CHAPTER 2: MUSCLE FUNCTION AND ISOKINETICS

2.1 INTRODUCTION

Before determining a muscle's maximum capacity to produce force, the following physiological aspects must be present. The muscle-tendon unit has to be intact. The muscle has to receive normal innervation from the central nervous system. The musculo-skeletal unit must also be free from pain (Perrin, 1993).

Theoretically, isokinetic movement implies that the limb moves at a constant velocity. Isokinetic muscle contraction or isokinetics is currently a widely used tool in muscle testing and conditioning. It may be used in clinical settings as a therapeutic modality, during physical rehabilitation, and in sport science as a way to improve performance levels.

2.2 DIFFERENT TYPES OF MUSCLE CONTRACTION

2.2.1 Isometric contractions

Various researchers have used isometric muscle testing and have extrapolated dynamic strength from isometric strength (Sale & Norman, 1982; Young & Bilby, 1993). Isometric tests have been popular for a number of reasons:

- they are easily standardized and hence reproducible (Bemben *et al.*, 1992);
- they require very little technique or skill and can thus be used with untrained and trained subjects;
- isometric tests are straightforward to administer and relatively safe for subjects to perform; and
- they require relatively inexpensive equipment (Wilson, 2000).

However, a number of researchers have reported that isometric tests have a poor relationship to dynamic performance measurements (Hakkinen *et al.*, 1986; Murphy *et al.*, 1994; Wilson *et al.*, 1995; Murphy & Wilson, 1996). Murphy *et al.* (1994) reported a 0.38 correlation between isometric rate of force production and seated shot-put, while there was a 0.86 correlation between concentric isoinertial/isotonic testing (using a weight of 30% of 1RM) and seated shot-put. Their findings correspond with that of Pryor *et al.* (1994), who reported that isoinertial testing correlated much more with the seated shot-put, compared to isometric testing (0.80 vs. 0.42).

Wilson (2000) states further that many of the previous studies regarding the relationships between dynamic performance and isometric testing were non-significant and that the correlation coefficients of those findings that showed significance were typically in the order of r=0.5. This implies that only approximately 25% of the variance was common. This is supported by Fry *et al.*

(1991), Abe *et al.* (1992); Wilson *et al.* (1993), Baker *et al.* (1994), Wilson & Murphy (1995), and Wilson *et al.* (1995).

Wilson *et al.* (1995) examined the relationship of isometric, isokinetic, and vertical jump tests to cycling performance (peak power output produced in six seconds). While the isokinetic and vertical jump tests showed a significant relationship (r=0.51-0.73) to cycling performance, there was a very poor relationship between the isometric test and cycling performance (r=0.38). Thus the isokinetic and vertical jump tests were capable of discriminating between subjects with different cycling performance levels. In support, Wilson & Murphy (1995) found that isometric tests were not significantly related to sprint performance over 30 metres and could not discriminate between sprinters of differing ability.

The rationale for the superiority of dynamic tests over isometric tests to predict dynamic performance levels is based on the neural and mechanical differences between the different contractions (Wilson, 2000). Thus dynamic muscular tests may be superior to isometric tests when evaluating dynamic performance, because they invoke a neural response that has greater similarity to the performance of interest. There are also large mechanical differences between isometric and dynamic muscular actions. Dynamic contractions make use of substantial quantities of elastic strain energy, while isometric actions do not benefit from it (Komi & Bosco, 1978; Wilson *et al.*, 1991).

Isometrics benefit from musculo-tendinous stiffness, whereas dynamic contractions (isotonic and isokinetic) do not. Muscle stiffness reflects the capacity of a muscle to absorb or dissipate forces such as the stress of force production from muscle activity. The effect of muscle stiffness is most relevant in the midrange of motion where there is significant overlap of actin and myosin, rather than at the ends of ROM (Hutton, 1992). Wilson *et al.* (1994) reported a correlation of 0.72 between musculo-tendinous stiffness and isometric rate of force development and 0.63 between stiffness and maximum isometric force. The isometric rate of force development represents the rate of force development over the initial 60-100 ms of a maximal isometric contraction. Hutton (1992) reported that isometric and eccentric exercises lead to a decrease in muscle stiffness and that concentric exercises increased muscle stiffness. Conceptually, a stiffer musculo-tendinous unit would enhance isometric force production, compared to a more compliant system. Stiffness will also determine, to some extent, how effectively and rapidly internal forces generated by the contractile component are transmitted to the skeletal system (Wilson, 2000).

Motor unit recruitment patterns differ for the performance of different tasks by the same muscle as well as when changes in the direction of force application occur (Ter Haar Romeny *et al.*, 1982; Ter Haar Romeny *et al.*, 1984). There are also definite differences in activation patterns between isometric and dynamic contractions at the same joint angle (Tax *et al.*, 1990; Nakazawa *et al.*, 1993).

Therefore, it would appear that dynamic tests are superior to isometric tests in predicting success in dynamic performance tasks. Hence, it is strongly recommended that dynamic muscular tests be used when evaluating functional athletic performance (Wilson, 2000).

The major disadvantage of isometrics is the fact that strength gains are restricted to no more than 20° within the angle at which the training took place (Houglum, 2001). Optimal strength gains are achievable at intensities above 66% of 1RM. Training at 35% to 66% of 1RM may produce some strength gains, but at a slower rate and the main effect will be an increase in muscle endurance (Houglum, 2001).

2.2.2 Isotonic or isoinertial contractions

Most functional movement patterns involve the acceleration and deceleration of a constant mass (i.e., a limb or an external object). Thus the majority of functional movements involve the development of isotonic or isoinertial force (Murphy *et al.*, 1994).

"Isotonic" may be the wrong word to describe traditional weight lifting movements for instance, since the muscle tension constantly changes with changes in joint angle and speed of movement. Thus the term **"isoinertial"** (i.e., involving constant mass), may better describe these movements (Abernethy & Wilson, 2000;

Houglum, 2001). Isoinertial loading implies a constant resistance to motion rather than merely a constant resistance or load throughout a weight-lifting task. Isoinertial strength correlates highly with dynamic sport performance (Wilson *et al.*, 1993; Abernethy *et al.*, 1995)

Performance in traditional weight-lifting tasks may provide only a limited diagnosis of an individual's capacity for developing functional isoinertial strength, since weight-lifting only supplies unidimensional feedback, based only on the muscle's capacity to either overcome or yield to a given load (Logan *et al.*, 2000). Isotonic exercise stresses the muscle maximally only at its weakest point in the ROM (also referred to as the "sticking point"). This implies that the greatest resistance that can be used during concentric isotonic exercise is equal to the maximum amount of weight that can be moved through the weakest point in the ROM (Perrin, 1993; Heyward, 1997). Under faster dynamic conditions, the momentum of the weights lifted may cause the subject to overcome the "sticking point" more easily and this leads to an even less effective muscle contraction intensity.

An eccentric contraction can produce about 30% more force than a concentric action (Wilmore & Costill, 1999). It is believed that the muscle's non-contractile elements provide the additional forces during eccentric muscle contraction. However, it takes more energy to perform a concentric muscle contraction compared to an eccentric contraction. Although it requires more energy to perform a concentric contraction, there does not seem to be any difference in strength gains between concentric and eccentric muscle training (Houglum, 2001).

The **force-velocity curve** (Figure 2.1) also demonstrates that as the contraction speed of a concentric activity increases, the muscle's ability to generate force declines. In a sense, the opposite is true for eccentric exercise: as speed of contraction increases, the force increases initially, then levels off or decreases (Houglum, 2001).

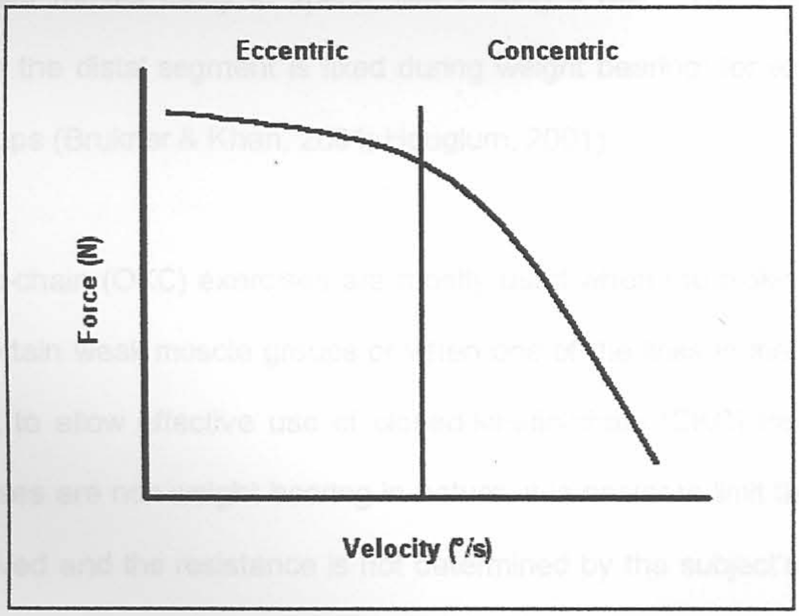

Figure 2.1: Force-velocity curve

Eccentric muscle contractions also have a greater likelihood of delayed onset of muscle soreness (DOMS), compared to concentric muscle action (Houglum, 2001).

The exact causes for this phenomenon is still unclear, but some believe that it may be the result of a combination of damage occurring to the muscle membranes and a secondary inflammatory response within the muscle's non-contractile components (Wilmore & Costill, 1999).

2.2.3 Open- and closed kinetic-chain contractions

A kinetic chain is a series of rigid arms linked by moveable objects and is identified in terms of the distal segment of the extremity. The kinetic chain is **open** when the distal segment moves freely in space, like kicking a ball. The kinetic chain is closed when the distal segment is fixed during weight bearing; for example when doing push-ups (Brukner & Khan, 2001; Houglum, 2001).

Open-kinetic-chain (OKC) exercises are mostly used when the biokineticist wants to isolate certain weak muscle groups or when one of the links in the kinetic chain is too weak to allow effective use of closed-kinetic-chain (CKC) training. Since OKC exercises are non-weight bearing in nature, it is easier to limit the size of the forces involved and the resistance is not determined by the subject's body mass. However, because the forces are small, one should guard against fast movements during OKC exercises (Houglum, 2001). CKC exercises have various advantages (Houglum, 2001).

OKC exercises are very functional in that they mimic actions like standing up, walking, and climbing stairs. The compression of the joints and the co-activation of opposing muscle groups during CKC exercises enhance stabilization (Brukner & Khan, 2001). Compare for example, the large shear forces involved during the last 30° of knee extension (OKC) to the stability observed during the squat (CKC) where the shear force is counteracted by co-contraction of the hamstrings (Houglum, 2001)! Another advantage to CKC exercises is the training of one's proprioceptors: keeping one's balance during a one-leg half-squat for example. The use of proprioception is largely absent during OKC exercises.

Osternig *et al.* (1986) investigated the myographic activity of the quadriceps and hamstrings muscle groups during isokinetic assessment at 100°/s and 400°/s. They found that hamstrings **co-activation** increased substantially during the last 25% of knee extension. In contrast, the quadriceps' antagonistic activity remained low during knee flexion. Although the authors could not explain this phenomenon fully, the test protocol used (they assessed knee flexion and extension torque from continuous reciprocal contractions) could have played a role in their findings (Perrin, 1993).

To conclude, CKC exercises are usually safer and more functional in nature than OKC exercises, which are predominantly used to isolate weak muscle groups. It would therefore be beneficial if isokinetic exercise could offer both open- and closed-kinetic-chain exercise modes.

2.2.4 Isokinetic contractions

2.2.4.1 Defining "isokinetics"

The Greek term **"isokinetic"** means, ***"having the same (iso) motion/movement (kinetic)"***. The concept ***"isokinetic"*** refers to constant velocity of movement and variable resistance (Hinson *et al.*, 1979; Perrin, 1993; Dvir, 1995; Houglum, 2001). Isokinetic dynamometry is concerned with measuring dynamic muscle performance at a constant angular velocity and variable or accommodating resistance (Dvir, 1995).

Machines used for isokinetics are referred to as "isokinetic dynamometers" or "isokinematic dynamometers". These machines attempt to accommodate to the torque applied by the subject, without any change in angular velocity, thus offering a variable resistance through the whole range of motion (ROM). Muscle torque (Nm) is the product of muscle force (N) applied at a perpendicular distance (m) from the axis of rotation (Hislop & Perrine, 1967; Gilliam *et al.*, 1979; Osternig, 1986; Perrin, 1993).

2.2.4.2 The history and uses of isokinetics

As with many other historical events, the different versions of the origin of isokinetics may vary or sometimes be challenged. However, the different written sources accessed, reveal the following.

The concept of "**isokinetics**" was developed by James Perrine and introduced to the scientific community in 1967 by Hislop & Perrine (Hislop & Perrine, 1967; Davies, 1992; Perrin, 1993) and in 1967 by Thistle *et al.* (Thistle *et al.*, 1967; Perrin, 1993).

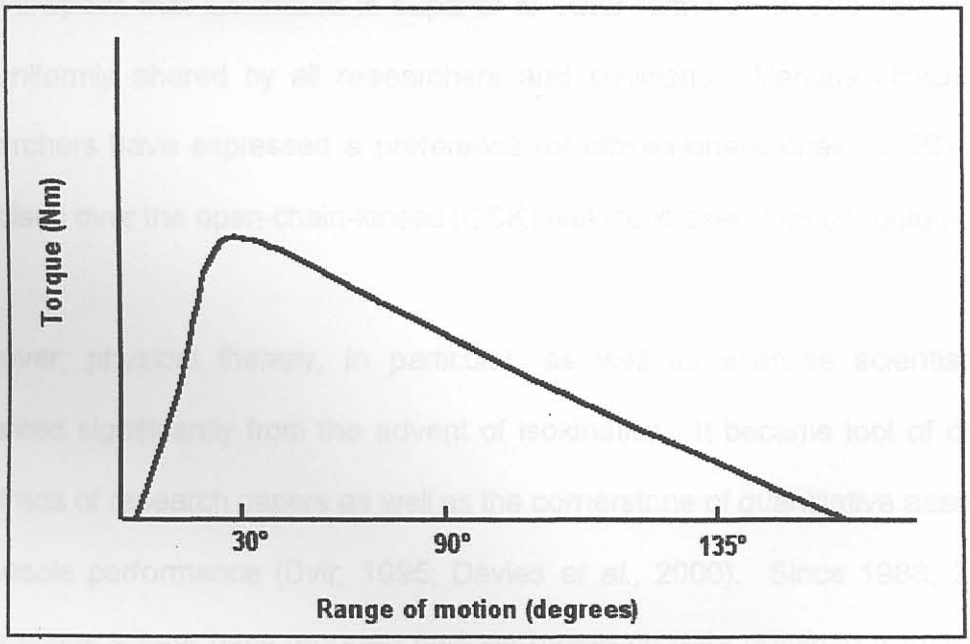

Figure 2.2: A standard torque curve of concentric knee flexion.

They reported on some of the advantages of isokinetic exercise. The length-tension relationship and overall effectiveness of muscle contraction are greatest near the midrange of ROM and are least near the beginning and end of the ROM (Perrin, 1993). This is illustrated by the isokinetic torque curve of concentric knee flexion (Figure 2.2).

Isokinetic exercise is considered by a large number of authors to have several advantages over other types of exercise like isometrics and isotonics, especially when dealing with injured individuals (Thistle *et al.*, 1967; Wilk *et al.*, 1991; Davies, 1992; Perrin, 1993; Ellenbecker, 1995).

The viewpoint that isokinetics is superior to other forms of muscle contraction, is not uniformly shared by all researchers and clinicians. Various clinicians and researchers have expressed a preference for closed-kinetic-chain (CKC) isotonic exercises over the open-chain-kinetic (OCK) isokinetic exercises (Houglum, 2001).

However, physical therapy, in particular, as well as exercise scientists have benefited significantly from the advent of isokinetics. It became tool of choice in hundreds of research papers as well as the cornerstone of quantitative assessment of muscle performance (Dvir, 1995; Davies *et al.*, 2000). Since 1988, 30 to 40 publications a year have reported findings based on data obtained from isokinetic dynamometers. The widespread use of isokinetics allowed researchers to exchange protocols and normative data (Davies *et al.*, 2000).

Various uses for isokinetic dynamometers have been stated previously:

- to collect normative values;
- to classify muscle performance as normal or abnormal;
- to collect and analyse torque curves;
- to establish the efficacy of various treatment regimens or training programmes;
- to quantify muscular work or effort during training;
- to investigate possible correlating factors, like muscle cross-sectional area and peak muscle torque;
- to assess the extent of disability in insurance claims (Keating & Matyas, 1996); and
- to assist in diagnosing musculo-skeletal disorders.

Isokinetic assessment of athletes provides valuable information that may be used to improve their performance levels (Davies, 1992; Dvir, 1995; Chan & Maffulli, 1996; Davies *et al.*, 1997). Data collected in the pre-season screening may be used as a baseline for future measurements of progress (Davies *et al.*, 2000), and it may serve as goals during rehabilitation after an injury.

Assessing **human performance** in the laboratory setting has always been controversial, no matter how closely the particular test or protocol resembled the real event. Some research indicates that there is no correlation between isokinetic testing and functional performance, and that it is not "specific" to athletic performance (Anderson *et al.*, 1991; Greenberger & Patemo, 1995; Wrigley, 2000). However, other researchers report conflicting results (Poulmedis *et al.*, 1988; Alexander, 1990; Anderson *et al.*, 1991; Klentrou & Montpetit, 1991; Mognoni *et al.*, 1994; Mookerjee *et al.*, 1995; Roetert *et al.*, 1996; Blazevich & Jenkins, 1998).

More than 60 studies have investigated the correlation between isokinetic strength and athletic performance, and numerous studies ***do*** demonstrate a positive correlation between isokinetics and functional performance (Tegner *et al.*, 1986; Wiklander & Lysholm, 1987; Sachs *et al.*, 1989; Barber *et al.*, 1990; Noyes *et al.*, 1991; Wilk *et al.*, 1994; Blazevich & Jenkins, 1998).

The following researchers have all reported correlations of 0.5 or higher between isokinetic strength and athletic performance measures. Bosco *et al.* (1983), Ashley & Weiss (1994), Newberry *et al.* (1997), and Pincivero *et al.* (1997a) have reported a significant correlation between isokinetic strength measurements and jumping. Berg *et al.* (1985), Alexander (1990), Anderson *et al.* (1991) and Blazevich & Jenkins (1998) have also reported a significant correlation between isokinetic strength and sprinting. Similar results have been reported for swimming (Ciccone

& Lions, 1987; Klentrou & Montpetit, 1991; Mookerjee *et al.*, 1995), throwing (Pedegana *et al.*, 1982; Roetert *et al.*, 1996), kicking (Poulmedis *et al.*, 1988; Mognoni *et al.*, 1994), and other sports like flat water kayaking (Fry & Morton, 1991), ice skating (Mascaro *et al.*, 1992), and tennis (Cohen *et al.*, 1994).

The only true test of validity however, is not face validity, but criterion-related validity! This is assessed by directly testing the relationship between scores on the test of which the validity is in question (i.e. isokinetic dynamometry) and athletic performance (i.e. "time" or "distance" achieved). The relevance of strength for a given sport should also be based on the ability to discriminate between elite and sub-elite performers (Wrigley, 2000).

Not all sports require muscle strength for peak performance. Most sports lie on a continuum when the importance of strength is considered. At the one end, one finds **strength-dependent** sports that demand high levels of strength for success (i.e. weight lifting, wrestling and hammer throw). On the other end of the continuum, one find **strength-independent** sports (i.e. long distance running, practical target shooting and snooker), which do not demand high levels of muscle strength for achievement. Between these two extremes lie the **strength-related** sports (hockey, tennis and sailing), for which strength is important but not critical for success (Wrigley, 2000).

Data collected during isokinetic dynamometry is used to plot peak torque, torque-angle curves, work, power and time-based indexes, to make comparisons between agonists and antagonists and between contra-lateral limbs (Marshall & Taylor, 1990; Taylor *et al.*, 1991).

Isokinetic machines or dynamometers make use of electronic servomotor control systems and hydraulic chambers. Although most isokinetic dynamometers have computer-based software for performing the torque calculations, some of the older models rely on a thermal writing system. Both concentric and eccentric muscle contraction may be assessed by using the modern isokinetic dynamometers (Bloomfield *et al.*, 1995). These machines thus allow the subject to work maximally through the whole ROM, in contrast to isotonic resistance methods that stress the joints maximally only at one specific joint angle (Perrin, 1993).

Isokinetic devices allow individuals to exert maximum voluntary muscle force up to a preset angular velocity. Up until the moment when the velocity of the subject's limb reaches that of the device, the device records no torque. Only after the subject's limb exceeds the preset velocity, does the dynamometer offer an equal counterforce. It is important to note that the limb, rather than the muscle is moving at a constant velocity. A constant rate of muscle shortening is not necessarily accompanied by a constant limb velocity, according to Hinson *et al.* (1979). They stated *"the term isokinetics may be reserved to denote the type of muscular* *contraction which accompanies a constant angular rate of limb movement rather than a constant rate of muscular shortening"*.

Isokinetic dynamometers objectively measure a subject's muscular force, work, power, and endurance, while being able to disengage if the subject experiences pain or severe fatigue (Anderson *et al.*, 2000). Examples of isokinetic machines include the Akron, Ariel, Biodex, Cybex, Kin-Com, Lido, Merac, Orthotron and Rev systems (Perrin, 1993; Brukner & Khan, 2001).

2.2.4.3 Contra-indications for using isokinetics

Isokinetic testing and exercise is contra-indicated in accordance to the guidelines set by the American College of Sports Medicine (ACSM, 1995). Additional contra-indications include:

- severely limited ROM;
- severe pain;
- severe effusion;
- acute ligament sprain;
- acute muscle/tendon strain;
- soft tissue healing constraints; and
- unstable joint fracture or joint (Davies, 1992).

When working with open-kinetic-chain isokinetics, the biokineticist has control over parameters like ROM, speeds, translational stresses (by different shin pad placements), varus and valgus forces, and rotational forces. When the individual progresses to closed-kinetic-chain exercise or testing, the biokineticist has less control of these variables, which increases the potential risk of injury (Davies, 1992; Davies, 1995; Davies *et al.*, 1995; Davies & Zillmer, 1999). In this case, the biokineticist should weigh up the possible dangers to the benefits associated with performing the specific evaluation.

2.2.4.4 Indications for using isokinetics

Isokinetic testing is indicated for determining a subject's torque capabilities. The results may be used to determine a subject's ability to return to competitive sport following an injury, or it may be used in the process of injury prevention, where each subject's values are compared to that of a suitable database. Thus isokinetics is often used to measure muscle imbalances. Another reason to make use of isokinetic testing is to measure an athlete's potential for a specific sport. Certain testing protocols may be used to measure the muscle fibre composition of an athlete. Isokinetic testing is also used to measure the success of a rehabilitation program.

Isokinetic training is especially indicated in cases where the biokineticist requires the subject to isolate a certain muscle group for training (for example, the hamstrings group). It is also very useful to regain muscle strength after a period of immobilization and atrophy, since the exercises are mostly non-weight-bearing and takes place under very strictly controlled conditions (Dvir, 1995). Since isokinetics allows one to train maximally through a large part of the ROM, it may lead to larger strength increases; this may be especially crucial to elite athletes, who are looking for that something extra to increase their performance levels.

2.2.4.5 Advantages of using isokinetics

Isokinetics has several **advantages** over other types of muscle contraction. Probably the biggest advantages of isokinetics is the fact that the muscle can contract maximally through the whole ROM **without a high risk of injury** due to the accommodating resistance of an isokinetic dynamometer (Perrin, 1993; Bloomfield *et al.*, 1995; Garrick & Webb, 1999). Isotonic exercise in contrast, stresses the muscle maximally only at its weakest point in the ROM (also referred to as the "sticking point"). This implies that the greatest resistance that can be used during concentric isotonic exercise is equal to the maximum amount of weight that can be moved at the weakest point in the ROM (Perrin, 1993; Heyward, 1997).

However, isokinetics may also be used at **sub-maximal levels**. This facility is particularly important in the early phases of rehabilitation, where the patient's injury is recent and the patient has too much pain to permit a maximum contraction (Houglum, 2001).

Because there is **no fixed resistance** to move through the weakest point in the ROM (as with isotonic exercise), isokinetics facilitates a maximum voluntary contraction through the entire ROM (Perrin, 1993). Figure 2.3 compares the force output and percentage of muscle capacity used during maximal isotonic and isokinetic exercise respectively.

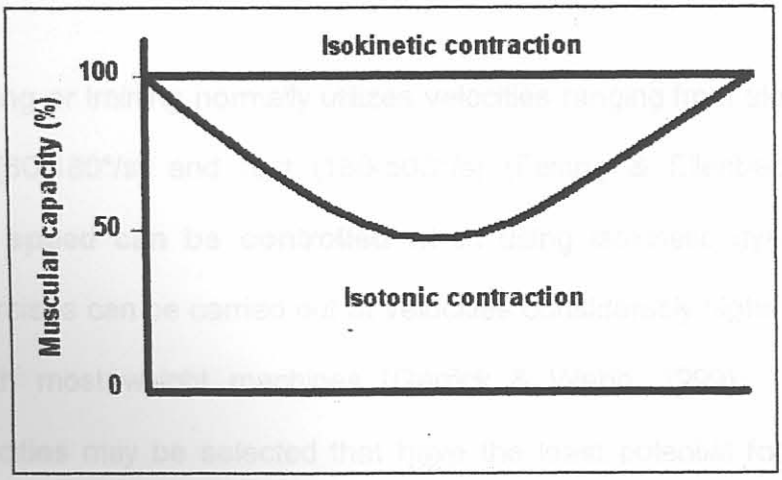

Figure 2.3: The percentage of muscle capacity utilized during isokinetic and isotonic contractions, respectively.

Another important aspect to consider is the velocity at which exercise is performed. Under faster dynamic (isotonic) conditions, the momentum of the weights lifted may cause the subject to overcome the **"sticking point"** more easily and this leads to a less effective muscle contraction intensity. This aspect was partly addressed by designing variable resistance equipment that utilized an elliptical cam. The cam was designed to provide the smallest resistance at the weakest points in the ROM (early and late in the ROM) and the greatest resistance where the muscle is at its optimal length-tension and mechanical advantage (usually midrange). Examples of machines offering variable resistance training include the Eagle Pulstar, Keiser, Nautilus, and Polaris systems (Perrin, 1993; Bloomfield *et al.*, 1995).

Isokinetic testing or training normally utilizes velocities ranging from slow (1-60°/s), intermediate (60-180°/s) and fast (180-500°/s) (Feiring & Ellenbecker, 1996). Because the **speed can be controlled** when using isokinetic dynamometers, isokinetic exercises can be carried out at velocities considerably higher than those attainable with most weight machines (Garrick & Webb, 1999). Additionally, exercise velocities may be selected that have the least potential for joint insult, especially during rehabilitation. Faster velocities cause less compressive forces in a joint than slow velocities (see Bernoulli's Principle). This is advantageous when treating a patient suffering from patella-femoral joint pain for instance (Perrin, 1993).

Isokinetic training and testing provides the biokineticist with **valuable information** regarding the client's torque at various joint angles, as well as the amount of work and power achieved during a set of repetitions. In contrast, isotonics and isometrics only provide the biokineticist with data regarding the maximum force produced (kg), the rate of force development (Young & Bilby, 1993), the distances attained with objects of various masses (for example, shot-put), and the amount of repetitions performed (Perrin, 1993; Young & Bilby, 1993).

Most isokinetic machines also offer the biokineticist the option of **limiting the limb's ROM** in order to **avoid painful angles** or to protect the joint from injury. Most modern isokinetic dynamometers have the ability to limit the ROM by means of mechanical or automatic "ROM stops". This feature is especially effective in the treatment of certain pathological conditions, for example anterior cruciate ligament repairs, patella femoral syndrome, and bursitis (Perrin, 1993).

Isokinetic dynamometers produce **reliable, objective, and reproducible results** during testing and training and involves the use of set protocols (Brown, 2000).

The dynamometer's computer records the muscle's output at every angle of the joint's ROM. The computer also makes it possible to store the data for future use. Another feature of the computer-based system is its ability to **present the data**

graphically within an instant; this is ideally suited for giving feedback to clients. During training, the computer's visual readings provide for **immediate feedback**, thus increasing motivation on the part of the client and supplying the biokineticist with all the relevant information to monitor the client's effort. This feature also improves goal setting for each session. Because the data is stored, progress from session to session can be monitored (Houglum, 2001).

By using isokinetics, it is possible for the biokineticist to **isolate certain muscle groups** for testing. If only closed-kinetic-chain testing was performed on a subject, the biokineticist could have missed a pre-existing isolated weakness (Davies *et al.*, 2000).

Isokinetics offers a **wide range of training options**. By varying the repetitions, sets, rest times, contraction modes and velocities, different muscular properties can be developed, for example, strength and endurance as well as concentric and eccentric muscle contractions (Houglum, 2001).

The **shape of the torque curve** may provide insights into angle-specific weaknesses in the ROM that could be addressed to improve performance (Davies, 1992). Although some clinicians may claim to predict a variety of joint and muscle pathologies from torque curves (Hoke *et al.*, 1983), there exists little or no scientific evidence to support this practice (Dvir, 1995). However, torque, work, and power measurements have been shown to be useful in making clinical decisions regarding muscle function (Perrin, 1993; Dvir, 1995; Davies *et al.*, 2000).

Certain protocols are used to improve **muscular control**; this may be used during muscle re-education therapy and in a wide variety of orthopaedic conditions (Houglum, 2001).

Since there is a **physiological overflow of strength** while training at a particular speed, isokinetic training also increases strength at speeds below and above the training speed (User's Guide: Norm testing and rehabilitation system, 1996).

Ballistic movements are **eliminated** since the dynamometer stops as soon as the subject ceases to produce force (User's Guide: Norm testing and rehabilitation system, 1996).

2.2.4.6 Disadvantages of using isokinetics

Isokinetics also has some distinct **disadvantages** when compared to isometrics and isotonics. Isokinetic equipment is **very expensive** compared to traditional weights and resistance machines and thus not readily accessible. A reliable dynamometer costs over $40,000 (Houglum, 2001). Furthermore, it takes up a substantial amount of space and may thus be impractical for practices with limited floorspace.

Most isokinetic devices **do not offer closed-kinetic-chain exercise**. This makes them non-functional, especially for the lower extremity (Houglum, 2001). Muscle co-ordination and co-contraction of stabilizers that is present in a closed-kinetic-chain exercise like the step-up, is largely absent during an isokinetic contraction. As with most open-kinetic-chain exercises, isokinetics make use of mainly **non-weight-bearing positions** (Perrin, 1993).

Isokinetics tend to be **time consuming**, especially if a client needs to exercise more than one joint in one session (Houglum, 2001), whereas isotonics permits exercise of multiple joints simultaneously. The application and interpretation of isokinetics **require highly trained personnel** that may be difficult to recruit depending on the location of the Centre (Perrin, 1993).

Reliable isokinetic assessment is also **limited to isolated muscle groups** through the cardinal ranges of motion (Perrin, 1993).

Even though an athlete or patient has not yet attained isokinetic measurements that correspond to that of the uninjured limb, the biokineticist cannot always regard the athlete as still disabled. Likewise, achievement of bilateral muscle balance and normative isokinetic values, do not mean that the athlete is completely cured (Garrick & Webb, 1999). Aspects like proprioception, coordination and sport-specific tasks should guide the biokineticist in making a final decision on the person's physical readiness.

Even at the fastest speeds, isokinetics **does not mimic functional speeds**. Throwing for example, results in forearm speeds of greater than 9000°/s (Braatz & Gogia, 1987). During a tennis serve, elbow extension may reach speeds between 982°/s and 1700°/s (Dillman, 1991; Kibler, 1994), and wrist flexion speeds of up to 315°/s (VanGheluwe & Hebbelinck, 1986).

Proper alignment of the exercised joint to the axis of rotation of the dynamometer is crucial to avoid **unwanted shear forces** and torques in the joint (Houglum, 2001).

Some patients struggle to grasp the technique required for effective isokinetic training or testing (own experience). Thus **careful instructions** should be given to all people before commencing to test or train isokinetically. The active or eccentric mode may be dangerous if not used with the utmost care (Davies *et al.*, 2000).

Failure in performing routine **calibration**, may lead to inaccurate results and thus inaccurate recommendations or diagnosis. Stabilization during isokinetics is not always sufficient to ensure isolation of a muscle group. Patients are inclined to

substitute and the clinician should therefore be very strict and observant during the application of isokinetics (Brown, 2000).

2.3 SUMMARY

The different types of muscle contractions each has its own role to play in human function, whether it is for posture, respiration, locomotion, or sports activities. The search for the optimum method of improving muscle function has led to the advent of isokinetics, a contraction characterized by a constant movement velocity and at a variable resistance. Isokinetics has distinct advantages, but also some important disadvantages, when compared to other types of muscle contraction like isotonics or isometrics. Although isokinetic dynamometers are expensive, the two features of isokinetics that stand out are its safety and accurate feedback. Furthermore, the development of closed-kinetic-chain isokinetic dynamometers, like the Lido Linea, has opened up a completely new window of applications for isokinetics (Davies *et al.*, 2000).