CHAPTER 1: INTRODUCTION AND AIM OF THE STUDY

1.1 INTRODUCTION

The biological system implies **variability**. Chemical reactions and physics are governed by strict laws of nature (like the laws of Newton). However, no one human being is exactly similar in his/her reaction to internal or external stimuli. Thus one of the most burning aspects of biological science is accurate and valid testing. This is especially true when investigating muscle function in terms of strength, power, torque, and endurance.

Scientists use different methods for evaluating muscle function. Measurements used to measure muscular strength for instance, range from manual resistance and gravity testing (Magee, 1992; Kendall *et al.*, 1993; Houglum, 2001), own body mass tests (callisthenics) (Houglum, 2001), isometric tests (Abernethy & Wilson, 2000), isotonic tests like free weights, exercise machines (Houglum, 2001), or dynamometers (Heyward, 1997; Abernethy & Wilson, 2000), cable tension systems (Gray *et al.*, 1962; Housh *et al.*, 1984) to computer-assisted methods like isokinetic muscle testing (Perrin, 1993, Dvir, 1995; Abernethy & Wilson, 2000). Although the reliability, validity, and accuracy of muscle testing have received considerable attention in the past (Watkins *et al.*, 1984; Arnheim & Prentice, 1993; Abernethy *et al.*, 1995), there is still some controversy regarding measurement techniques. The search for objective and quantitative criteria dominates worldwide research efforts regarding the measurement of muscle strength (Abernethy & Wilson, 2000). According to Sale (1991) and Schmidtbleicher (1992), there are four main purposes of strength and power assessments, namely:

- determining the importance and relevance of strength and power to performance;
- developing a profile of the athlete;
- monitoring an athlete's progress in training; and
- monitoring the rehabilitation of injuries.

The **relevance** of strength and power testing in athletes would depend upon the degree of association between strength measurements and performance and the ability of such measurements to discriminate between elite and sub-elite performers (Sale, 1991).

According to Abernethy *et al.* (1995), the development of better strength and power assessment procedures is dependent upon three considerations. Firstly, gaining improved insights into the mechanisms underpinning the acute and chronic adaptations to strength and power training. Secondly, to accurately describe the effect of different training programmes upon strength and power, and lastly, to ensure that measurement techniques are reliable and valid.

Isokinetics has come to the fore and is increasingly being used by researchers and clinicians involved in the testing of muscle function and in orthopaedic rehabilitation (Moffroid *et al.*, 1969; Grimby *et al.*, 1980; Scudder, 1980; Wyatt & Edwards, 1981; Sherman *et al.*, 1982; Murray *et al.*, 1984; Olerud *et al.*, 1984; Watkins *et al.*, 1984; Wong *et al.*, 1984; Grace, 1985; Burnie & Brodie, 1986; Osternig, 1986; Thomee *et al.*, 1987; Ellenbecker *et al.*, 1988; LoPresti *et al.*, 1988; Rutherford, 1988; Baltzopoulos & Brodie, 1989; Heyward, 1997).

The advantages of isokinetics are numerous. The main advantage of isokinetics is that it allows for accommodating resistance, making it a very **safe** method of testing (Perrin, 1993). Since the velocity of movement is limited to a preset maximum angular velocity, the resistance of the device is always equal to the applied muscle torque. A muscular contraction resulting in an angular velocity less than that of the device would thus result in no resistance. If however, the muscular contraction aims to accelerate the limb to an angular velocity higher than the device's preset value, the applied force will be met by an equal and opposite force or resistance (Hislop & Perrine, 1967; Thistle *et al.*, 1967; Baltzopoulos & Brodie, 1989; Perrin, 1993).

Another advantage of isokinetic testing is that it causes **minimal insult** to the musculature (Perrin, 1993). Concentric isokinetic testing results in less muscle soreness and damage than traditional resistance training which incorporates both concentric and eccentric contractions (Talag, 1973; Armstrong, 1984; Jones *et al.*, 1986).

Some key questions arise when evaluating different protocols and forms of dynamometry:

- how reliable is the test?
- what is the correlation between the test score and athletic performance in a specific sport?
- does the test discriminate between the performance of members of heterogeneous and/or homogeneous groups?
- is the evaluation sensitive to the effects of training, rehabilitation and/or acute bouts of exercise? and
- does the test provide insights into the mechanisms underlying strength and power performance (Abernethy *et al.*, 1995)?

Questions have also been raised concerning isokinetic muscle testing (Winter *et al.*, 1981; Sapega *et al.*, 1982; Nelson & Duncan, 1983; Perrin, 1993). Pertinent factors have been highlighted as having a major effect on the reliability of isokinetic testing. These include the specific **isokinetic device** used, the **method** of testing, the reliability of **axis alignment**, machine **calibration**, **damp settings**, **torque overshoot**, the training of the **personnel** who conduct the test, and the validity of isokinetics regarding **functional**, multi-joint movement patterns (Rothstein *et al.*, 1987; Perrin, 1993).

Despite some unanswered questions, isokinetics is currently viewed to be the most reliable, accurate, and objective method of evaluating single-joint muscle strength in human subjects (Baltzopoulos & Brodie, 1989). For this reason, computerized isokinetic testing of muscle strength has become a **very popular** evaluation method amongst exercise and sport scientists, as well as amongst various professions in the medical field (biokineticists, physiotherapists and sports physicians).

Biokinetics is a specialized field in complementary medicine. A biokineticist would typically qualify by completing a three-year university degree, followed by an honours degree. A one-year internship under the guidance of a qualified biokineticist must then be completed in order to register with the Health Professions Council of South Africa (HPCSA). Thus only after five years' theoretical and practical training, the biokineticist may conduct independent rehabilitation. The biokineticist in South Africa is involved in the fields of "Total Wellness", "Sport Science", "Rehabilitation of cardiac and chronic metabolic diseases", like diabetes, as well as in "Orthopaedic Rehabilitation". Biokineticists are specifically involved in **final phase** orthopaedic rehabilitation, that is, after a patient has been treated for acute symptoms by a physiotherapist. Orthopaedic patients are normally referred to a biokineticist by physiotherapists, chiropractors, podiatrists, and medical doctors.

In order to set **realistic goals** for orthopaedic rehabilitation programmes and to evaluate the **effectiveness** of treatment programmes, accurate, objective, valid and reliable measurements of muscle strength and endurance are crucial. Biokineticists are also involved in physical pre-participation examinations of elite athletes. The **absence** of applicable population- and sport specific **norms** hampers the interpretation of collected data. Population specific normative data has to consider age, gender, body mass, activity levels and nationality (Falkel, 1978). Specific norms established in one population group **cannot be extrapolated** to another population group without consideration of the differences between population groups.

Normative isokinetic data relating to the **knee joint** musculature is by far the most prolific (Wyatt & Edwards, 1981; Stafford & Grana, 1984; Sclinkman, 1984; Berg *et al.*, 1985; Poulmedis, 1985; Appen & Duncan, 1986; Fillyaw *et al.*, 1986; Hageman *et al.*, 1988; Highgenboten *et al.*, 1988; Kannus, 1991; Knapik, *et al.*, 1991; Worrel *et al.*, 1991;). An aspect that has received a fair amount of attention is the "desirable" norm for the **hamstrings-quadriceps ratio** (H/Q). The **40:60 ratio** (H/Q: 67%) of hamstrings/quadriceps torque at an angular velocity of 60°/s, has become a widely used norm for different athletes and the general population.

However, this ratio has been **challenged** by various researchers, especially when dealing with athletes like sprinters (Housh *et al.*, 1984; Berg *et al.*, 1986; Alexander, 1990) and tennis players (Ellenbecker & Roetert, 1995). Perrin (1993) states that the general ratio of hamstrings to quadriceps at slow isokinetic velocities is about 60% (37.5: 62.5). The following authors have reported hamstrings-quadriceps ratios at 60°/s of between 54% and 64% (all the torque ratios were corrected for the effect of gravity):

- 54% in the dominant limb of male college track athletes (Appen & Duncan, 1986);
- 54% in the dominant limb of female university soccer players (Fillyaw *et al.*, 1986);
- 54% in the dominant limb of high school male football players (Sclinkman, 1984);
- 60% in the uninjured limb of male and female subjects (Kannus, 1988b);
- 61.5% in the uninjured limb of male and female subjects (Kannus, 1991);
- 64% in the dominant limb of male and female subjects (Kannus, 1988a);
- 64% in male athletes' dominant limb (Worrel *et al.*, 1991).

Research data on isokinetic **shoulder norms** is freely available (Berg *et al.*, 1985; Ellenbecker *et al.*, 1988; Otis *et al.*, 1990; McMaster *et al.*, 1991; McMaster *et al.*, 1992). The most common value to consider when evaluating shoulder function seems to be the external/internal rotation ratio (Brown *et al.*, 1988; Connelly

Maddux *et al.*, 1989; Ellenbecker, 1992). An "ideal' ratio of 66% for external/internal shoulder rotation at 60°/s is commonly reported (Connelly Maddux *et al.*, 1989; Ellenbecker, 1992).

However, despite efforts by various researchers, normative isokinetic data is **largely lacking for the other joints** like the ankle (Fugl-Meyer *et al.*, 1985), elbow (Berg *et al.*, 1985; Griffen, 1987), and wrist joint (VanSwearingen, 1983; Nicholas *et al.*, 1989). Although some normative data exists regarding the hip joint, it is also a joint for which there are still more questions than answers, especially where hip rotation torque is concerned (Smith *et al.*, 1981; Smith *et al.*, 1982; Poulmedis, 1985; Alexander, 1990; Donatelli *et al.*, 1991).

The lack of normative data is problematic for the biokineticist, especially in dealing with patients with bilateral muscle atrophy or bilateral muscle imbalances (Dvir, 1995). Isokinetics may also serve as objective criteria for confirming a clinical diagnosis (Yamamoto, 1993). Again, normative isokinetic data becomes very important, especially when rehabilitating a patient with **bilateral injuries** or conditions (Olerud *et al.*, 1984; Dvir, 1995), or when screening healthy individuals (like athletes) for muscle imbalances. For an athlete to return to his or her sport, the injured limb must have achieved torque values of at least 90% of the uninjured limb (Davies, 1992). Despite the wide use of isokinetics in **South Africa**, clinical decision-making continues to be hampered by inadequate normative data

(Charteris & Goslin, 1986; Krüger *et al*., 1995). The utilization of **foreign norms** by local Biokineticists may also **not** be **valid** for the South African population. It may result in either an overestimation or an underestimation of an individual's muscle strength (Krüger *et al*., 1995).

1.2 AIM OF THE STUDY

The aim of the study is to establish normative isokinetic torque values in young South African men for the shoulder, elbow, forearm, knee, and ankle joints.