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Isokinetic Exercise - A Review of the Literature

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Introduction

In contrast to the studies of isotonic and isometric exercises, research investigating isokinetic training have been few in number. Most of these have also been limited in scope.

Isometric exercise occurs when a muscular contraction, though maximum, results in no motion because the resistance is greater than the force applied due to muscle tension. No work is performed since the joint is locked and the muscle length remains constant. All force is applied at a few points of joint bearing surface.

The only advantage of isometric exercise is that it can be performed anywhere at any time with little or no equipment. Isometrics have several disadvantages. One is the difficulty of motivating since there is no movement and therefore no positive feedback to the subject. People usually evaluate their efforts by the weight of the object moved or by the distance and speed of motion.

The strength which is developed by isometrics tends to be static, not dynamic. The increased strength is only effective in a narrow range close to the joint angle at which it was developed. It has been found that isometrics have little influence on desirable changes in motor performance tasks so important in athletics.

A final disadvantage is the danger to older people with atherosclerosis. During an isometric contraction the glottis is closed which creates very high pressure in the thoracic cavity. This in turn reduces the flow of blood from the lower extremities to the heart and brain.

Isotonic exercise involves dynamic muscular contractions against a constant load, therefore the resistance is constant throughout the

entire range of motion. The magnitude of the resistance is limited to the maximum load which can be moved at the weakest angle. The weakest angle will be at the extremes of the range of motion. Only at this angle will a maximum contraction be elicited. At all other angles the muscle tension which develops will be much less than maximum. Since the load is constant and the torgue varies with the angle, the speed of motion will likewise vary with the angle. The most common example of isotomic exercise is weight lifting.

Isotonic exercise has these disadvantages. Strength is increased most for the weakest angle and much less for all other angles through out the range of motion. Also, the joint is trained to handle only a fraction of the maximum torgue which the muscle is capable of developing. Finally, at the beginning of training there is an initial loss of strength due to muscle soreness.

Isokinetic muscular training, a relatively new concept, was introduced in 1967 (4,13). This training method has all the advantages of isometrics and isotonics while minimizing their deficiencies. Isokinetics involves dynamic exercise in which the resistance varies throughout the full range of motion in direct proportion to the force exerted by the muscle. The muscle is loaded maximally at every angle of the joint without overloading at any point. The joint therefore is also loaded optimally at every angle so that its strength increases in harmony with that of the muscle.

In isometrics the distance is controlled. In isotonics the resistance is controlled. In isokinetic the speed of the movement is controlled. With the speed of the movement held constant throughout the full range of motion, the isokinetic training device responds with in-

creased resistance rather than acceleration when the power output of the muscle is increased. In isotonic exercise limb speed rarely exceeds 60° per second, while in athletics limb speed is usually greater than 90° per second. There are isokinetic devices in which the limb speed or a movement can be varied from 0° per second (isometric) to 200° per second.

Research has shown that there is a high degree of specificity in training. Development of power, force or endurance at one angle has a minimal effect at other angels in the range of motion. This is the reason that isometrics has fallen into disfavor. Only isokinetics permits optimal strength development throughout a full range of motion.

Isokinetics has other advantages. This method of training produces very little or no muscular soreness (8,15). Another plus is that isokinetic training devices will automatically adjust (1.) with increased resistance as the strength of the muscle increases, (2.) with decreased resistance to tiring muscles, and (3.) to the strength of any individual who uses it. Some isokinetic equipment can also be used to measure the power, force, and endurance of a muscle at every angle in the full range of motion. Maximum work is obtained with the isokinetic method and can be integrated over the full range of motion.

Equipment

Exer-Genie

The Exer-Genie is one of the simplest isokinetic devices. The speed of the movement can be varied and is controlled by the friction of a nylon rope which is wrapped internally around a cylinder. The greater the number of wraps, the greater the friction and the slower the movement. Slight tension on the rope feeding into the cylinder

greatly increases friction. The speed of the movement can also be controlled in this manner. The device can be attached to the floor, wall or ceiling so that a great number of different movements are possible.

Mini-Gym

The Mini-Gym is an isokinetic device that uses a rope and a centrifigal clutch to maintain constant speed. This clutch is similar to the governor used on automotive engines. On some models the speed is variable. Some models have a read-out of the force exerted by the muscle. In some models this is a graph; in others it consists of a circular scale and pointer. These are not accurately calibrated in any specific units. Like the Exer-Genie, the Mini-Gym units can be attached to any surface to obtain virtually any kind of movement. The units have also been built into stationary bicycles.

Nautilus

The Nautilus appears to be essentially isokinetic although the manufacturer denies this. The resistance is varied throughout the full range of motion by using a cam. This allows the muscle to be near maximally loaded at every angle of the joint. Specialized equipment is manufactured in order to obtain a number of different movements.

Cybex (Orthotron)

The Cybex is the most sophisticated isokinetic device that is available. It employs either an electromagnetic device or a hydraulic cylinder to maintain constant speed throughout the movement. However, speed of movement can be varied by altering the rate at which fluid flows through the cylinder. The angular speed can be varied from 0^{o} per second to 200^{o} per second. Specialized equipment is manufactured to obtain diff-

erent movements. The Cybex II is adjustable so that the axis of rotation can be aligned to match the atomical axis of rotation. The Cybex II also has strip chart recording capabilities. This allows the accurate measurement of the force exerted by the muscle at every joint angle.

Research Results

A number of the papers in the list of References do not report original research. They merely explain the concept of isokinetics, compare and contrast isokinetics with isometrics and isotonics, or give basic knowledge concerning isokinetic training equipment and techniques. Most of the research that is reported is limited in scope.

Three papers have reported electromyographic st dies. Hinson and Rosentsweig (3) in comparing mean muscle action potentials of isometric, isotonic and isokinetic contractions concluded that (1.) no single type of contraction will elicit the greatest action potentials for all subjects, (2.) isometrics appear to produce the greatest action potentials, and (3.) the isokinetic method produces greater action potential than the isotonic method for the largest number of subjects.

Rosentsweig and Hinson (10) examined action potentials at four angles during isometric, isotonic and isokinetic work, their conclusions were that (1.) the action potential of a muscle will significantly vary with the angle during isotonic work, (2.) there were no significant differences in muscle action potentials (MAP) at the four angles during isometric or isokinetic work, (3.) isokinetic contractions elicited significantly greater mean MAP than isometric or isotonic contractions, and (4.) the differences in strength at different angles is a function of the lever and not due to muscle activity.

Rosentweig, Hinson and Ridgway (11) examined MAP during isokinetic

contractions at three different speeds. It has been generally believed that slower contractions develop strength and faster contractions develop endurance. They found no significant differences in MAP at different speeds. They interpreted this to mean that muscles, regardless of the speed of contraction accomodate so that they are maximally loaded at all speeds.

Wilson (16) worked high school athletes on a 12 station Mini-Gym circuit. Good increases in strength were obtained. There was no control group and no comparisons were made with other types of work.

Van Oteghen (14) examined the increases in strength and vertical jump height in female intercollegiate volleyball players who trained at fast and slow speeds on a Mini-Gym Leg Press machine. He found that only those who trained at a slow speed had a significant improvement in strength as compared to controls. Both the fast and slow groups significantly increased their proformances in the vertical jump when compared with controls.

The increase in peak muscular force with isokinetic, isotonic and isometric training was examined by Thistle, Hislop and Moffroid (13). Their results are presented in the table below.

Group	Increase in Peak Force of Left Quadriceps Femoris
Isokinetic	42.2%
Isotonic	28.6%
Isometric	13.1%

Using the Cybex, Moffroid, Whipple, Hofkosh, Lowman and Thistle (6) established norms of different muscle groups for measurements of torque, work, range of motion, and power. They also compared isokinetic with isotonic and isometric exercise. They found that (1.) isokinetic exercise increases the work a muscle can do more rapidly than isometric or isotonic training, and (2.) muscle response to training tends to be specific; that

is, a muscle which is overloaded in a partial range of motion will increase in strength significantly more in this range than at other less exercised joint angles.

Pipes and Wilmore (8,9) have reported the most extensive investigation of isokinetics. They compared isotonic, isokinetic low speed, isokinetic high speed and control groups with respect to relative body fat, motor performance tasks, specificity of training, muscular soreness, and strength. Isometric procedures were not investigated because of previous extensive study and the fact that it has been shown that isometrics has little influence on motor performance tasks. They measured static strength by cable tensiometer, isotonic strenth with weights and isokinetic strength at slow and fast speeds using a Cybex.

They found that the isokinetic high speed group had a significantly greater decrease in relative body fat than the isotonic or isokinetic low speed groups. Both isokinetic training groups had significant desireable changes in motor performance. None of five motor performance tasks were altered by isotonic training. The isotonic group experienced initial muscle soreness which was not observed in either isokinetically trained group.

Strength measurements showed that both isokinetic low speed and isokinetic high speed training increased static strength to a significantly greater degree than isotonic training. While the isotonic group had no significant changes in strength when measured on the Cybex at high and low speeds, both of the isokinetic groups had significant increases in strength at both speeds. The isokinetic groups had the greatest gains in strength regardless of the manner in which strength was expressed, whether isometrically, isotonically, or isokinetically. The isokinetic high speed group had the greatest overall strenth increases.

Conclusions

Isokinetic training is superior to isometric and isotonic training with respect to increases in strenth however expressed, specificity of training, desireable changes in motor performance tasks such as those occurring in athletics, lack of muscle soreness, and decreases in relative body fat. Isometric training has the advantage of requiring little or no equipment. Isotonic training provides more motivation for many people who are accustomed to lifting weights.

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