A Study of Isokinetic Exercise

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▶ *This paper presents some practicalities and established norms for isokinetic exercise. Reliability and validity of the isokinetic device were determined for measurements of torque, work, range of motion, and power. These parameters were evaluated for the conditions under which isokinetic exercise was employed to establish norms and to evaluate the effectiveness of that exercise in increasing muscular strength. The norms are given for the quadriceps and hamstring muscle groups of normal young subjects. They pertain to force through the range of motion at varying speeds of contraction. The practicalities include objective comparison of effects of isokinetic exercise and two types of conventional exercise.* ◀

ISOKINETIC EXERCISE is a new dimension in the field of resistive exercise and muscle evaluation.[1, 2] It is made possible by an electromechanical device which keeps limb motion at a constant, predetermined velocity. Any effort applied encounters an equal counterforce. Increased muscular output produces increased resistance rather than increased acceleration, as would occur in a gravity-loaded system of resistive exercise. Hence, the resistance developed is in proportion to the amount of muscle force exerted, and a maximal effort can be experienced, as if a maximal load were being applied at all points throughout the arc of motion. Such maximal loading is inherent in manually applied resistance which, unfortunately, taxes a therapist's energy and lacks objectivity of measurement.

Figure 1 illustrates isokinetic exercise for knee extension and flexion. The device is adjustable so that the anatomical axis of rotation (the joint where the torque is created) is aligned with the machine's axis of rotation (where the torque is transmitted).

RELIABILITY AND VALIDITY

The factors which were measured and recorded from an isokinetic contraction were: torque, range of motion, work, power, and speed of contraction. These values were obtained from pen recorder tracings of the torque, which is created at the axis of rotation of the device. Clinical evaluation and verification of these measurements were made and are presented below.

Torque

Torque is a force which acts about an axis of rotation. It is the product of this force times its perpendicular distance from the axis of rotation. Hence, thirty pounds acting per-

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This study was supported in part by Research Grant RT–1 (C6) from the Social and Rehabilitation Service of the U.S. Department of Health, Education and Welfare, under the designation of New York University as a Research and Training Center.

pendicularly to the horizontal lever arm at a distance of two feet from the axis equals sixty foot-pounds of torque. When various loads (sixty, fifty, forty, thirty, twenty, ten, five pounds) are placed on the isokinetic device at this same distance and position, a true linear relationship is produced (Fig. 2). Ten test-retest sessions using these seven loads at this one position produced a coefficient of reliability of $r = 0.995$.

On the other hand, when the same load is placed at various positions through an arc of 180 degrees, it is possible to determine if a calibration holds when the position is changed. Selected angles were obtained by setting the lever arm at given positions, turning the speed of the device to zero, and placing a thirty-pound load on a 1.5 foot lever arm. These values were correlated with predicted values, where the predicted torque for any given angular position is load times distance times the sine of the angle (Table 1).

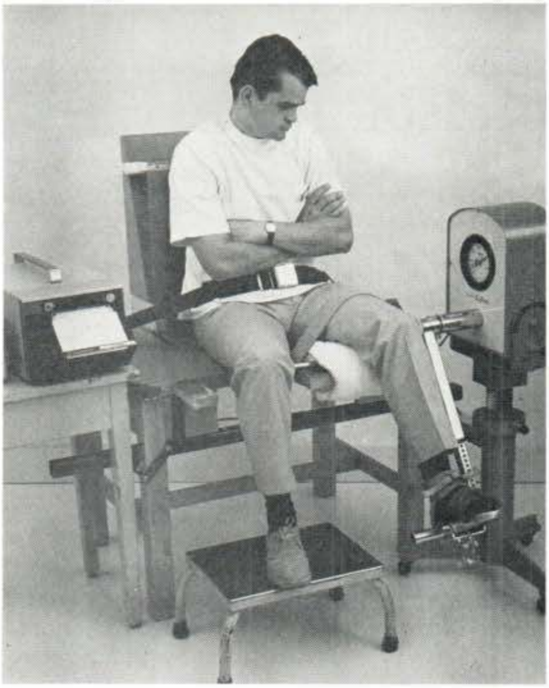


Fig. 1. Subject using an isokinetic device. The joint axis is aligned with the axis of the device.

Work

Work is a force acting through some distance. If the distance is angular displacement, as with an isokinetic device, work is:

$$T \text{ x } 2\pi \text{ x } d$$

where T is torque in foot-pounds and d is distance in portion of arc traveled. For example, when a thirty-pound weight is allowed to fall from the vertical position at the end of 1.5 foot lever arm, the distance traveled is 180 degrees in 7.5 seconds (see Fig. 3.) The resultant work is equivalent to the area under the curve, as seen in Figure 4.

TABLE 1

VALIDITY OF TORQUE MEASUREMENTS AT VARIOUS ANGLES

Angular Position Θ (Degrees)	Predicted Torque in Foot-Pounds (1.5 x sin Θ)	Obtained Torque in Foot-Pounds[a]
6	4.7	5.0
18	13.9	11.5
30	22.5	20.0
42	30.1	29.5
54	36.3	36.0
66	41.1	41.0
78	44.0	44.0
90	45.0	45.0
102	44.0	44.0
114	41.1	41.0
126	36.3	35.5
138	30.1	30.0
150	22.5	22.0
162	13.9	12.0
174	4.7	5.0

[a] The coefficient of validity of predicted-to-obtained torque measurements was found to be $r=0.999$.

For this recording, the paper speed was set at 1.5 inches per second. One square is 0.75 inches, and thus represents 0.5 seconds or 12 degrees of motion. The marked square in Figure 4 has an average torque of forty foot-pounds. The work represented by this square area of 0.5625 square inches is 40 times 6.28 times 12°/360°, or 8.37 foot-pounds. The total area of the curve in Figure 4 was determined by planimetry to be 5.9 square inches. A simple proportion, of known area over known work to measured area over unknown work, gives:

$$\frac{\text{5.9 square inches}}{\text{unknown work}} = \frac{\text{0.5625 square inches}}{\text{8.37 foot-pounds}}$$

The work of this curve equals 87.8 foot-pounds.

The validity of this measure was established by mechanical computation of the same situation. A thirty-pound weight was allowed to fall from the vertical position (Fig. 3). It descended at a constant rate, as governed by the isokinetic device. This load, acting at a 1.5 foot distance from the axis, traveled a vertical distance of three feet in the 180-degree arc. Work in this case equals force times vertical distance, or ninety foot-pounds.

Five measures were made, as shown in Table 2. The correlation between the mechanical computation and the measured value was $r=0.946$. The isokinetic device was thus shown to transmit torque reliably through a range of motion at the test speed of four revolutions per minute and to measure torque validly.

Range of Motion

Work is a function of torque and angular displacement. Since torque and work measurements have been shown to be independently reliable, it follows that measurements of angular displacement are also reliable. Simple tests can be made on this deduction. Figure 3 illustrates a 180-degree excursion at a machine setting of four revolutions per minute (24 degrees per second). Since the paper was moving at 1.5 inches per second, the 180-degree arc should measure 11.25 inches along the abscissa, as demonstrated in Figure 4.

Because of a mechanical error in technique, this measurement is not practical for velocities of more than twelve revolutions per minute. Furthermore, unless a fast-response recording system is used, range-of-motion readings at high velocities tend to be nonlinear in calibration because of pen inertia in the present recording system.

Power

Power is the rate of doing work. The work of one repetition, divided by the time, repre-

TABLE 2

Validity of Work Measurement over Distance of 180 Degrees

Load in Pounds	Predicted Work Load x Vertical Distance	Measured Work in Foot-Pounds[a]
10	30	24.6
20	60	57.5
30	90	88.6
40	120	111.2
50	150	154.8

[a] The coefficient of validity of predicted-to-obtained work measurements was found to be $r=0.946$.

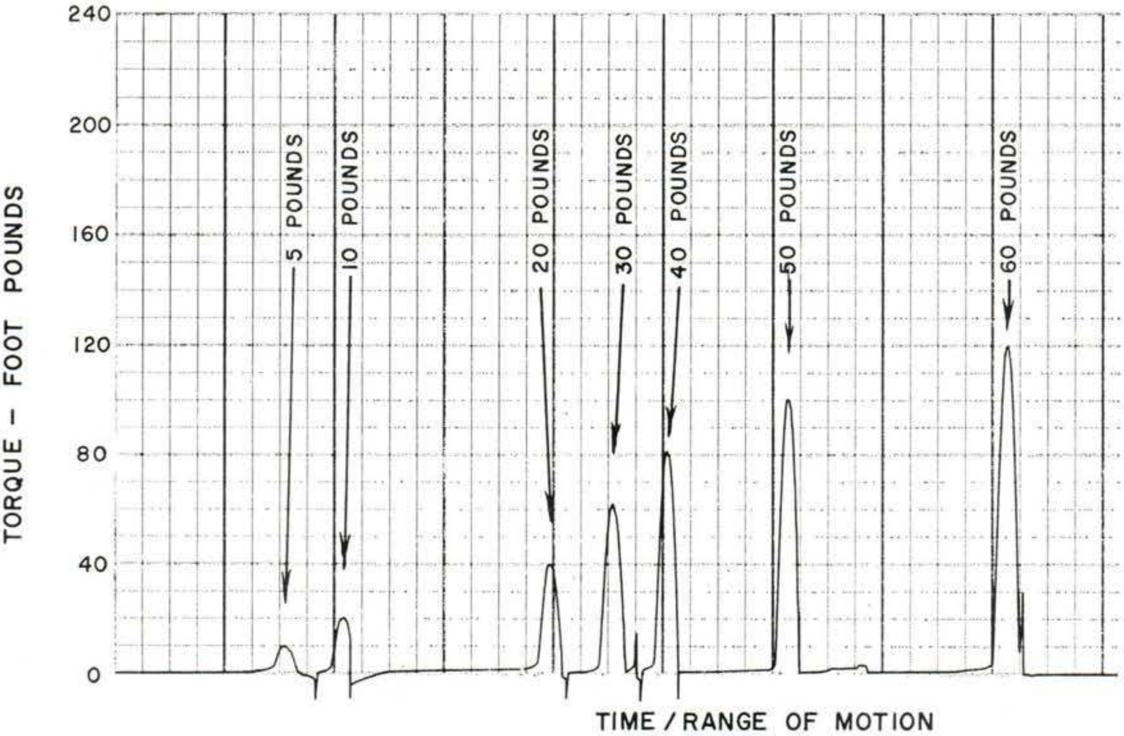


Fig. 2. Calibration of torque produced by successive load increments on a two-foot lever arm. The relationship is linear.

sents the average power output during that one repetition. Instantaneous power would be the rate at which the muscle is working at any one instant in an arc of motion.[3] Because muscular torque varies through an arc of motion, this value of instantaneous power introduces a more definitive concept of muscular performance at different velocities of contraction.

To ascertain if power is accurately measured by the system presented here, the torque must be reliably transmitted, regardless of the velocity of the lever arm. In other words, if a given torque is accurately measured, the power will vary as the speed setting varies. Power is calculated as shown in Table 3.

TABLE 3

Derivation of Formula for Instantaneous Power in Units of Horsepower

(1) Two $\pi \cdot (X)$rpm = angular displacement in radians per minute

(2) $\dfrac{\text{Torque} \cdot \text{two } \pi \cdot (X)\text{rpm}}{\text{minutes}} = \text{power}$

(3) $\text{One horsepower} = \dfrac{33{,}000 \text{ foot-pounds}}{\text{minute}}$

(4) $\dfrac{(Y) \text{ Horsepower}}{\text{Step (2)}} = \dfrac{\text{one horsepower}}{33{,}000 \text{ foot-pounds per minute}}$

(5) $(Y) \text{ Horsepower} = \dfrac{\text{torque} \cdot (X)\text{rpm}}{5252}$

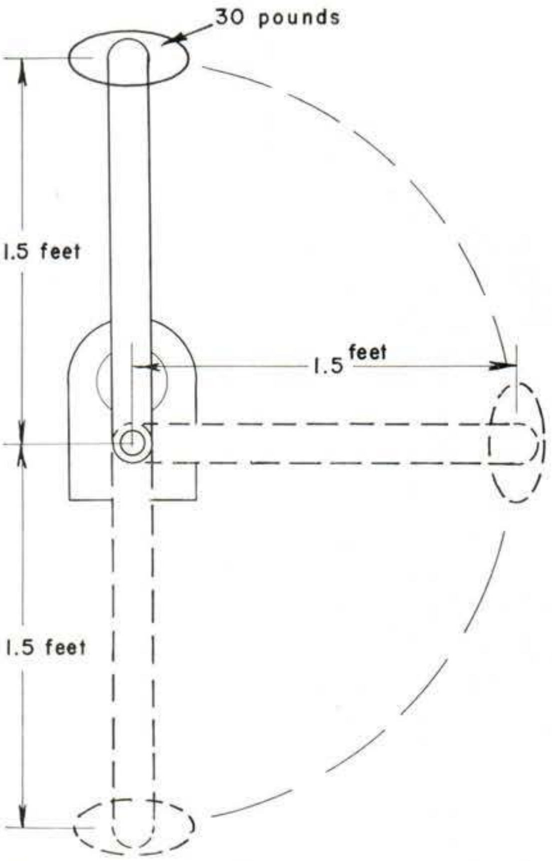


Fig. 3. A 30-pound weight dropped through 180 degrees. The speed is constant at 24 degrees per second. The vertical distance is 3 feet.

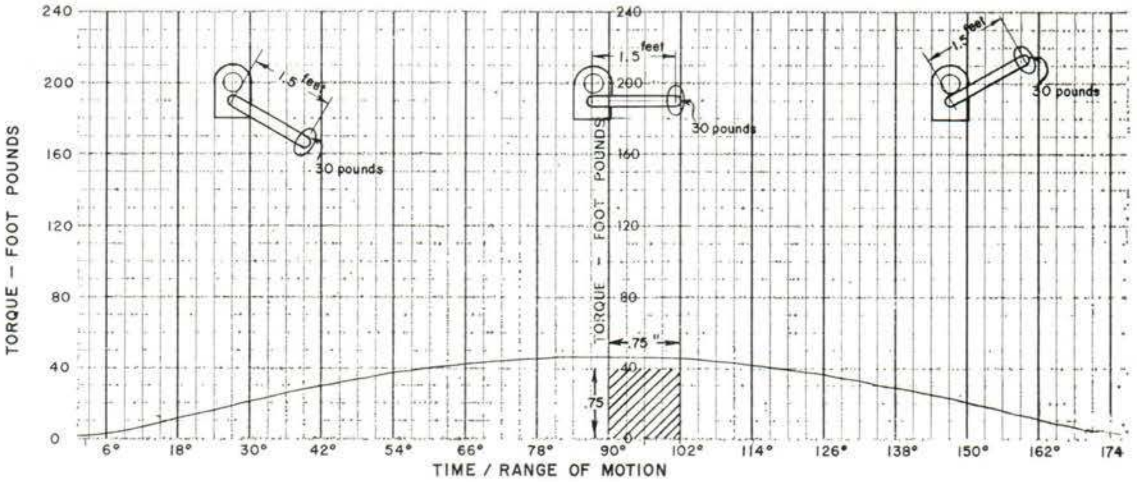


Fig. 4. A 30-pound weight acting on a 1.5 foot lever arm through 180 degrees at a velocity of 24 degrees per second.

Figure 5 represents sixty pounds acting on a two-foot lever arm. The first three drops were made at four revolutions per minute, the second three drops at eight revolutions per minute, and the third three at twelve revolutions per minute. The predicted power in units of horsepower (torque x revolutions per minute/5252) was calculated. The figures are presented in Table 4. A correlation between predicted power and obtained power of the nine trials was $r=0.999$. Thus, peak torque is reliably measured at different velocities, since the power varies directly with the velocity of the machine.

Speed

Because the principle of accommodating resistance depends on the constancy of speed, it is valuable to be able to verify the constancy of the speed. The measurements made with the isokinetic device and the manner of recording were found to be valid, reliable, and objective. Figure 4 demonstrates the clinical evaluation of the factor of constant speed. Since it has been shown that the abscissa reliably records range of motion at four revolutions per minute, a correlation between predicted and obtained points on either side of the curve should reveal a very high correlation. If this were not so, the

TABLE 4

RELIABILITY OF TORQUE MEASUREMENTS AT VARIOUS VELOCITIES

Velocity (rpm)	Predicted Horsepower (T x rpm/5252)	Obtained Horsepower[a]
4	0.091	0.091
	0.091	0.091
	0.091	0.091
8	0.182	0.182
	0.182	0.181
	0.182	0.182
12	0.274	0.274
	0.274	0.279
	0.274	0.275

[a] The coefficient of validity between predicted and obtained values for horsepower was $r=0.999$.

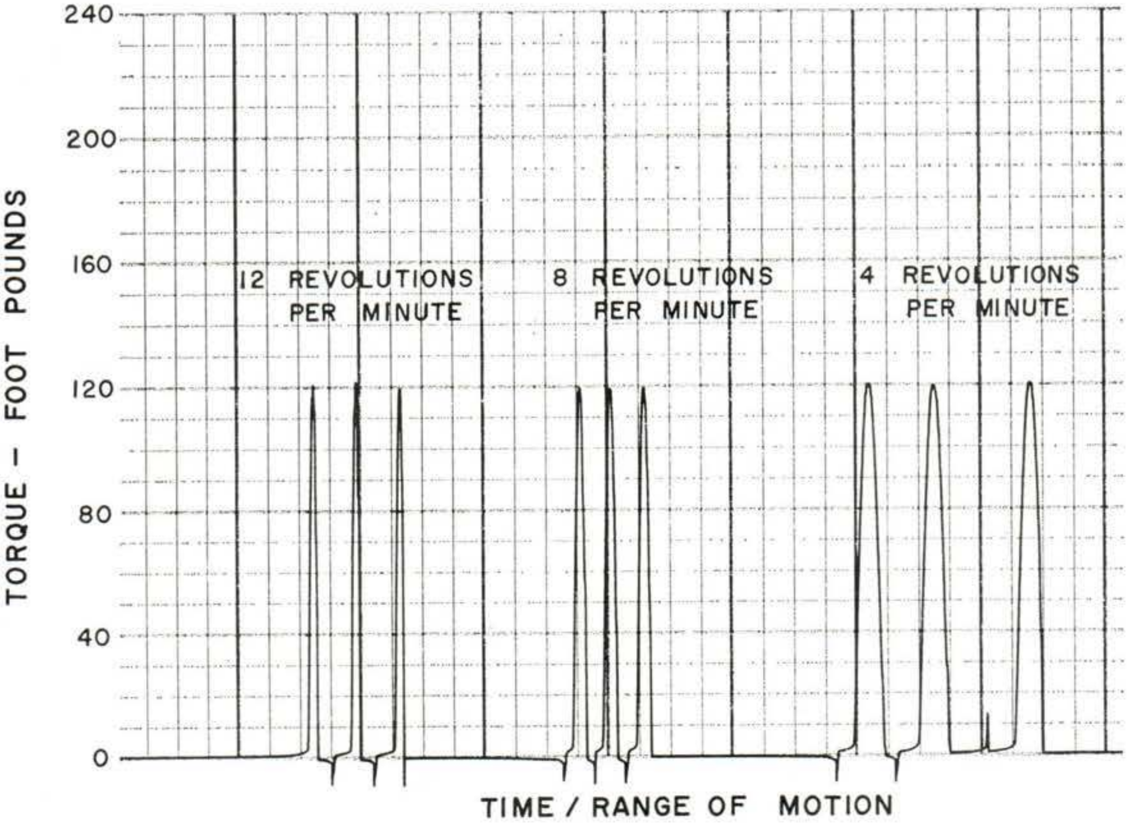


Fig. 5. Calibration of 120 foot-pounds at four, eight, and twelve revolutions per minute. The power varies directly with the velocity if the torque is accurately recorded.

reason would be an acceleration or a deceleration throughout the arc of motion. A correlation of thirty-four points revealed an $r=0.985$.

EXPERIMENTAL FINDINGS

Comparative Effectiveness

In an attempt to evaluate the isokinetic device as a useful means for increasing muscular torque, a study was designed to compare the increases of muscular torque after four weeks of isometric, isotonic, or isokinetic exercise.

Method. Sixty subjects—twelve men and forty-eight women—were randomly selected from the staff of the Institute of Rehabilitation Medicine. They ranged in age from eighteen to thirty-one, and all of them were familiar with the isokinetic device, although not trained in a formal strengthening program.

Initial testing consisted of performing five reciprocal contractions of the quadriceps and hamstring muscle groups at 3.75 revolutions per minute. The dominant limb was tested as determined by dominant handedness. Maximum effort was requested.

These sixty subjects were then randomly assigned to one of the three groups—isometric, isotonic, and isokinetic—for a total of twenty subjects in each group. All the subjects exercised daily for four weeks and were tested once weekly for strength on the isokinetic device. Subjects in the isometric group delivered ten maximal holds at each of two joint positions, 90 degrees and 45 degrees. This test was repeated for knee flexion at the same two joint positions. Subjects in the isotonic group performed three series of ten repetitions in knee extension. The final series was the ten-repetition maximum load as established by weekly testing. Subjects in the isokinetic group performed thirty maximal repetitions daily.

Results. Figure 6 shows the representative torque curves from the five reciprocal contractions in the initial testing procedures. The velocity of the contractions was at 3.75 revolutions per minute (22.5°/sec.). The paper speed was 0.75 inches per second. (Again, one large square is 0.75 inches long.) In the resultant three hundred initial recordings, the peak torque of the quadriceps was generally twice that of the hamstring muscle group (Fig. 6). At this velocity of 22.5 degrees per second, the peak torque values were 105±6 foot-pounds for the quadriceps and 51±4 foot-pounds for the hamstring muscle group.

The peak torque of the quadriceps contractions occurred at 63±2 degrees. The peak torque of the contractions of the knee flexors was found to occur at 34±2 degrees (Fig. 6).

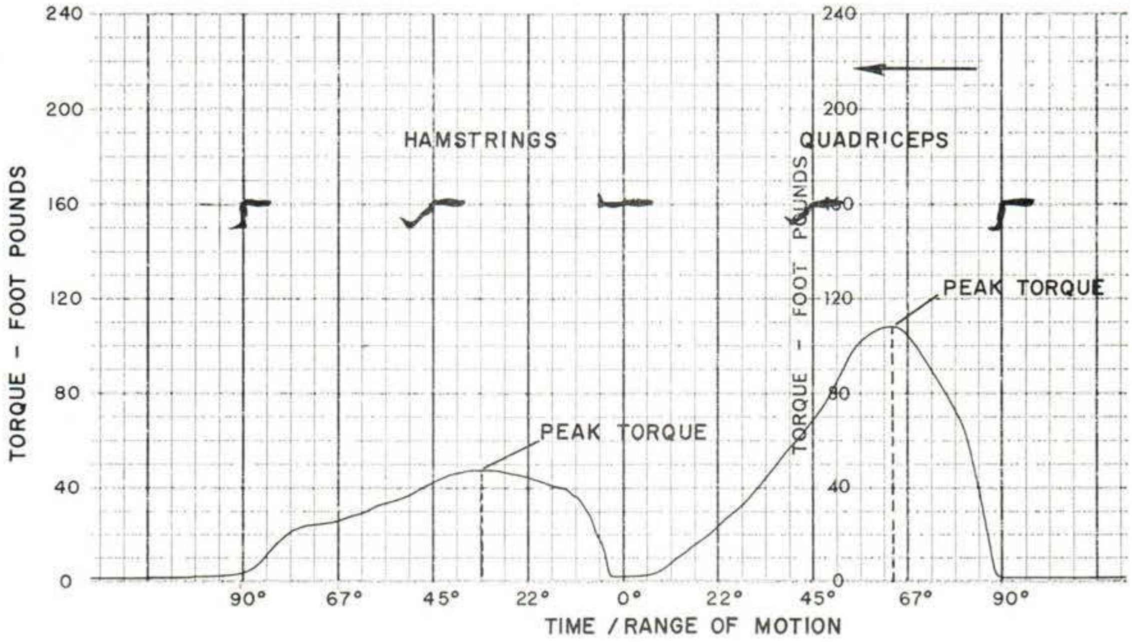


Fig. 6. Torque curves of quadriceps and hamstring muscle groups of normal subject performed at a constant velocity of 22.5 degrees per second.

Initial scores and increases of the three groups after four weeks of exercise are given in Tables 5, 6, and 7. Table 5 presents the isometric torque for the quadriceps and hamstring muscles at the 90-degree position; Table 6, the isometric torque for the quadriceps and hamstring muscles at the 45-degree position; and Table 7, the isokinetic work values for the quadriceps and hamstring muscles. The scores are the means and the standard errors. Percentage increase means increase in foot-pounds in relation to final score, e.g., an increase from

TABLE 5

ISOMETRIC TEST SCORES AT 90 DEGREES

				Significance of Increase	
Group	No. of Subjects	Initial Score ($\bar{X}$±S.E.)	% Increase ($\bar{X}$±S.E.)[a]	Student t-test	p
		Quadriceps			
Isokinetic	20	87±6 ft.-lbs.	14±6%	2.00	<0.05
Isometric	20	87±7 ft.-lbs.	17±5%	2.12	<0.05
Isotonic	20	97±6 ft.-lbs.	−2±5%	....	N.S.
		Hamstrings			
Isokinetic	20	37±4 ft.-lbs.	11±5%	1.24	N.S.
Isometric	20	34±3 ft.-lbs.	26±4%	3.06	<0.01
Isotonic	20	36±4 ft.-lbs.	4±4%	....	N.S.

[a] Percentage increase reflects the percent increase in foot-pounds of the final peak torque in foot-pounds.

TABLE 6

ISOMETRIC TEST SCORES AT 45 DEGREES

				Significance of Increase	
Group	No. of Subjects	Initial Score ($\bar{X}$±S.E.)	% Increase ($\bar{X}$±S.E.)[a]	Student t-test	p
		Quadriceps			
Isokinetic	20	77±8 ft.-lbs.	24±4%	2.75	<0.01
Isometric	20	79±6 ft.-lbs.	14±5%	2.06	<0.05
Isotonic	20	77±4 ft.-lbs.	13±7%	2.08	<0.05
		Hamstrings			
Isokinetic	20	47±4 ft.-lbs.	19±3%	2.20	<0.05
Isometric	20	47±4 ft.-lbs.	24±4%	2.47	<0.05
Isotonic	20	50±5 ft.-lbs.	1±3%	....	N.S.

[a] Percentage increase reflects the percent increase in foot-pounds of the final peak torque in foot-pounds.

TABLE 7

ISOKINETIC TEST SCORES FOR WORK

				Significance of Increase	
Group	No. of Subjects	Initial Score ($\bar{X}$±S.E.)	% Increase ($\bar{X}$±S.E.)[a]	Student t-test	p
		Quadriceps			
Isokinetic	20	78±4 ft.-lbs.	11±6%	1.52	<0.10
Isometric	20	83±5 ft.-lbs.	3±4%	....	N.S.
Isotonic	20	82±4 ft.-lbs.	3±4%	....	N.S.
		Hamstrings			
Isokinetic	20	45±3 ft.-lbs.	16±7%	2.59	<0.01
Isometric	20	47±4 ft.-lbs.	3±7%	....	N.S.
Isotonic	20	45±3 ft.-lbs.	1±6%	....	N.S.

[a] Percentage increase is the percent increase in foot-pounds of work of the final value for work in foot-pounds.

seventy-five to one hundred foot-pounds would be a 25 percent increase.

Discussion. The approximate ratio of two-to-one of mean peak torque of knee extension to knee flexion, and the configuration of the entire torque curves, are similar to the force variations through the range of motion for the knee extensors and knee flexors as described by Williams and Stutzman (see Fig. 7).[4] Their values were obtained by plotting the force values of maximal isometric contractions at successive points along the arc of motion.

Presumably, the significant increase of work output of the isokinetic group may have occurred because the subjects were exercising maximally throughout the range of motion. Those in the isometric group exercised maximally in two static positions for each muscle group. The subjects in the isotonic group lifted weights of ten-repetition maximum using a pulley system. They received maximal resistance only during the latter part of knee extension because of the nature of the loading system.

The subjects in the isotonic group increased muscular torque of the quadriceps at the 45-degree position more than at the 90-degree position ($p=0.05$). A biomechanical comparison of the two systems of dynamic exercise demonstrates how the muscle is made to work in each of the two systems.

Isotonic and Isokinetic Exercise

Thus far, muscular force has been expressed in terms of torque. This torque is the product of the rotational component of muscular force times the distance from the axis of rotation to the insertion of the muscle. If an isokinetic contraction is viewed as a series of isometric contractions where the load is always applied at right angles to the extremity, the torque which is created and transmitted to the pen recorder can also be interpreted as the product of a load times the leg length. This same torque can also be computed for selected joint positions during isotonic exercise (pulley-loading system) if the load acting at right angles to the extremity is determined.

In an effort to compare the loading systems of the two types of exercise, one subject was asked to perform a one-repetition maximum on the isotonic exercise system. The subject attempted to maintain a speed of 42 degrees per second, as governed by an adjacent lever moving at that speed. The torque exerted during this maximal lift was computed at seven different joint positions. Figure 10 gives an example of the computation. The one-repetition maximum for this individual was determined to be 47.5 pounds.

After a fifteen-minute rest, the same subject was asked to perform a maximal isokinetic contraction at the same velocity (42 degrees per second). This torque curve was compared with the curve determined by connecting the points of torque measured from the isotonic contraction, as shown in Figure 11.

Figure 11 also illustrates why a person exercising maximally with this particular form of isotonic loading would tend to be taxed more at the end of the excursion. It is necessary to

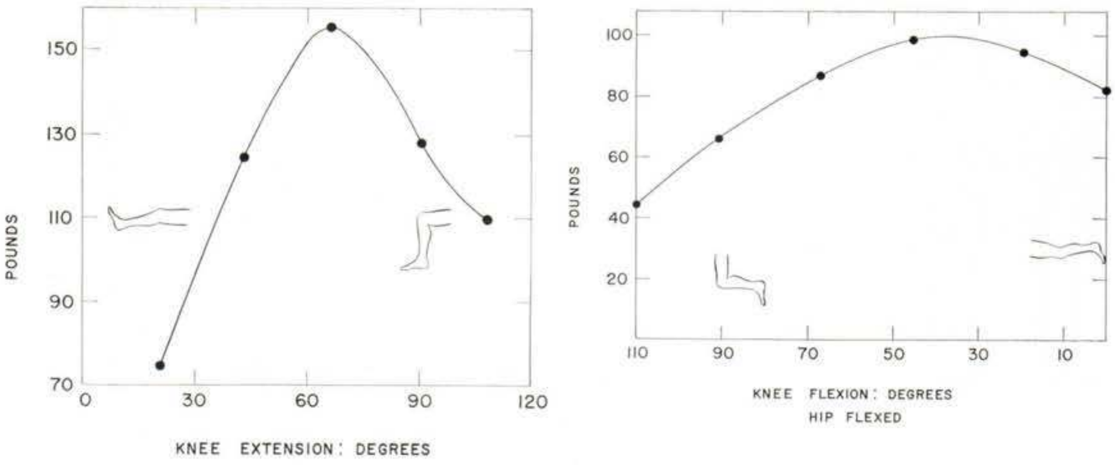


Fig. 7. (a) Knee extension (college men). Reprinted with permission from The Physical Therapy Review, 39: 145–152, March 1959. (b) Knee flexion with hip flexed. Adapted from Williams and Stutzman.[4]

recall the force curve of the quadriceps muscle (Fig. 6).

Because the subjects who exercised with an isotonic pulley system increased muscular torque predominantly at the end of the range, and because the subjects who exercised maximally throughout the range increased throughout the range of motion, it was tentatively concluded that muscular response to a given exercise system is relatively specific with regard to the effects on the torque curve.

Torque-Velocity Relationships

It has been observed that muscular tension decreases as velocity of shortening increases.[5–7] The relationship depends on the muscle being studied and the conditions under which it is observed.[8] A study was conducted to establish this relationship for the quadriceps and the hamstring muscle groups of untrained, normal subjects.

Method. Thirty subjects were selected at random and ranged in age from eighteen to thirty-one. Like those in the previously described study, the subjects were untrained.

The task was to perform five maximal reciprocal isokinetic contractions of the knee extensors and flexors. The subjects were tested every second day for two weeks. In order to balance the effect of learning or strengthening, the repetitions were performed at a different and randomly selected velocity at each test session. The velocity selected ranged from zero to eighteen revolutions per minute.

Results. The torque at 65 degrees of knee extension was plotted for velocities of shortening up to eighteen revolutions per minute (Fig. 8). The shape of the resulting torque-velocity curve depicts maximal torque which the muscle can create at a given joint position for velocities between zero and eighteen revolutions per minute. As this graph shows, the torque values decrease markedly with increasing velocities. It remains to be seen at what velocity the torque will decrease to zero.

Discussion. The classic force-velocity curve

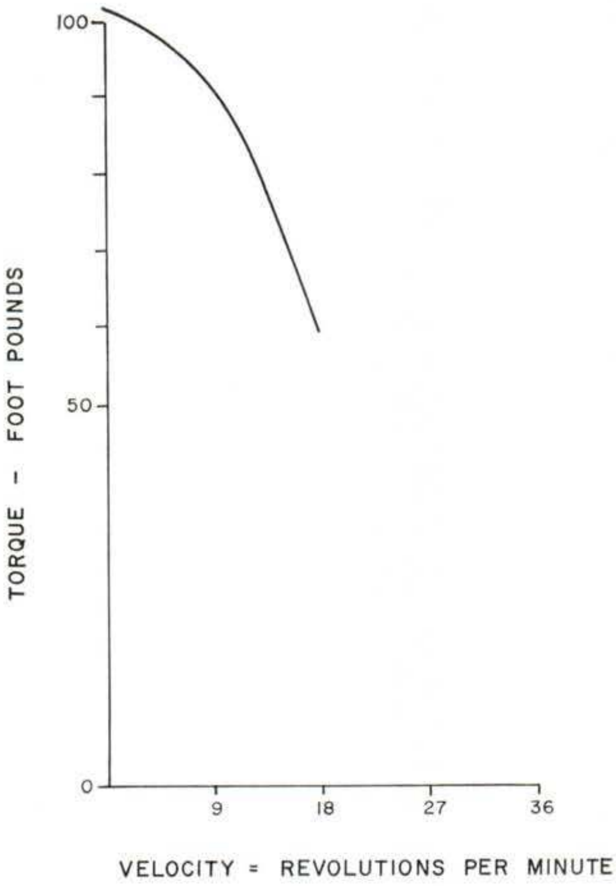


Fig. 8. Torque-velocity curve of the quadriceps of normal subjects measured at 65 degrees of knee extension.

for isolated muscle fiber is given in Figure 9. This curve was obtained by having an *in vitro* muscle fiber shorten against a fixed load. The force was measured when the muscle was approximately five-sixths of its most lengthened state.[6]

Although it is difficult to compare the two curves, it is possible to conjecture that the force-velocity curve in Figure 8 is similar to the first third of the classic curve derived for all velocities of shortening up to the maximal velocity. The initial plateau might possibly be attributable to a reluctance to exert more force at the slower speeds of shortening (zero to six revolutions per minute). Other neuromuscular influences must also be considered, such as the length of muscle, the temperature, the intact neurophysiological system with facilitatory and inhibitory contributions, the angle of pull of the muscle, the degree of motivation in delivering a maximal effort, and the nature of the muscle itself.

At slower velocities of shortening, the peak torque of the quadriceps contraction occurred at 63±2 degrees, indicating that the muscle can perform optimally at this joint position because of leverage and muscle length. As long as there is enough time for the contractile com-

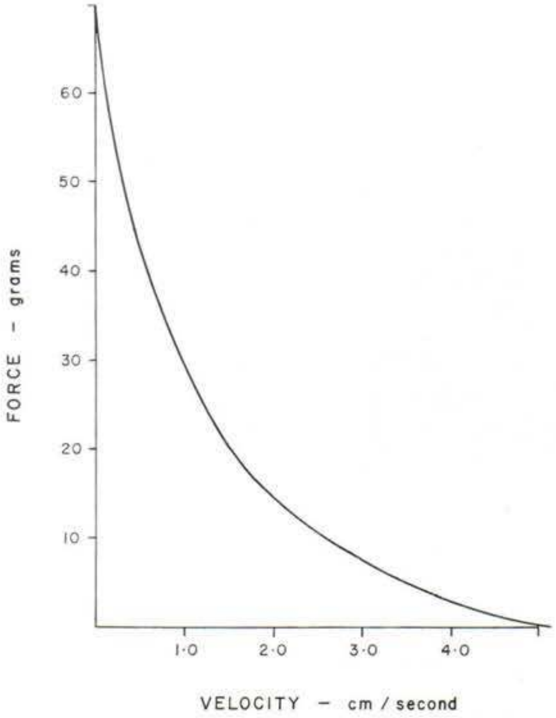


Fig. 9. Relationships between load and speed of shortening in isolated frog sartorius. Adapted from Hill.[5]

TABLE 8

RELATIONSHIP OF PEAK TORQUE TO VELOCITY

	Revolutions per Minute[a]						
Muscles	0	3	6	9	12	15	18
Quadriceps $N=30$	103±6	107±7	103±6	98±5	89±5	81±3	76±3
Hamstrings $N=30$	57±4	65±4	62±3	60±3	56±2	53±3	50±3

	Significant Differences of Peak Torques at Various Test Velocities		
Muscles	Test Velocities	*t*-test	*p*
Quadriceps $N=30$	6 and 12 rpm	1.9	0.05
	9 and 15 rpm	4.9	0.001
	12 and 18 rpm	2.38	0.01
Hamstrings $N=30$	3 and 9 rpm	1.88	0.05
	6 and 15 rpm	2.09	0.05
	9 and 18 rpm	2.22	0.05

[a] Values are peak torque in foot-pounds. Mean ± S.E.

ponent of the muscle to develop to its fullest capacity, the point in the range where the peak torque of the quadriceps occurs will remain constant with increasing rates of shortening.

However, with high speeds of shortening, the knee joint can often pass by that point of optimal performance by the time the contractile component attains maximum tension. As a result, the peak torque tends to occur later and later in the range with increasing speeds.

Therefore, in evaluating muscular performance through a range of motion, the shape of the torque curve must be considered in relation to the speed at which the contraction was performed.

Significant differences in peak torque were found at all increment levels of six revolutions per minute or more (for example, between three and nine, twelve and eighteen revolutions per minute) for the quadriceps. In the hamstring muscle group, the significant differences were between intervals of nine revolutions per minute (that is, three and twelve, nine and eighteen revolutions per minute) ($p=0.05$). The values are given in Table 8.

Studies are now in progress to ascertain the effects of exercise at both slow and fast speeds on the basis of the force-velocity relationships given above.

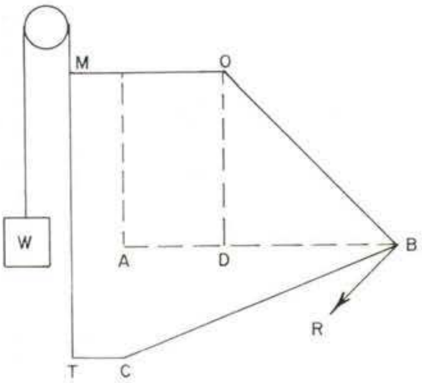
A recent engineering refinement of the isokinetic exercise device enables the speed to be preset anywhere between zero and twenty-five revolutions per minute; therefore, it is now possible to analyze the effects of varied contractile speed when effort is maximal. Recent investigations suggest that, for increasing muscular force, work is not as important as the rate at which it is done.[10]

It seems apparent, therefore, that one means of increasing muscular torque through a specific arc of motion is to apply resistance at a speed which produces an optimal power output. Since the specific way in which the muscle is loaded influences the degree of effort required, or, in effect, the degree of neuromuscular response, perhaps more selectivity in exercise techniques will affect the specific needs of patients.

SUMMARY

Various practicalities of isokinetic exercise have been presented. The measurements made

Fig. 10. Schematic diagram of computation for torque created by a one-repetition maximum on a pulley system. The measurement is made when the leg is in a 45-degree position.



GIVEN:

OB (LEG LENGTH) = 1.54 FEET
W (WEIGHT) = 47.5 POUNDS
KNEE ANGLE = 45 DEGREES

MEASUREMENTS:

AD = 7 INCHES
MT = 21 INCHES
$\angle$ OBD = 45 DEGREES

DERIVATION TORQUE:

TORQUE = R x OB
R = 47.5 cos CBR
$\angle CBR = 90° - (45° + \angle ABC)$
$\tan \angle ABC = \frac{AC}{AB}$
$\frac{AC}{AB} = \frac{21 - 18.3 \sin 45°}{7 + 18.3 \cos 45°} = 0.4050$
$\angle ABC = 22°$
$\angle CBR = 23°$
R = 43.7 POUNDS
TORQUE = 43.7 LBS. x 1.54 FT.
TORQUE = 67.3 FOOT POUNDS

by the isokinetic device and recorded by a pen-recorder (torque, work, power, range of motion, and speed) have been shown, thus far, to be reliable and valid. Norms established to date concern the quadriceps and the hamstring muscle groups of normal young adults. The pertinent findings are:

1. In the seated position, the quadriceps has a peak torque which is approximately twice that of the hamstring muscles.
2. At slow speeds of contraction, the torque curves of these muscle groups agree with previous findings stated for isometric forces at various joint positions.
3. At increasing speeds of contraction, the torque decreases.
4. With increasing speeds of contraction, the peak torque tends to occur later in the range, and the configuration of the muscular torque curve is altered.

Comparative findings of the usefulness of isokinetic exercise with normal subjects suggest that:

1. Isokinetic exercise is an effective means of increasing muscular torque throughout an arc of motion.
2. Isokinetic exercise increases the work a muscle can do more rapidly than does isometric exercise or isotonic exercise using pulleys.
3. Muscular response to different loading systems tends to be specific; that is, a muscle which is overloaded in a partial range of motion will increase significantly more in this range than in other, less exercised joint positions.

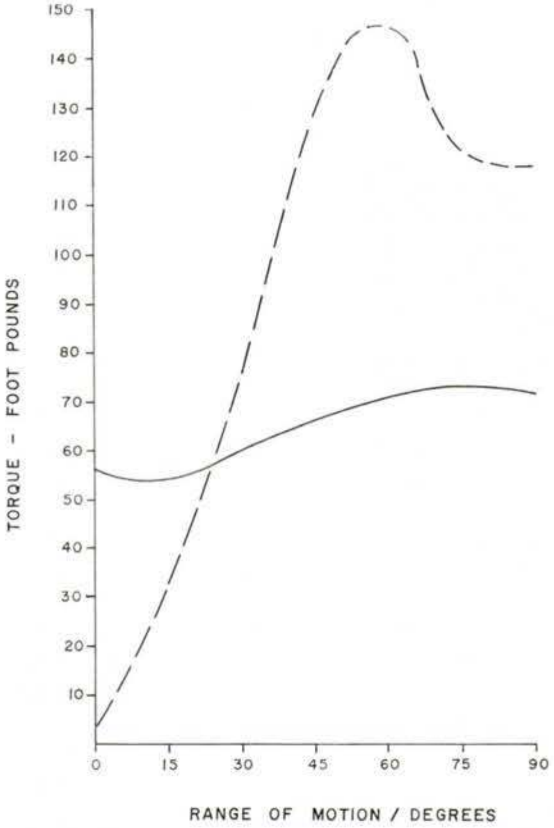


Fig. 11. Resistance offered by a maximal isotonic contraction (solid line), and by a maximal isokinetic contraction (dotted line), as performed by one subject at a velocity of six revolutions per minute.

Acknowledgments. Louis Gerstman, M.D., assisted in statistical analysis reported in this study. James J. Perrine conceived and introduced the device for isokinetic exercise.

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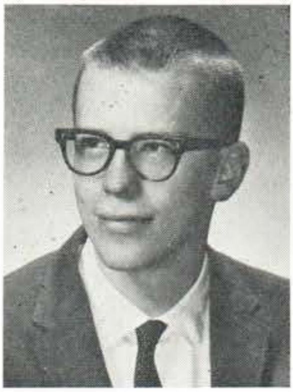

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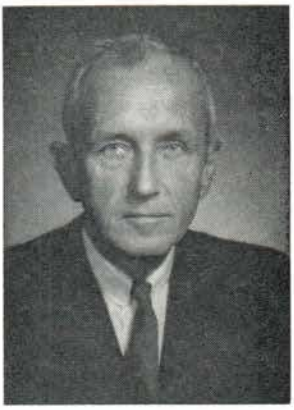

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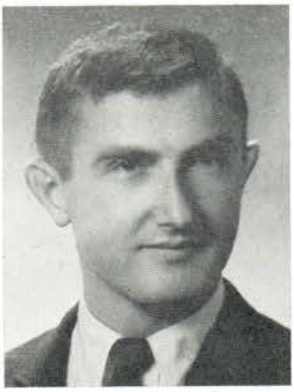

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