A CASE FOR ISOKINETICS

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DEFINITION OF TERMS

Before beginning the text of this manual, it is important to define some of the terminology used throughout it, and may be useful as a reference:

- **Isokinetics:** exercise with possible varying resistance and a fixed maximum speed.
- **Isotonics:** exercise with a fixed resistance or constant load, and varying speeds throughout the range of motion; also known as isoinertial.
- **Concentric action:** muscle shortening; often called positive work.
- **Force:** mass X acceleration; a push or pull that results in acceleration of an object; expressed in Newtons.
- **Work:** applied force X distance; usually expressed in terms of Newton-meters (Nm).
- **Power:** time required to perform work; (force X distance) / time; usually expressed in terms of Watts.
- **Torque:** a force that produces rotation about an axis; usually expressed in terms of Newton-meters.
- **Velocity:** distance traveled in a specified amount of time.
- **Peak Torque:** the highest point on a torque curve; probably the most commonly used number as a test of program results, though other parameters can also be examined depending upon desired training effect.
- **Time to Peak Torque:** how long it takes to reach maximum torque; indicator of acceleration.
- **Average Peak Torque:** peak torques for each repetition divided by the number of repetitions; indicates strength-endurance levels.
- **Average Power:** A total of the work performed; divided by the time it took to perform it, in any given set of exercises.

INTRODUCTION

The use of isoknetic dynamometers, and their protocols, has been in use for over 30 years, mostly in the rehabilitation of injuries in a clinical setting. But it is quickly becoming a widely accepted form of resistance exercise for performance enhancement (19). For our purposes, the question then becomes; if these machines can rehabilitate an injured athlete, then why not *train* a healthy athlete, using the same principles, and maximize their gains, often at velocities similar to that which is required in their sport? That has been the premise of our training protocols for over 8 years now.

This manual will attempt to bridge some of the knowledge gaps between *training* with isokinetic machinery, and using it clinically for the rehabilitation of injuries. The ability to bridge those knowledge gaps has come from years of training athletes, and fitness clients, from a multitude of sports and varied backgrounds, on this equipment, and from years of researching the subject. Most of that experience is empirical, yet our results coincide with the known studies on the subject of how isokinetics can be used to increase athletic performances. This manual will define some of the attributes of this type of training, as well as present scientific studies that can back-up the results that the coaches, and athletes alike, will see on the field of play.

What you have in your hands will be just a starting point for your journey of discovery in the world of isokinetics. This, along with the hands-on training that you will receive, should put you well down the track to becoming the best trainer you can be to your athletes, and fitness clients. There are thousands of athletes out there already who can testify to the efficacy of this type of training regimen, so we know it works. And our fitness clients are amazed at their ability to lose weight, utilizing this regimen. You will see it too! We hope that this manual will be a useful source of information, and reference, for years to come.

Nobody can achieve perfection; but in the pursuit of perfection, one can obtain excellence.
-Vince Lombardi

ISOKINETICS and ISOTONICS

Isokinetics, as a word, is defined as “same speed”, meaning there are no velocity changes within a movement; it is a constant velocity throughout all joint angles. Traditional weight lifting methods are defined as isotonic, which are defined as “same tension”, or in this case “same weight” throughout a movement, with changes in velocity occurring as the joint angle, and muscle length changes.

Isokinetic machinery controls the maximum velocity of the movement. The resistance is an equal, and opposite force, to the force supplied by the athlete, throughout the range of movement in an exercise, but not being able to exceed a prescribed angular velocity (2). This allows/forces the muscles to “work” at a constant, and maximal voluntary rate throughout the entire range of motion. For example, midway through a joint’s range of motion, the muscle group involved in moving that joint, will be at it’s greatest mechanical advantage, yet the isokinetic dynamometer maintains it’s preset angular velocity by producing more counterforce against that advantage point. But, at the beginning and the end of the joint’s range (where the muscle group is at a mechanical *disadvantage*) the preset velocity is still maintained by the machine, while less counterforce is required to oppose the muscle’s lack of force production capability. This is in opposition to an isotonic exercise, which would allow for an initial explosive acceleration to be applied, and therefore momentum added to the mass or weight, which allows the muscles involved to “coast” through certain portions of the range of movement (6). Therefore, using isokinetics, the muscles are being worked to their maximum potential throughout every degree in the range of motion, and more work is done in the same amount of time (as compared to other modes of exercise) which results in greater strength gains, especially at higher velocities (5,6). Also, isotonic movements require deceleration of the momentum created on the mass, in order to not exceed the particular joint’s range of motion, which may lead to injuries, or create safety issues as a whole. This is especially true of single joint, open kinetic chain movements. The use of isokinetic machinery allows you to work at high velocities without the fear of having to decelerate a mass at the end of the range of motion of that joint. Thus, it is “weighted” high-speed movement with minimal safety issues attached, no skill-set required, and no spotter is required.

STRENGTH AND POWER

In the context of this manual, strength is the maximum amount of force a muscle can generate in a specified movement (2). Since isokinetics allows you to work at a constant maximal rate throughout an entire range of a movement, gains in strength are maximized (as compared to other modes of training). Numerous studies have shown that gains in strength can be achieved with as little as 2 sets of 15 repetitions performed at different speeds i.e. 1 X 15 @ 60 deg/s and 1 X 15 @ 240 deg/s (16,17, 20). Other studies have shown strength increases using many different combinations of sets, reps, and velocities. One question then comes to mind; is there an optimal combination of the three? So far no conclusive answer has presented itself. Most studies do agree that for strength gains, training at slower speeds shows greater force production than high-speed training (20). The literature also shows that if strength gains over a wide range of velocities are desired, then training between 180 deg/s and 240 deg/s is optimum. But, if there were a need to increase strength at a specific velocity, some training at that particular velocity would be prudent. Several of these studies have also shown that strength gains are achieved, regardless of what testing mode was used to determine the gains i.e. isokinetics, used as the sole training mode, has been shown to be able to increase strength in the isometric mode, the isotonic mode, and the variable resistance mode (13,15).

Power is considered to be a critical component in training and performance. Because isokinetic dynamometers provide information about force of muscular action with respect to time and limb speed, they have been used to measure muscular power. But again that leaves us with the question; why not *train* on these machines instead of just using them for measurement?

Power is defined as: (an applied force) X (a distance traveled) / (the time it takes to travel that distance). For example, if two athletes can lift the same amount of weight, and move it the same distance, the person who can do it the fastest is the more powerful athlete. In most sports, with everything else being equal (such as: skill levels, experience, conditioning levels, etc) the more powerful athlete(s) usually dominate the contest. Traditionally, the Olympic lifts, and their derivative lifts (isotonic), have been the method used to develop power in today's athlete. In doing so, to get a training effect, one must use the most weight possible, and still be able to complete the lift explosively, and as safely as possible. There are a variety of reasons that this isn't always achievable such as: available space to lift safely within, no one to spot the lifter, and not the least of which, not all isotonic exercises can be performed safely with high velocities (there are skill-sets that need to be learned before Olympic lifts can be effective). Training with isokinetics eliminates most, if not all, of those factors; no deceleration is needed, no spotter is needed, and there are no safety issues to the athlete, or to their surroundings. Studies have shown that isokinetics can increase the average power of a repetition significantly, and over a wide range of tested velocities (1,7,17). Which means more total work can be done in shorter time spans. It has also been well documented that maximal *force* output decreases with increasing velocities. *Power*, on the other hand, is low at slow velocities, increases to a maximum at intermediate velocities, and then decreases progressively as velocity continues to rise (18,19). This also suggests that if gains in average power are sought across a variety of velocities, average power can be trained maximally at the intermediate velocity range of 180 to 240 deg/s (19).

ISOKINETICS AND ATHLETIC PERFORMANCE

It is well documented in studies, that training on isokinetic equipment improves athletic performance. Athletic performance being defined as every characteristic needed, and then combined, to perform a skill at a high level, from neuromuscular responses to endurance issues. There are over 60 studies that have shown a correlation (.5 or higher) between isokinetic strength, and athletic performance (19). One of those studies has shown that many different sports are similar in their relative strength requirements, using concentric knee extension as the measured parameter, which as a parameter may not discriminate between sports, while the required athletic performances *within* each sport have shown a high correlation to isokinetic strength (7). Improvements in athletic performance are logarithmic, and several of the studies noted, (5,6,9,10) used well-trained athletes as subjects, and even *these* athletes saw improvements in their performance, which is important to note, since it is much more difficult to show improvement in well-trained athletes as opposed to a not-so-well trained athlete. Of the known studies, there are approximately 6 that were unable to show a correlation. In some of those studies, some of the aspects studied were a weak correlation anyhow, and they might have found good correlations had they chosen different parameters in the same study.

Most standardized athletic performance tests are performed at high speeds of movement, and isokinetic training, allows the athlete to train at speeds that closely mimic the speeds at which they will be performing, or playing. Speeds ranging from 0 to 600 deg/s are not uncommon with these types of machines (19). This is in comparison with the much slower velocities used in conventional weight training, even when comparing it to the Olympic lifts that are normally used to create an explosive training effect. Studies have shown that training at high rates of speed, increases strength at those speeds, *and* to a range of speeds above and below the training speeds used, and also to a greater extent *within* that range of speeds, than when training at slower speeds (1,6). Therefore, training on isokinetic machines, should elicit a high-speed training effect that will allow the athlete to perform more efficiently at those speeds, and with no safety issues in doing so.

Peak velocities of athletic movements are much greater than what can be trained on, or measured with, isokinetic machinery. These peak velocities are measured at/or near the last joint in a multi-joint kinetic chain. For example, in a punting motion, the extension of the knee joint has been measured at angular velocities approaching 2000 deg/s. The velocity for an unloaded, and *isolated,* knee extension is in the range of 500 – 700 deg/s (10). Therefore, adding the resistance of an isokinetic machine's lever arm reduces that angular velocity even further. Granted, this is a comparison of an isolated joint, versus the action of that same joint in a kinetic chain that has been accelerated by previous joints in the chain, however, this doesn't reflect negatively on the limits of the machinery, for if you can increase the angular velocity of individual joints in the kinetic chain, through training at high speeds, then the angular velocities measured unloaded, during athletic performances, should increase.

EFFECTS OF ISOKINETICS

The literature supports the facts that maximal-effort isokinetic training improves the strength, power, peak and average torques, and endurance factors (enzymatic activities such as: ATP - CP, glycolytic and mitochondrial) of skeletal muscle (1,3,9,11,12,13). Though some studies have shown an increase in cross-sectional areas (CSA) of both Type I and Type II fibers, frequently, gains in strength and power occur without any increases in CSA, or muscle hypertrophy. This would suggest that enzymatic, and neural adaptations play an important role as well, in functional strength and power improvements (3). Costill and coworkers (12) showed that protocols using 6s, or 30s maximal isokinetic bouts, produced similar increases in strength, power, and CSA, but the only the 30s group showed significant enzymatic activity changes, which has been proven to enhance athletic performance. Esselman and coworkers (13) showed similar results using various angular velocities, though no significant increases in CSA were noted; yet they showed great torque gains, especially at the slower velocities. The absence of significant increases in CSA suggests that increased neural adaptation played an important role in strength (maximal torque) gains. These gains represent increased levels of motor learning, neuro-muscular recruitment, and more efficient synchronization of the motor units involved. These findings are not only are useful in rehabilitation, but taken a bit further down the same path, can be of use in increasing athletic performance through increased muscle fiber recruitment, and better coordination of those fibers.

In the clinical setting, therapists have rehabilitated patients with the use of a variety of angular velocities. This type of protocol is called *velocity spectrum* exercising. The literature, and our empirical observations, seems to support the results that the clinicians are reporting (4). The theory behind velocity spectrum exercising is to innervate every possible muscle fiber by knowing muscle twitch rates, and recruitment patterns. Type I (Slow-twitch) fibers are activated at lower thresholds, and Type II (Fast-twitch) fibers are then recruited as more force is needed for movement. The two fiber types are not mutually exclusive of each other, rather different velocities and duration of bouts, require different percentages of each fiber to be recruited. The maximal effort required during isokinetic training should recruit both fiber types, regardless of the velocity. Muscle fiber recruitment is dependent to a greater extent upon force requirements, than on velocity, yet the two parameters are inversely related. As velocities increase, peak torque (force) decreases (8,11,14,18). In general, the literature supports the facts that slow velocity training has shown greater strength gain “carry-over” to a variety of other angular velocities. And that intermediate velocities maximize both strength and power, over a wide range of velocities. In contrast, fast velocity training induces maximal force and power, at higher velocities of movement only, but improves motor learning at those speeds, which is useful in most athletic performances.

So, in a practical application, the strength and conditioning specialist, should vary the velocities, and repetition schemes within each exercise session, and periodize the exercise sessions in order to maximize all potential means to increasing athletic performance. In addition, some velocity specific training, which will maximize strength and power at a specific velocity, is appropriate as well. This is the principle of specificity of exercise, which states that one should create training demands that correspond to the demands of the motor performance(s) in question.

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ASSESSMENT

A baseline, or starting point, assessment should be done before starting the program, to be used as a benchmark for progress, when later assessments are done. For the athlete, a general functional movement assessment should be done. Not all of the tests supplied will apply to every sport, so it is left up to the practitioner to decide which tests are applicable to the sport. One test that is always performed, because it is an indicator of overall body power, is the vertical leap. For the fitness enthusiast, a skin fold assessment, and a flexibility test, along with some strength tests would be sufficient for most goals to be measured against. Maybe a resting heart rate, or a working heart rate, using a standardized 1-minute protocol (such as a 1 ft step-up) could be taken to determine fitness levels. For both the athlete, and the enthusiast, subsequent assessments should take place every 6 weeks. This time period accomplishes 2 objectives: 1) it will allow for the current program to be sufficiently analyzed and 2) while if there are any adjustments to be made, the subject will not have gone too far down a path that may not be as productive as it could be.

THE WORKOUT

The workout should take approximately 1 hour to complete.
It consists of:

0:00 – 0:07 Dynamic Warm-up exercises

0:07 – 0:15 Ground Ladder and Hurdle Work

0:15 – 0:45 Machine Circuit

0:45 – 1:00 Conditioning And Core