit and train both type I and type II muscle fibers by varying the velocity of the movement over the course of the exercise session (2,3,9,10,19). This method of training is practiced to promote an optimal neuromuscular response and is supported by current theory concerning velocity-specific resistance training (9,13,15). Arthroscopic meniscectomy patients showed improved muscle function within three weeks using velocity spectrum isokinetic training (10,19).

Because isokinetic velocity spectrum training improves muscle function, we wondered if the order in which the velocity progression was performed would influence work and power production. A review of the literature indicated an absence of information concerning velocity spectrum training and the influence of exercise progression order on a muscle's ability for work and power production. The purpose of this study was to compare the influence that the order of the performance of different velocity exercise progressions has on muscle average power and total work production during a velocity spectrum isokinetic training session.

Methods

Twenty-two recreationally active college students volunteered and participated in this study (12 males, 10 females, age 21.3±2.6 yr; wt=157.7±28.7 lb; ht=67.7±3.4 in). We instructed each participant to refrain from participating in heavy resistance weight training or endurance training during the study. Usual recreational and daily living activities were permitted; however, each subject was instructed to refrain from physical activity for 24 hours prior to each exercise trial.

According to institutional guidelines, before they gave their signed consent to participate, we informed each subject of the nature, purpose, and possible risks involved in this study.

A repeated measures design was employed. A single independent variable (type of velocity spectrum training protocol) had four levels. Each subject participated in all protocols. The dependent variables were average power for knee flexion and extension, and total work. Data comparisons between protocols were first analyzed using a Doubly Multivariate (DM) analysis. Follow-up procedures consisted of separate multivariate analyses of variance (MANOVAs) run on each dependent variable with the Bonferroni adjustment. Then, the Scheffé post hoc test was used for univariate contrasts (16). A possible training effect was evaluated with dependent t-tests between pretest and posttest peak torque.

Each of the four exercise trials consisted of an isokinetic exercise training session involving the dominant knee extensors and flexors. One week prior to the first exercise trial, we read a definition of isokinetic exercise to each subject. He or she then observed and participated in an isokinetic exercise familiarization session. We made pretest and posttest strength comparisons (using dependent t-tests) three days prior to and following the exercise trials to assess whether a training effect occurred as a result of participation in the study. Each subject was randomly assigned to a group prior to performing the four protocols.

The exercise trials involved performing reciprocal knee extensions and flexions. A random order of velocity-specific exercise progressions with four different isokinetic exercise protocols was used (Table 1). Each exercise trial consisted of two sets of 10 repetitions at speeds of 30°, 90°, 150°, and 210°/sec. Measurements were made using two standard velocity spectrum training protocols (P1 and P2) and two modified velocity spectrum protocols (P3 and P4). In the modified protocols, the velocity of movement was not increased or decreased until all sets and repetitions were performed at the given speed. Once a week for four weeks, each subject performed one of the four protocols. The isokinetic testing was performed through a range of 90°, where terminal extension was considered to be 0°. We encouraged each subject to exert a maximal effort at all times. Seven days separated each exercise trial.

The pretest, posttest, and experimental session muscle function measurements were assessed using the LIDO Active isokinetic dynamometer (Loredan Biomedical, West Sacramento, CA). The reliability and validity of this dynamometer have been reported previously (1). Selected measurements of muscle power and work were used to make comparisons between protocols. The data were sampled by a computer interfaced with the dynamometer so that angular position (degrees), velocity (degrees/sec), average power (joules/sec), and total work (joules) were recorded continually. While the actual testing range of motion (ROM) was 90°, an 80° ROM (between 5° and 85°) was analyzed to exclude measurements taken during acceleration and deceleration (6) and to standardize the ROM so that work values could be calculated.

Initial data reduction involved calculating the average power and total work for each set and the speed for each of the four protocols. Data analysis was performed on individual repetitions by adding the average power values (joules/sec) for each speed of the protocol and entering the mean value in the statistical analysis. Total work was analyzed by adding the work value (joules) for each speed of the protocol and using the sum of the total work in the statistical analysis.

Table 1.—Summary of the Four Isokinetic Protocols (P1-P4)

P1:	Speed (Deg/Sec)	:	30	90	150	210	210	150	90	30
	Reps	:	10	10	10	10	10	10	10	10
	Sets	:	1	1	1	1	1	1	1	1
	Rest	:	1 minute between each set							
P2:	Speed (Deg/Sec)	:	210	150	90	30	30	90	150	210
	Reps	:	10	10	10	10	10	10	10	10
	Sets	:	1	1	1	1	1	1	1	1
	Rest	:	1 minute between each set							
P3:	Speed (Deg/Sec)	:	30	90	150	210				
	Reps	:	10	10	10	10				
	Sets	:	2	2	2	2				
	Rest	:	1 minute between each set							
P4:	Speed (Deg/Sec)	:	210	150	90	30				
	Reps	:	10	10	10	10				
	Sets	:	2	2	2	2				
	Rest	:	1 minute between each set							

Results

There was no training effect as a result of participation in this study. Pretest versus posttest comparisons of peak torque for flexion and extension at 30°, 90°, 150°, and 210°/sec were not significant ($t(21)<1.68; p>.108$).

The means and standard deviations for the four protocols for each dependent variable are presented in Table 2. The overall Doubly Multivariate analysis was significant ($F(3,19)=6.84; p=.001$). There was no difference in total work across the four protocols ($F(3,19)=2.60; p=.082$). Significant MANOVAs were found for the average power variable for both extension ($F(3,19)=17.32; p=.001$) and flexion ($F(3,19)=25.34; p=.001$). Protocol four produced greater average extension power than protocols one, two, and three (Scheffé, $p<.05$)). For average flexion power, protocols four and two produced greater power than protocols one and three.

Discussion

The significant differences noted between protocol four (where the faster speeds were performed before progressing to the slower speeds) and the other protocols might be explained by the force-velocity and power-velocity curvilinear relationships reported in the physiological literature (7,9). That is, when exercising at faster speeds, the potential for producing power is greatest, and, when exercising at slower speeds, force production is greatest. Our results concur with the notion that when progressing from fast to slower speeds for both extension and flexion, performing the faster speeds early in the exercise trial, either in the velocity spectrum or the modified velocity spectrum protocols, generally produces a greater average power.

The enhancement of muscle power output by high-velocity training is supported by Coyle et al (3). Because the slower speeds are performed under greater resistance than the faster speeds, the muscle may fatigue more quickly (2). This may partially explain why the other three protocols generally produced less average power. The faster speed sets that are associated with greater power production were performed early in the exercise trials of protocols four and two, before fatigue may have become a factor.

Table 2.—Summary of Average Power (Joules/Sec) and Total Work (Joules) for Knee Flexion and Extension Across Protocols (N=22; Mean±SD)

	Protocol 1	Protocol 2	Protocol 3	Protocol 4
Average Power Flexion	114.91 ± 28.75	125.80 ± 33.85	114.00 ± 27.34	133.35 ± 31.17
Average Power Extension	169.78 ± 39.00	174.17 ± 46.04	165.83 ± 34.94	187.25 ± 42.73
Total Work	15267.68 ± 3654.17	15700.49 ± 3638.12	15541.24 ± 3384.44	16084.33 ± 4267.75

Muscle power production has not often been the focus of attention in determining specific velocities and progressions for velocity spectrum exercise. Because power is a product of force and velocity, it was used in this study as a measurement of work performed per unit of time. It appears that even though comparisons of the total work values between the four protocols revealed no differences, the ability of the muscle to produce force positively affected the average power produced in protocol four. Therefore, if an individual exercises isokinetically for rehabilitation or sport participation that requires muscular power, performance of fast speed training prior to progressing to slow speed training is recommended.

While we recommend caution in generalizing the results of this study to other populations (e.g., athletes, children, special populations) and other velocity spectrums, a basic practical implication might be made. When an individual exercises isokinetically, the velocity progression may be important to power production during that training/rehabilitation session even though total work may not be influenced. Future studies need to examine other factors such as training effects and different velocities, repetitions, and sets performed, as well as examining the interaction of fatigue and velocity spectrum training.

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