THE DETERMINATION OF UNILATERAL RATIOS
(KNEE AND SHOULDER MUSCLE STRENGTH),
OF PROVINCIAL CRICKETERS.

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Thesis accepted for the degree of Masters

in Medical Science (M. Med Sc) in the

Department of Physiology, Faculty of Medicine,

University of Natal.

DECLARATION

This is my own unaided work.

This work has not been submitted previously to the University of Natal or any other University.

SIGNATURE OF CANDIDATE: [redacted] DATE: 22 NOV 2002

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To my husband, Brendan, for his neverending love and support and for being my best friend.To our precious daughter, Jessica, that is an absolute treasure.

To them, I lovingly dedicate this writing.

ABSTRACT

Muscle injury is thought to be associated with imbalance in agonist – antagonist muscle strengths and re-attainment of 'normal' strength ratios is now a cornerstone of rehabilitation. The strength ratios used to evaluate rehabilitation are based on general population norms and not sport specific norms.

This study investigated the peak torques of the quadricep, (Q) and hamstring, (H) muscles of the leg, and the internal rotators (IR) and external rotators (ER) of the shoulder both concentrically (con) and eccentrically (ecc). This study compared the dominant and non-dominant extremities and compared the conventional hamstring/quadriceps; external rotator/internal rotator strength ratios (H/Q ratio; ER/IR ratio) and functional eccentric hamstring/concentric quadricep; eccentric external rotator/concentric internal rotator; strength ratios (H ecc/Q con; ER ecc/IR con) in 20 provincial cricketers and 20 sedentary controls.

The cricketers and controls were matched for age; height and body mass. Ten provincial cricketers and ten controls were randomly selected to perform isokinetic strength training for 6 weeks to produce ratios that are put forward for the general population. The 40 subjects were assessed isokinetically (kin com dynamometer) at an angular velocity of 60 degrees/second. The tests were performed at inception and 6 wks and 12 wks later.

A significant improvement was observed in both training groups for all peak torque measurements after the 6 wk period ($p<0.05$). A significant decrease was observed in both

training groups between the test after the 6 wk period and the final post-training test ($p<0.05$). The H/Q ratio ranged from 0.63 to 0.75. The H ecc/Q con ratio ranged from 0.74 to 0.96. The ER/IR ratio ranged from 0.48 to 0.55. The ER ecc/IR con ratio ranged from 0.58 to 0.66. These data suggest that:

(i) There is no significant difference between dominant and non-dominant extremities of the extensor and flexor knee muscles and internal and external shoulder rotator muscles in professional cricketers.

(ii) There is a significant difference between the intervention and non-intervention trials in both groups.

(iii) Isokinetic training for 6 wks will produce significant increases in peak concentric and eccentric torque measurements.

(iv) The knee extensor to flexor strength relationship put forward for the normal population is significantly different from provincial cricketers.

(v) The shoulder internal rotator to external rotator strength relationship indicated moderate to severe external rotator weakness relative to internal rotator strength for both groups, this imbalance could predispose cricketers to shoulder injuries.

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CHAPTER ONE

STATEMENT OF THE PROBLEM

1.1 INTRODUCTION

The concept of isokinetic exercise was developed by James Perrine and introduced in the scientific literature in 1967 by Hislop and Perrine (1967) and Thistle, Hislop, Moffroid and Lohman (1967). The term isokinetics can be best defined as the dynamic muscular contraction when the velocity of movement is controlled and maintained constant by a specific device (Thistle et al, 1967, cited in Baltzopoulos and Brodie, 1989). Isokinetic exercise has been proposed as an alternative to isotonic and isometric exercise.

Muscle injury is thought to be associated with imbalance in agonist-antagonist muscle strengths and re-attainment of 'normal' strength ratios is now a cornerstone of rehabilitation. These strength ratios used to evaluate rehabilitation are based on general population norms and not sport specific norms. Sport specific training may result in unequal development of muscle strength in agonistic muscles and hence strength ratios which may differ from the general norm. What is not known is whether these differences place the athlete at risk of muscle injury, or whether these differences now constitute a new sport specific norm. Present rehabilitation goals based on existing normative data may therefore be inappropriate for certain sports.

Virtually all studies of upper and lower extremity reciprocal muscle group ratios report concentric to concentric or eccentric to eccentric ratios. For example, the concentric hamstring to concentric quadricep muscle group ratios are typically reported, and the same is found for the shoulder external to internal rotator ratios. However, the hamstring muscle group's eccentric contraction is essential for deceleration of knee extension during sprinting, as is shoulder external rotator's eccentric contraction during deceleration of shoulder rotation during throwing. Perrin (1993) suggested reporting of quadriceps concentric to hamstring eccentric ratios, and shoulder concentric internal rotator to eccentric external rotator reciprocal muscle group ratios.

1.2 PURPOSE OF STUDY

In cricket the following muscle groups warrant examination, the hamstrings and the quadriceps muscles of the leg, and the shoulder girdle musculature which is placed under tremendous stress during bowling and throwing.

Since isokinetic equipment is commonly used in the rehabilitation of sporting injuries, a normative data base or sport specific ratios is highly desirable especially for selected elite sporting groups.

Accordingly, the aim of this study will be:

(i) To determine whether significant differences exist between the dominant and non-dominant extremities of the extensor and flexor knee muscles and internal and external shoulder rotator muscles in professional cricketers.

(ii) To determine whether the knee extensor or flexor strength relationship (hamstring/quadricep ratio) and shoulder internal rotator to external rotator strength relationship (external rotator/internal rotator ratio) put forward for the normal population is the same as for provincial cricketers.

(iii) To compare the conventional hamstring/quadricep; external rotator/internal rotator strength ratios (H/Q ratio; ER/IR ratio) and functional-eccentric hamstring/concentric quadricep; eccentric external rotator/concentric internal rotator strength ratios (H ecc/Q con; ER ecc/IR con).

An awareness of the correct sport specific strength ratios would help Biokineticists tailor strength training programmes to give the relevant muscle groups sufficient strength to cope with the activities they would be involved in. This would also help reduce the likelihood of injury and also improve performance. This study will set the groundwork for further work on the relationship of muscle strength ratios to injury in cricketers and for the national gathering of ratios that will be sport specific.

1.3 HYPOTHESIS

Sport specific training leads to differential development of muscle groups; which will result in the strength ratio of agonist-antagonist muscle groups to differ from the general population.

1.4 DEFINITIONS

1.4.1 Isokinetics

Hislop and Perrine (1967) describe Isokinetics as:

"Movement that occurs at a constant angular velocity with accommodating resistance. Maximal muscle tension can be generated throughout the range of motion because the resistance is variable to match muscle tension".

1.4.2 Concentric muscle contraction

It involves active contraction with shortening of a muscle where the muscle's origin and insertion approximate.

1.4.3 Eccentric muscle contraction

It involves active contraction during lengthening of a muscle where the muscle's origin and insertion separate.

1.4.4 Conventional Ratios

Report concentric to concentric or eccentric to eccentric strength ratios, merely indicates whether a qualitative similarity exists between the moment velocity patterns of the agonist-antagonist muscle groups (e.g. H/Q ratio, ER/IR ratio).

1.4.5 Functional Ratios

Report concentric to eccentric strength ratios or vice versa, more representative of knee flexion and extension and shoulder internal and external rotation (e.g. H ecc/Q con; H con/Q ecc; ER ecc/IR con; ER con/IR ecc).

1.4.6 Torque:

When a muscle is stimulated to contract; it produces force, if this force is measured about a joint's axis of rotation, the moment of force is known as torque.

1.5 ASSUMPTIONS

In conducting this study the following will be assumed:

- The cricketer's training methods are similar, and that they will, therefore have similar strength ratios.
- The sedentary controls have no training methods, and that they will, therefore have similar strength ratios.
- Each individual will perform to his maximum during the tests.
- The subjects are not affected by any illness or injury that they are not aware of.
- The Isokinetic dynamometer will produce consistent results.
- The methods used to familiarise the subjects with the Kin-Com dynamometer will be sufficient to allow them to complete the test unhindered.

1.6 DELIMITATIONS

- The sample was delimited to the Natal Cricket academy.

  The cricketers were male provincial players with twenty cricketers volunteering for this study.

  The control group were sedentary males whom were matched for age; height and body mass, twenty controls volunteered for this study.
- The Kin-Com dynamometer has a gravity correction feature; this is an important factor in limiting error in isokinetic testing.
- All subjects had to be free from illness and injury for at least 12 weeks before testing.

1.7 LIMITATIONS

- The subject's motivation to do their best may be a limiting factor.
- Subjects that have been exposed to isokinetic equipment, may have an advantage over the others who have not been exposed to isokinetic testing.
- The sample size is relatively small because of the nature of the study. (20 cricketers and 20 controls). The cricketers were provincial players and one is limited by the number of players available for testing.

The isokinetic testing was an hour in duration for each test; each subject was tested three times (20 cricketers x 3 = 60 hrs; 20 controls x 3 = 60 hrs).

The 18 isokinetic training sessions were an hour in duration for each session for the intervention groups (10 cricketers x 18 = 180 hrs; 10 controls x 18 = 180 hrs).

Thus the total hours of isokinetic testing for subjects were 120 hours and the total hours of isokinetic training for subjects was 360 hours.

In view of the time required for this study; the sample size was limited because the entire procedure of isokinetic testing and training was undertaken by myself.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 ISOKINETICS AS A CONCEPT

2.1.1 Historical Considerations

In 1967 the concept of isokinetic exercise was introduced in the scientific literature as an alternative to isotonic and isometric exercise (Hislop and Perrine, 1967 and Thistle et al, 1967).

This was followed by the recognition that torque values in Newton-meters developed by an extremity isokinetically could be graphed and measured. It was proposed as an accurate and reproducible measurement, which represented a more objective determination than manual muscle testing.

During the next decade and a half, isokinetic exercise and measurement devices have become extremely popular and commonplace.

2.1.2 Definition

The term isokinetics can be best defined as, "the dynamic muscular contraction when the velocity of movement is controlled and maintained constant by a specific device" (Thistle et al, 1967, cited in Baltzopoulos and Brodie, 1989).

2.1.3 Advantages and Disadvantages

A number of advantages of isokinetics have been given (Perrin, 1993).
One advantage is that a muscle group may be exercised to its maximum potential throughout a joint's entire range of motion. At the midrange of joint motion the isokinetic dynamometer will maintain its preset velocity, and maximal force will be produced. Conversely, at the extremes of joint motion the dynamometer will still maintain its preset velocity, but less force will be produced. Because there is no fixed resistance to move through the weakest point in a given arc of motion, isokinetic exercise facilitates a maximum voluntary force to be produced throughout the entire range of motion.

Isokinetic resistance may also provide a safer alternative to other exercise modalities during the process of rehabilitation. The dynamometer's resistance mechanism essentially disengages when pain or discomfort is experienced by the patient. An isokinetic apparatus may also be adapted to the particular rehabilitation at hand. The exercise may be sub-maximal and easily set through pain-free ranges within the total available range of joint motion, and exercise velocities may be selected that have the least potential for joint insult. Isokinetic exercise may be used to quantify a muscle group's ability to generate torque or force, and it is also useful as an exercise modality in the restoration of a muscle group's pre-injury level of strength.

The limitations of isokinetic exercise are that isokinetic exercise is not a movement common to everyday activities and the training is thus specific to the speeds at which the training was performed. The equipment is costly and there is a lack of individuals trained to use it. The time taken to change positions on the apparatus is also time consuming and finally it requires as with most test procedures, procedures for test condition which, if not followed correctly, can produce error (Rothstein et al, 1987).

2.2 ISOKINETIC PARAMETERS

2.2.1 Maximum Torque

The maximum torque during isokinetic movements is a measure of the muscular force applied in dynamic conditions (Baltzopoulos and Brodie, 1989). Various testing protocols have been used for the assessment of maximum torque. The main difference between these protocols is the number of repetitions required in order to develop the maximum torque. The maximum torque is always evaluated from the first 2 to 6 maximal repetitions and is defined as the maximum single torque value measured during these repetitions (Baltzopoulos and Brodie, 1989).

2.2.2. Factors That Affect The Torque Output

There are a number of factors that can affect the output of isokinetic dynamometry that should be considered before testing takes place. These include issues like positioning and stabilisation; correcting for the effect of gravity; the torque-velocity relationship; inertial forces; load cell placement and subject motivation (Amell, 1995).

Age, gender and activity level have also said to influence the reciprocal ratios (Baltzopoulos and Brodie, 1989). These factors are important for Biokineticists to be aware of not only in testing patients but also in interpreting their results. An awareness of these influences on peak torque will help the Biokineticist limit the error involved with isokinetic tests but more importantly will help him/her better understand inter-subject variations. This is of particular importance to Biokineticists when rehabilitating patients as it would help the biokineticists tailor programs to suit different types of patients.

2.2.2.1 Subject Positioning

In isokinetic testing it is important to have a standard test position across all the subjects tested and for all subjects and all movable parts of the dynamometer to be securely stabilised. This helps to control as many extraneous variables as possible so that all subjects can be tested in as similar an environment as possible.

In an attempt to provide a guide for the standardisation of test subjects Goslin and Charteris (1979, cited in Holmes and Alderink, 1984) proposed three principles to follow for testing :

1. parallel alignment of the limb with the lever arm of the dynamometer;
2. alignment of the anatomical axis of rotation of the joint with the rotational axis of rotation of the dynamometer;
3. proper stabilisation

   These principles are important as they serve as a guideline indicating the correct position for all patients to be tested in.

Knee Flexion/Extension

When performing a knee flexion/extension test there are three positions that can be used: the seated, prone and supine positions. In the seated position, the subject sits with his/her back slightly reclined. An important point to consider here is that the angle of recline can vary anywhere from 75 to 90 degrees (Dvir, 1995). There is evidence that the angel of recline can affect the strength of the quadriceps and hamstrings (Bohannon et al, 1986, cited in Dvir, 1995). However, Dvir (1995) proposes an angle of 80 degrees to be optimal.

The prone and supine positions have been compared (Barr and Duncan, 1988, cited in Dvir, 1995) showing that the hamstrings exerted a greater movement of force in the prone position than in the supine position, when corrected for gravity. Worrell et al (1989, cited in Dvir, 1995) tested the hamstrings and quadriceps strength in the seated and supine positions and found that the seated position produced greater moments for both muscle groups.

Shoulder Internal/External Rotation

Shoulder strength has been tested in many positions, with results varying greatly depending on the position tested (Hinton, 1988, Kuhlman et al, 1992, Soderberg and Blaschak, 1987 and Walmsley and Szybbo, 1987).

Numerous studies have shown that alternating the glenohumeral position results in significant variation in torque values (Hageman et al, 1989, Soderberg and Blaschak, 1987 and Walmsley and Szybbo, 1987).

Soderberg and Blaschak (1987) tested the internal and external rotator muscles in six different positions. They demonstrated that the external rotator muscles were optimally tested with the subject seated and with the arm of the subject in 90° of shoulder abduction and in 90° of elbow flexion. They found the internal rotator muscles to be strongest with the shoulder in neutral position, the 90°/90° position yielded the third highest overall torque values.

It is imperative to test the shoulder in a position that closely resembles the throwing act, whilst also isolating the muscle groups to be tested. For this reason, it has been suggested that all testing be performed in a seated position (Wilk et al, 1991). This allows for the natural gravitational stabilisation of the trunk and lower extremities. Testing of the shoulder internal rotators/external rotators should be performed in 90 degrees of shoulder abduction and 90 degrees of elbow flexion (90 deg/90 deg position). This test position has been recommended as it affords a close reproduction of the throwing position (Wilk et al, 1991, Sirota et al, 1997). Falkel et al (1987) reported that testing in a position and posture specific to the athlete's sport yielded higher values than those obtained by testing nonsport specific positions.

2.2.2.2 Subject Stabilisation

Stabilisation is an important factor in maintaining the validity of isokinetic tests. Stabilisation helps to improve maximal torque readings and also helps limit the contribution of muscles not being tested and thus prevents them influencing the results.

Knee Flexion/Extension

Femoral and pelvic strapping is normally used in the seated position (Dvir, 1995), although, the increased quadriceps strength has been found with thoracic strapping (Hart et al, 1984, cited in Dvir, 1995).

Having the subject grip the sides of the table during a test has also been found to increase subject stability. In fact it has been shown (Dvir, 1995) that having the subject grip the sides of the table without any other form of stabilisation was sufficient to provide stability similar to 'maximal stabilisation' (femoral, pelvic and thoracic) strapping.

Shoulder Internal/External Rotation

It has been shown (Rothstein, 1987) that when testing complex joints like the ankle and shoulder a considerable amount of movement occurs regardless of the amount of stabilisation. This uncontrolled movement may lead to a certain amount of measurement error. Stabilisation of the trunk significantly increases test retest reproducibility (Wilk, 1990) and is recommended at the hip, trunk and feet (Wilk et al, 1991). It is therefore, important to limit as much movement outside the limb being tested as possible.

2.2.2.3 Resistance Pad Placement

The placement of the resistance pad is also an important consideration in attempting to reduce test error as changing it's position can significantly affect test results.
The position of the resistance pad on the subject's leg will determine the lever arm length and if this length is changed by more than 25 percent, the torque produced is significantly affected (Prentice, 1994).

Wilk and Andrews (1993) found that the knee extension and flexion strength dropped as the resistance pad moved closer to the knee joint (decreasing the lever arm length). Similar findings were seen in a study by Steward et al (1975, cited in Dvir, 1995). However, this measurement has not been researched in regard to isokinetic testing of the shoulder. In testing the shoulder internal/external rotators, the axis of rotation is aligned through the centre of the olecranon and the shaft of the humerus (Wilk et al, 1991). Finally, all movement in the system should be severely restricted to allow movement in only the lever arm (Amell, 1995).

2.2.2.4 Correcting for the Effect of Gravity

During isokinetic testing involving movement in the vertical plane (e.g. Knee flexion/extension), there are two forces acting on the lever-limb system : muscular force and gravitational force (Baltzopoulos and Brodie, 1989). This means that the resulting torque output is a result of the muscular and gravitational forces. Thus it can be seen that correcting for the effect of gravity is an important factor in limiting the error in isokinetic tests.

A number of studies have demonstrated significant differences between isokinetic tests of muscle groups that were gravity compensated and those that were not during seated knee flexion and extension (Barr and Duncan, 1988, Figoni et al, 1988, Fillyaw et al, 1986).

When gravity compensation is not utilised, the muscle assisted by gravity will produce inflated torque values, whilst muscles that oppose gravity will exhibit significantly smaller torque values. In addition, as angular velocity increases, so does the relative effect of gravity on torque values (Winter et al, 1981, cited in Wilk et al, 1991).

Few reports in the literature have employed a gravity correction procedure when assessing shoulder internal and external rotation. However, the influence of gravity on assessment of this musculature has an effect similar to the quadriceps and hamstring muscle groups (Perrin et al, 1992, cited in Perrin, 1993).

When assessed from a seated position, the absence of gravity correction significantly under predicts the muscle group opposed by gravity (external rotators) and over predicts the muscle group assisted by gravity (internal rotators). Because gravity correction adds to the external rotators and subtracts from the internal rotators, the external/internal rotator reciprocal muscle group ratio is appropriately higher, in some cases to the point where it approaches 1.0 (Perrin et al, 1992, cited in Perrin, 1993).

A thorough examination of gravity correction procedures has not been done. For example, the Cybex II isokinetic dynamometer's computer provides the automatic correction of gravity but the methods used for this correction, however, have not been described or shown to be valid (Rothstein, 1987).

Similarly, in evaluating the gravity-correction feature of the Kin-Com isokinetic dynamometer Finucane et al, (1994) found certain errors in the gravity-correction feature. The instructions supplied with the Kin-Com indicated that when performing the gravity-correction procedure the limb segment being tested should be as close to the horizontal as possible without inducing muscle tension. Finucane et al (1994) however, found greater accuracy when the gravity-correction procedure was performed with the lever arm (not the limb) near the horizontal. Clearly, more conclusive research is needed to determine an accurate procedure for correcting for the effect of gravity.

2.2.2.5 Test Velocity

The test speed or angular velocity of the body segment being tested also has an influence on the output of an isokinetic test.

In the context of isokinetic testing, strength has been defined at any velocity at or below 60 degrees per second. Therefore if one is testing strength in an individual, the pre-set speed is at a slower than 60 deg/second, commonly used speeds are 30 deg/second; 45 deg/second and 60 deg/second (Davies, 1992).

It is recommended to not regularly test joints at speeds slower than 60 deg/second because of the stress on the joint, the pain and reflex inhibition which may negatively influence the test, and most appropriately, because speeds lower than 60 deg/second are not functional (Davies, 1992).

The feeling at present is that 60 deg/second is the acceptable test speed for assessing concentric muscle strength at the knee (Prentice, 1994).

2.2.2.6 Angular Position

The angular position is important in the assessment of muscle function because it provides information about the mechanical properties of the contracting muscles. It can be used to evaluate the optimum joint angle for maximum muscular force. The maximum torque depends on the angular position (i.e. the joint position) where it is recorded. The maximum torque tends to occur later in the range of movement with increasing velocity and not in the optimal joint position (Baltzopoulos & Brodie, 1989).

2.2.2.7 The Torque-Velocity Relationship

The torque-velocity relationship describes the effect of different test speeds on maximal torque output. The general finding is that as the angular velocity increases, the muscular torque produced decreases (Barnes, 1980, cited in Baltzopoulos and Brodie, 1989, Holmes and Alderink, 1984).

The decline in torque output has been attributed to different neurological activitation patterns of motor units at different velocities (Barnes, 1980, cited in Baltzopoulos and Brodie, 1989).

Strength tests that require maximal readings would, thus, require lower speeds and rehabilitation (where lower compressive forces are required) would require higher speeds.

2.2.2.8 The Effect of Inertia on Isokinetic Movement

During isokinetic movements the feedback mechanism that produces the resistance is not activated until the limb has reached the preset velocity. During this period there is no resistance applied by the dynamometer and the limb is free to accelerate. As a result the limb velocity tends to exceed the preset angular velocity (Sapega et al, 1982, cited in Baltzopoulos and Brodie, 1989).

When the feedback mechanism is activated, the dynamometer exerts a resistive force to decelerate the overspeeding lever arm. This produces a 'torque overshoot' that represents this reaction of the dynamometer to the overspeeding lever arm. This 'torque overshoot' frequently shows in older isokinetic recordings (Sapega et al, 1982, cited in Baltzopoulos and Brodie, 1989) and always occurs in the initial part of the movement. Modern isokinetic dynamometers account for this 'overshoot' through a process called 'ramping' where the excess force is absorbed and the resulting torque curve is smoothed (Amell, 1995). It is important to be aware of this 'torque overshoot' effect when analysing torque curves, even though the effect is absorbed in modern isokinetic dynamometers.

2.2.2.9 The Effect of Activation Force/ Preload

The activation force is defined as the force that must be applied in order to activate the resistance arm of an isokinetic dynamometer. A pre-selected minimum force must be applied to the load cell in order to activate the arm of the dynamometer. This feature is only available on the Kin-Com but is of importance to Biokineticists as it has been shown to affect peak torque readings (Kramer et al, 1991, and Jensen, et al, 1991).

It has, therefore, been said that the test results achieved on these dynamometers that have an activation force should not be compared to the results achieved on dynamometers which do not have an activation requirement and are characterised by free acceleration up to the specific angular velocity, like the Cybex and Akron (Kramer, 1991). Kramer et al, found that the use of static preload level of 75 percent of the maximal voluntary isometric contraction significantly increased the torque produced at 90 degrees per second.

2.2.2.10 The Effect of Learning

Murray et al, (1980) in a study of the strength of isometric and isokinetic contractions tested subjects on two separate occasions, one week apart with each test session also involving two successive trials. This was to assess the affect of leaning on peak torque. It was found that, in 52 percent of the cases, the second of the two consecutive trials was found to have a significantly higher peak torque values than the first of the two consecutive trials. The difference in torque between the first and second weeks showed that the tests conducted on the second week showed significantly higher peak torque values in 56 percent of the cases.

Mawdsley and Knapik (1982, cited in Wilk et al, 1991), reported significant differences between the values demonstrated in the first testing session and those of all remaining sessions in a sequence of six test trials. This show that learning definitely has an effect on the peak torque and that it is necessary to introduce the subject to the testing apparatus, explain how it works and what results will be provided. The subjects should be given the opportunity to practice before conducting the test, as isokinetic exercise is different compared to isotonic exercise on normal gym equipment.

Familiarising them with how to perform the movements correctly will enable them to give a maximal effort, as the aim is to achieve as high readings as possible in order to correctly assess maximum muscular strength.

2.2.2.11 Visual Feedback

It has been reported that knowledge of results during strength testing may increase some parameter of performance (Figoni and Morris, 1984, Hald and Bottken, 1987, Pierson and Rasch, 1964, cited in Wilk et al, 1991). Therefore, visual feedback in the form of knowledge of results can significantly influence performance and must be consistently used or not used during testing.

2.2.2.12 Active Warm-up

Many studies have indicated no direct relationship between warm-up and increased isokinetic torque production (Davies, 1987, Richard and Currier, 1997, Wiktorsson – Moller et al, 1983, cited in Wilk et al, 1991).

However, a physiological rationale exists for a warm-up to precede activity (Astrand and Rodahl, 1997, Wiktorsson Moller et al, 1983, cited in Wilk et al, 1991). An active warm-up should facilitate muscular performance by increasing blood flow, muscle/core temperature, facilitation of higher contraction speed, oxygen utilisation, and nervous system transmission, as well as by decreasing muscular viscosity.

2.2.2.13 Rest Interval

The rest interval during isokinetic testing must be standardised to ensure reproducibility. Ariki et al (1985 cited in Wilk et al, 1991) have identified the optimal period of rest between each isokinetic test speed to be 90 seconds.

2.2.2.14 Verbal Commands

It is important to standardise the verbal commands provided during testing to ensure consistency from test to test and from subject to subject.

Johansson et al (1983, cited in Wilk et al, 1991) reported that loud verbal commands result in greater isometric torque values.

Wilk et al (1991) recommended that the verbal commands during isokinetic testing should be consistent, encouraging, and moderate in intensity.

2.2.2.15 Age, Gender and Type of Activity

Age, gender and activity level have been said to affect muscle group ratios (Baltzopoulos and Brodie, 1989).

Age

Age has been said to have a significant influence on peak torque readings (Murray et al, 1980), which, if true, could have significant influences on expectations for rehabilitation programs for older individuals.

It has been shown that expressing strength values as values relative to body weight or lean body weight are more sensitive when comparing strength values between different groups of individuals (Clarke et al, 1992).

Gender

Females have been shown to be significantly weaker in muscular strength than males (Holmes and Alderink, 1984, Sanderson et al, 1984 and Coetzee et al, 1992).

Coetzee et al, however, found that when expressed as values relative to body weight the females showed no difference in flexion or extension strength as compared to the males.

Type of Activity

The type of activity involved in is closely liked to the peak torque produced for a number of reasons. Firstly, the intensity and duration of the activity affects the muscle fibre type recruited.

According to Henneman's law muscle fibres will be recruited in the following order as intensity of exercise increases, Type 1, Type 11a and finally Type 11b. Type 1 fibres are largely oxidative slow twitch fatigue resistant. Type 11a fibres are fast twitch; oxidative glycolytic fibres and Type 11b are fast twitch, largely anaerobic glycolytic fibres that fatigue rapidly.

High intensity, short duration exercise is associated with an increased involvement of Type 11 muscle fibres and anaerobic metabolism. Endurance activity, however, is associated with a high functional capacity of Type 1 fibres and mainly aerobic metabolism (Johansson, 1992).

The maximal isokinetic extensor peak torque is proportional to the Type 11 fibre of the vastus lateralis muscle (Johansson, 1992) and this muscle has been shown to be representative of the quadriceps femoris muscle and is, therefore, the muscle used when biopsies are taken. Type 11 fibres are, therefore, associated with greater strength than the Type 1 fibres. We can, therefore, expect endurance athletes to show weaker strength values than power athletes.

High intensity, short duration activities are likely to show greater peak torque values as compared to activities that are more aerobic in nature.

More importantly, what they show is that when comparing sportsmen and women involved in different types of sports it is necessary to compare them on the basis of strength values relative to body weight as the difference in absolute strength levels were as a result of differences in body weight (Coetzee, 1992). If one were to extend this one could see that when comparing athletes involved in sports associated with significantly different body mass characteristics, like swimming and running, it would be necessary to compare them on the basis of strength relative to lean body weight.

All of the above factors can affect the output of isokinetic dynamometry and should be considered before testing takes place. It is the responsibility of the Biokineticist to be aware of these factors and to try to control them as much as possible.

2.2.3 Balance Versus Imbalance

Muscle imbalance literally means a lack of balance, in that either an asymmetry exists between extremities, or muscle strength differs from normal values. The asymmetry or differential, termed an ipsilateral-contralateral imbalance, may be strength, power, power-endurance or another value when comparing extremities within the same subject.

It can also indicate a difference in comparison between opposing muscle groups within the same extremity, such as the hamstring to quadriceps ratio termed agonist-antagonist imbalance.

The actual magnitude of what constitutes balance has never been accurately defined. A 10% discrepancy has been mentioned in the literature (Gilliam et al, 1979, Mira et al, 1980) and a 10 to 20% discrepancy is utilised in practice as a guideline to returning to athletic participation after knee injuries (Grace, 1985).

2.2.4 Normal Versus Not Normal Versus Abnormal/pathological

Normal limits are those that, statistically, represent the majority of the population. This would include all measured values falling within two standard deviations of the mean. If the results represented a normal or bell-shaped curve, then they would represent 95 percent of the population.

Not normal would apply to those subjects whose measurements do not fall within the range of the normal. It is important, at this point, to distinguish what is not normal from what is abnormal or pathological. The normalcy of isokinetic measurements is only important in assessing actual injury or a drop in functional performance. Little work has been done in this area of research regarding isokinetic measurements specifically regarding muscle imbalance and injury (Grace, 1985).

2.2.5 Reciprocal Muscle Group Ratios

The muscle groups on both sides of a joint necessarily act reciprocally to produce smooth and coordinated motion. When a muscle group produces a desired joint action it is the agonist for the observed motion. The muscle group producing the opposite joint action is the antagonist.

It has been postulated, though not scientifically proven that excessive imbalances in reciprocal muscle group ratios predispose the joint or weaker muscle group to injury. Because of this, the ratios about most major joints have received considerable attention in preseason screening and rehabilitation of athletes (Perrin, 1993).

The strength ratios used to evaluate rehabilitation are based on general population norms and not sport specific norms. Sport specific training may result in unequal development of muscle strength in agonistic muscles and hence strength ratios which may differ from the general norm. What is not known is whether these differences place the athlete at risk of muscle injury, or whether these differences now constitute a new sport specific norm. Present rehabilitation goals based on existing normative data may therefore be inappropriate for certain sports.

It is interesting that virtually all studies of upper and lower extremity reciprocal muscle group ratios report concentric to concentric or eccentric to eccentric ratios. For example, the concentric hamstring to concentric quadriceps muscle group ratios are typically reported, and the same are usually found for the shoulder external to internal rotator ratios.

However, the hamstring muscle group's eccentric contraction is essential for deceleration of knee extension during sprinting, as is the shoulder external rotator's eccentric contraction during deceleration of shoulder internal rotation during throwing.

This kinesiological observation would seem to support reporting of quadriceps concentric to hamstring eccentric ratios, and shoulder concentric internal rotator to eccentric external rotator reciprocal muscle group ratios. Perin (1993) suggested reporting of quadriceps concentric to hamstring eccentric ratios, and shoulder concentric internal rotator to eccentric external rotator reciprocal muscle group ratios.

Conventional Hamstring to Quadriceps Ratio (H/Q ratio)

A number of studies have investigated the hamstring/quadriceps (H/Q) ratio. A ratio of approximately 0.60 is generally accepted as 'normal' (Kellis and Baltzopoulos, 1995). Kannus (1989, cited in Kellis and Baltzopoulos, 1995) concluded that this ratio is a patient-specific parameter, and general recommendations on its optimal value are difficult. This would support the argument that different sports may require sport specific norms. Historically based on Cybex evaluations, a 0.66 ratio between the Hamstring and Quadriceps at 60 degrees per second has been described as the normative value (Prentice, 1994), although a number of studies have shown different findings.

A study of elite track and field athletes (Coetzee et al, 1992), at 30 degrees per second found ratios of 0.61 for throwers, 0.60 for jumpers and sprinters, 0.62 for middle distance runners and 0.59 for long distance runners.

Sanderson et al (1984) found a hamstring to quadriceps ratio using uncorrected torque values of 0.60 (± 0.009) in 17 male and 17 female subjects. Holmes and Alderink (1984) in examining high school students found a mean ratio of 0.57 at 60 degrees per second.

Recent studies have indicated that, if the moment measurements are corrected for gravity effects, the H/Q ratio may not significantly change as speed increases. (Westing and Seger, 1989, Griffin et al, 1993, Appen and Duncan, 1986).

When gravity – corrected data were used, the concentric H/Q ratio remained similar, with some exception s, showing an increase with increasing angular velocity. Gravity corrected eccentric H/Q ratio remained relatively similar as velocity increased (Kellis and Baltzopoulos, 1995).

Functional Hamstring to Quadriceps ratio (H ecc/Q con, H con/Q ecc)

The nature of many athletic and normal movements involves both concentric and eccentric actions; the eccentric antagonist/concentric agonist moment ratio (ecc/con) may be more valid indicators of muscular imbalance than the eccentric (ecc/ecc) or concentric (con/con) reciprocal parameters.

In daily or athletic activities, the agonist muscles (knee extensors) produce concentric work to accelerate the limb forward whereas the antagonists (flexors) generate eccentric work to control the movement of he limb and/or prevent joint overloading. It has been reported that eccentric antagonist/concentric agonist moment deficits at a given velocity may be related to injuries (Bennet and Stauber, 1986, cited in Kellis and Baltzopoulos, 1995).

The functional H ecc/Q con ratio may be used to indicate the extent to which the hamstring muscles are capable of counteracting the anterior tibial shear induced by maximal quadriceps muscle contraction (Perrin, 1993). Values for conventional H/Q strength ratios of 0.40 to 0.50 have been reported based on peak moments, independent of contraction mode and velocity (Aagaard et al, 1995, Westing and Seger, 1989).

In contrast, a functional H ecc/Q con ratio of about 1.00 was found for fast isokinetic knee extension, indicating a significant capacity of the hamstring muscles, to provide dynamic joint stabilisation during active knee extension (Perrin, 1993).

This capacity for dynamic joint stabilisation was enhanced after high-resistance strength training, but unchanged after fast low-resistance types of strength training (Cabri, 1991, cited in Aagaard et al, 1998).

Low values (0.30) have been reported for functional H/Q ratios representative of fast isokinetic knee flexion (H con/Q ecc) (Cabri, 1991, Perrin, 1993, cited in Aagaard et al, 1998), which suggests that the hamstring muscles have a reduced capacity for dynamic knee joint stabilisation during forceful knee flexion movements with simultaneous eccentric quadriceps muscle contraction.

Conventional External Rotator to Internal Rotator Ratio (ER/IR ratio)

A number of investigators have quantified shoulder external and internal rotator muscle strengths (Alderink and Kuck ,1986, Davies, 1992, Hinton, 1988, Ivey, 1985, Wilk et al, 1993). These studies were performed in an isokinetic concentric mode. This mode was chosen because of concern about the significant amount of delayed onset muscle soreness that often occurs with eccentric contractions (Sirota et al, 1997).

Ivey (1985), reported an ER/IR ratio of 0.66 at both 60 and 180 degrees/second. Davies (1992), reported an ER/IR ratio of 0.64 at 60 degrees/second.

Sirota et al (1997), reported an ER/IR ratio of 0.98 for the dominant throwing shoulder and 0.85 for the non-dominant shoulder at 60 degrees/second.

Sirota et al (1997), hypothesised that the lower mean torques found in the other studies, may have been due to the relative weakness of athletes compared to the more developed professional athletes in their study.

Recently, Magnusson et al (1990), reported on 'break test' strength of shoulder external and internal rotator muscles using a hand-held dynamometer. Although these results were reported as eccentric strength, they actually represented isometric strength because break testing measures the force needed to overcome an isometric contraction.

Injury prevention may be more dependent on eccentric contractions during throwing. Eccentric testing provides a closer reproduction of the eccentric contraction performed by the external and internal shoulder rotator muscles during the throwing motion.

<u>Functional External Rotator to Internal Rotator Ratio</u> (ER ecc/IR con; ER con/IR ecc)

The glenohumeral joint is inherently unstable and must rely extensively on the rotator cuff for dynamic stabilisation during demanding stability to the glenohumeral joint during throwing and other overhead activities.

The use of dynamic strength evaluations may help clinicians prevent and rehabilitate shoulder injuries in throwing athletes.

Isokinetic testing could be done in the preseason to establish baseline data, and the testing could also be part of an injured athlete's rehabilitation program (Sirota et al, 1997). Comparative evaluations may help to determine when it is safe for the athlete to return to throwing. However, further studies are needed to determine the role of eccentric shoulder strength testing in the prevention and rehabilitation of injuries.

2.3 CONCLUSION

Isokinetic exercise and measurement devices have become extremely popular. Isokinetic exercise is used to quantify a muscle group's ability to generate torque or force, and is also useful as an exercise modality in the restoration of a muscle group's pre-injury level of strength.

There are a number of factors that affect the output of isokinetic dynamometry and a number of factors that influence the reciprocal ratios.

These factors are important for Biokineticists to be aware of not only in testing patients but also in interpreting their results.

To date there is minimal published normative data for 'functional ratios'.
Anecdotal evidence suggests that these ratios are superior in their ability to predict injury than the traditional 'conventional ratios'.

CHAPTER THREE

METHODS AND PROCEDURES

This chapter will deal with (1) the selection of subjects; (2) the collection of the test data and finally, (3) the methods used to analyse the data.

The study was conducted with the approval of the Bio-ethics committee of the Faculty of Health Sciences of the University of Natal.

3.1 SELECTION OF SUBJECTS

The criteria for subject entry into the study were that (1) the cricketers had to be male provincial players; (2) the controls had to be sedentary males matched for age, height and body mass and (3) all subjects had to have been free from illness and injury for at least 12 weeks before the testing.

Twenty-four cricketers and twenty-four controls volunteered for this study. Some subjects were excluded due to a recent illness or injury and others were disqualified for not meeting the time requirement. The results of 20 cricketers and 20 controls were analysed for this study.

3.2 DATA SELECTION

The data were collected at inception of the trial, 6 weeks later and 12 weeks later. The subjects were instructed to report to the Addington Biokinetic Centre in a rested and relaxed state and with the appropriate training gear. The subjects were also asked not to have a strenuous training session in the twenty four hours before the tests were scheduled. Informed consent forms were obtained from all participants before testing. Testing was performed at the same time of day for each consecutive test.

3.2.1 Preliminary Testing

The subjects' weight and height were taken and their age recorded. Their body fat was assessed using skinfold measurements, the sum of 6 skinfolds with the Lange skinfold calliper (Durnin and Womersley, 1974). The sites for males included supra-iliac, triceps, thigh, subscapularis, calf and abdominal.

3.2.2 Isokinetic Testing

Subjects were tested on a Kin-Com dynamometer (Kinetic Communicator, Chattecx Corp, Chattanooga, USA). Subjects were positioned and stabilised on the dynamometer using the three principles proposed by Goslin and Chateris (1979, cited in Holmes and Alderink, 1984): (1) parallel alignment of the limb being tested with the lever arm of the dynamometer; (2) alignment of the anatomical axis of rotation of the knee joint and shoulder joint with the rotational axis of rotation of the dynamometer and (3) proper stabilisation. Stabilisation included tightly securing the limb and upper body with velcro straps and the appropriate pieces of equipment. Once the subject was correctly positioned and stabilised, all moving parts were checked to see that they were severely restricted to prevent any unwanted movement, as it has been shown that movements in the dynamometer that occurs over and above the movement in the lever arm can introduce error (Amell, 1995).

The subjects performed a thorough warm up which included at least 5 min of low-level aerobic work (e.g. 5 min cycling and stretching). The non-dominant limb was always assessed first and each concentric contraction was immediately followed by an eccentric contraction. Once positioned on the machine, each subject performed 2 sets of 15 reps each at 90 degrees per sec. This served both as a warm-up exercise and as a means of familiarising the subjects with the machine.

They then performed 3 sub-maximal repetitions and 1 maximal repetition, with a 30 second rest period between each repetition at the angular velocity to be tested. This allowed the subject to be acclimatised to the speed of movement at the test velocity. The subject then performed a ten second maximal test at 60 degrees per sec.

Verbal encouragement was given to each subject during the test to facilitate a maximal reading. In addition to this verbal encouragement the subjects were also motivated using visual knowledge of results. The Kin-Com isokinetic dynamometer displays the torque produced during exercise in the form of two vertical columns of lights, situated on the control panel which show the values achieved. The subjects were instructed to try to make the lights go as high as possible. Hobbel and Rose (1993) showed that subjects who practice using visual knowledge of results show significantly greater improvements in mean peak torque output than those who practice without visual knowledge of results. It was hoped that this would facilitate maximal efforts in the subjects.

Knee assessment

Subjects were tested in the seated position with the back rest set at 80 degrees, the seat bottom angle at 15 degrees. The ratios of the extensors and flexors of the knee joint were tested eccentrically and concentrically at a test velocity of 60 degrees per second on both limbs. The upper body and the thigh of the leg being tested were stabilised using velcro and the appropriate pieces of equipment. (Figure 1).

The subject's leg and testing apparatus were statically weighed to provide gravity compensation.

Figure 3.1 : Isokinetic strength testing of extensor and flexor knee muscles

Shoulder Assessment

Subjects were tested in the seated position, a position that closely resembles the bowling action, whilst also isolating the muscle groups being tested. The backrest was set at 80 degrees, the seat bottom angle at 15 degrees. The upper body was stabilised using velcro and the appropriate pieces of equipment. Testing of the shoulder internal rotators and external rotators was performed in 90 degrees of shoulder abduction and 90 degrees of elbow flexion (90 deg/90 deg position). This test position closely approximates that of a normal throwing motion while ensuring muscle isolation. The ratios of the internal rotators and external rotators were tested eccentrically and concentrically at a test velocity of 60 degrees per second on both limbs. (Figure 2).

The subject's arm and testing apparatus were statically weighed to provide gravity compensation data.

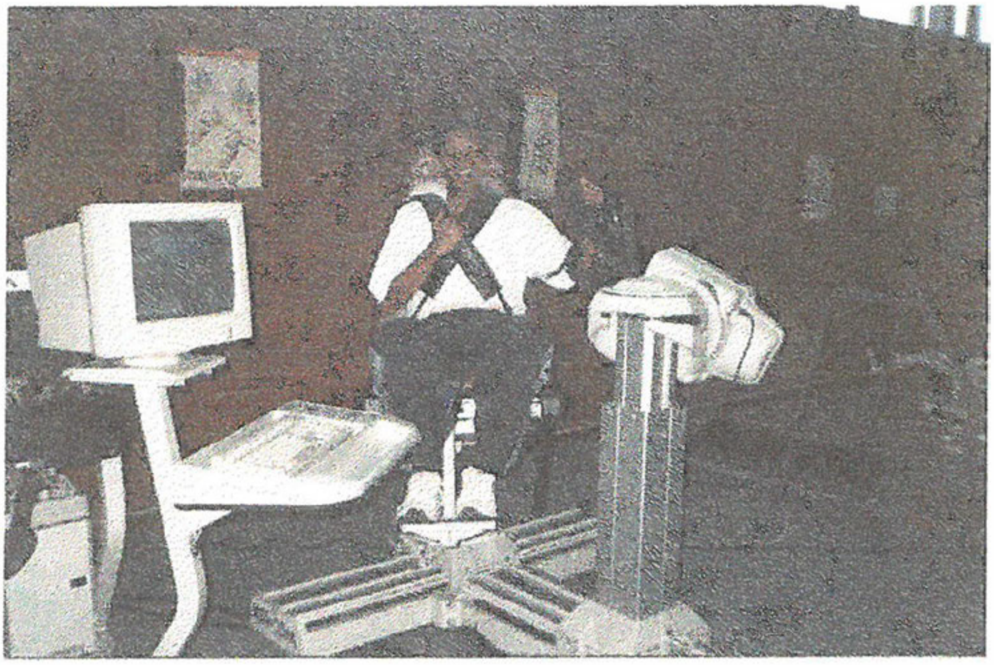

Figure 3.2 : Isokinetic strength testing of internal and external rotator muscles

3.2.2 Isokinetic Strength Training

Ten provincial cricketers and ten subjects of the control group were randomly selected to perform isokinetic strength training to produce ratios that are put forward for the normal population. In general, the external rotator muscle produces approximately 60% to 80% of the peak torque values generated by the internal rotators (Griffin et al, 1993).

Knee flexors produce approximately 60% of the peak torque of the knee extensors (Coplin, 1971 and Kellis and Baltzopoulos, 1995). Each subject performed a total of 18 training sessions performed over 6 weeks. The training sessions were determined from the exercise test results. A training session consisted of 2 sets of 15 repetitions each at 90 degrees per sec, to serve as a warm-up. The subject then performed a number of repetitions at the test velocity for that particular muscle group.

3.2.3 Isokinetic Testing schedule

The subjects performed Test 1 (Inception August) during the pre-season, Test 2 (6 wk November) during the season and Test 3 (12 wk January) during the season.

The intervention groups (10 cricketers [I] and 10 controls [I]), were tested isokinetically at the inception of the trial (Test 1).

The intervention groups then completed 18 isokinetic strength training sessions and were re-tested at 6 weeks (Test 2).

Training was stopped, and the intervention groups were then re-tested at 12 weeks (Test 3).

The non-intervention groups (10 cricketers [NI] and 10 controls [NI]), were isokinetically tested at the inception of the trial (Test 1).

The non-intervention groups did not perform any isokinetic strength training sessions and were re-tested at 6 weeks (Test 2) and then re-tested at 12 weeks (Test 3).

3.3 DATA ANALYSIS

The data was analysed using the statistical program SPSS.

Wilcoxon matched pairs test was conducted on the obtained values on the dominant and non-dominant limbs to determine whether or not there were significant differences between the absolute strength values and conventional and functional ratios ($p < 0.05$ level of significance).

- peak concentric quadricep torque (Q con)
- peak eccentric quadricep torque (Q ecc)
- peak concentric hamstring torque (H con)
- peak eccentric hamstring torque (H ecc)
- peak concentric internal rotator torque (IR con)
- peal eccentric internal rotator torque (IR ecc)

- peak concentric external rotator torque (ER con)
- peak eccentric external rotator torque (ER ecc)
- conventional hamstring/quadricep ratio (H/Q ratio)
- functional eccentric hamstring/concentric quadricep ratio (H ecc/Q con)
- conventional external rotator/internal rotator ratio (ER/IR ratio)
- functional eccentric external rotator/concentric internal rotator ratio (ER ecc/IR con)

Friedman test for repeated measures was conducted on the obtained values of the limbs to determine whether or not there were significant differences between the absolute strength values and functional and conventional ratios for the various tests, test 1 (inception); test 2 (6 wks isokinetic training) and test 3 (12 wks post-training). ($p < 0.05$ level of significance).

Mann Whitney test was conducted on the obtained values of the limbs to determine whether or not there was significant differences between the various groups, controls with non-intervention [NI]; controls with intervention [I]; cricketers with non-intervention [NI]; cricketers with the intervention [I] ($p < 0.05$ level of significance).

CHAPTER FOUR

RESULTS

The results of this study are presented and discussed in major sections, namely:

4.1 Details of the Demographic data

4.2 Details of Dominant and Non-dominant limbs

4.3 Details of Absolute Strength values

4.4 Details of Conventional H/Q ratios

4.5 Details of Functional H ecc/Q con ratios

4.6 Details of Conventional ER/IR ratios

4.7 Details of Functional ER ecc/IR con ratios

4.1 DETAILS OF DEMOGRAPHIC DATA

A comprehensive summary of the demographic data are shown in the table below (Table 4.1).

The results of 10 controls with non-intervention; 10 controls with intervention (randomly selected for training); were included for analysis.

There were no significant differences for the age; height; body mass and percent body fat between the various groups, controls with non-intervention (NI); controls with intervention (I); cricketers with non-intervention (NI) and cricketers with intervention (I).

Table 4.1: Details of Demographic Data

(Mean Age; Height; Body Mass; % Body fat ± S.D.)

	CONTROLS (NI)	CONTROLS (I)	CRICKETERS (NI)	CRICKETERS (I)
Age (yrs)	25 ± 3.37	22 ± 4.29	21 ± 3.63	20 ± 2.41
Height (cm's)	176.90 ± 6.66	176.60 ± 9.20	181.70 ± 4.50	179.10 ± 7.20
Body Mass (kg's)	73.40 ± 10.39	74.00 ± 14.64	76.40 ± 6.59	74.80 ± 10.59
%Body Fat	10.29 ± 1.38	9.22 ± 1.48	9.19 ± 2.35	7.72 ± 1.16

4.1.1 Controls with non-intervention [NI]

The mean age was 25 years (± 3.37); the mean height was 176.90 cm (± 6.66;) the mean body mass was 73.40kg (± 10.39) and the mean percentage body fat was 10.29 (± 1.38). In this group the dominant hand was the right and the dominant foot was the right.

4.1.2 Controls with intervention [I]

The mean age was 22 (± 4.29); the mean height was 176.60cm (± 9.20); the mean body mass was 74.00kg (± 14.64) and the mean percent body fat was 9.22 (± 1.48). In this group the dominant hand was the right and the dominant foot was the right.

4.1.3 Cricketers with non-intervention [NI]

The mean age was 21 (± 3.63); the mean height was 181.70cm (± 4.50); the mean body mass was 76.40kg (± 6.59) and the mean percent body fat was 9.19 (± 2.35). In this group the dominant hand was the right and the dominant foot was the right. The cricketers consisted of 3 batsmen; 3 bowlers; 4 batsmen/ bowlers.

4.1.4 Cricketers with intervention [I]

The mean age was 20 years (± 2.41); the mean height was 179.10cm (± 7.20); the mean body mass was 74.80kg (± 10.59) and the mean percent body fat was 7.72 (± 1.16). In this group the dominant hand was the right and the dominant foot was the right. The cricketers consisted of 5 batsmen; 2 bowlers; 3 batsmen/ bowlers.

4.2 DETAILS OF DOMINANT AND NON-DOMINANT LIMBS

4.2.1 Knee Data

Mean torque values for the extensor and flexor knee muscles of the dominant and non-dominant legs are shown in the table below (Table 4.2A)

Table 4.2A: Details of dominant and non-dominant limbs at inception

Knee Data (Q con; Q ecc; H con; H ecc) * $p < 0.05$

VARIABLE	GROUP	INTERVENTION/ NON-INTERVENTION	DOMINANT LIMB Nm ± S.D	NON-DOMININANT LIMB Nm ± S.D
Q con	Controls	Int	502.10 ± 138	510.70 ± 165
	Controls	Non-Int	475.70 ± 106	450.40 ± 75
	Cricketers	Int	502.30 ± 74	519.50 ± 107
	Cricketers	Non-Int	543.20 ± 103	502.10 ± 138
Q ecc	Controls	Int	597.50 ± 106	607.90 ± 116
	Controls	Non-Int	619.60 ± 175	630.90 ± 190
	Cricketers	Int	546.10 ± 149	562.80 ± 80
	Cricketers	Non-Int	680.90 ± 122	682.30 ± 89
H con	Controls	Int	324.70 ± 53	322.60 ± 47
	Controls	Non-Int	333.70 ± 85	313.80 ± 61
	Cricketers	Int	343.20 ± 55	349.70 ± 52
	Cricketers	Non-Int	343.30 ± 62	340.30 ± 67
H ecc	Controls	Int	404.40 ± 84	377.90 ± 88
	Controls	Non-Int	425.10 ± 123	411.30 ± 126
	Cricketers	Int	386.10 ± 92	385.40 ± 120
	Cricketers	Non-Int	463.60 ± 120	443.80 ± 83

There was no statistically significant different in either extensor or flexor knee muscle strength between the dominant and non-dominant limbs for both concentric and eccentric testing. Wilcoxon matched pairs test exhibited no significant difference for any comparison between dominant and non-dominant legs (Q con; Q ecc; H con; H ecc), ($p < 0.05$).

4.2.2 Shoulder Data

Mean torque values for internal and external shoulder rotator muscles of the dominant and non-dominant arms are shown in the table below (Table 4.2B).

Table 4.2B: Details of Dominant and Non-dominant limbs

Shoulder Data (IR con; IR ecc; ER con; ER ecc) * $p < 0.05$

VARIABLE	GROUP	INTERVENTION/ NON-INTERVENTION	DOMINANT LIMB Nm ± S.D	NON-DOMININANT LIMB Nm ± S.D
IR con	Controls	Int	187.10 ± 47	181.00 ± 54
	Controls	Non-Int	197.30 ± 46	173.90 ± 53
	Cricketers	Int	198.90 ± 44	181.30 ± 52
	Cricketers	Non-Int	204.30 ± 42	190.70 ± 31
IR ecc	Controls	Int	225.40 ± 67	215.60 ± 103
	Controls	Non-Int	227.70 ± 58	206.50 ± 63
	Cricketers	Int	220.60 ± 52	199.20 ± 64
	Cricketers	Non-Int	233.20 ± 32	213.80 ± 44
ER con	Controls	Int	101.80 ± 29	109.00 ± 32
	Controls	Non-Int	104.70 ± 34	102.20 ± 32
	Cricketers	Int	99.00 ± 28	93.80 ± 43
	Cricketers	Non-Int	106.30 ± 21	100.70 ± 20
ER ecc	Controls	Int	117.60 ± 26	124.70 ± 20
	Controls	Non-Int	133.60 ± 39	122.40 ± 37
	Cricketers	Int	120.40 ± 33	113.60 ± 29
	Cricketers	Non-Int	132.60 ± 11	126.80 ± 19

There was no statistically significant difference in either internal rotator or external rotator muscle strength between the dominant and non-dominant arms for both concentric and eccentric testing.

Wilcoxon matched pairs test exhibited no significant difference for any comparison between dominant and non-dominant arms. (IR con; IR ecc; ER con; ER ecc), ($p < 0.05$).

4.3 DETAILS OF ABSOLUTE STRENGTH VALUES

4.3.1 Knee Data

A table of the Absolute strength values for the knee data are shown in the table below (Table 4.3A).

Table 4.3A: Details of Absolute Strength Values

Knee Data (Q con; Q ecc; H con; H ecc) * $p < 0.05$

VARIABLE	GROUP	INTERVENTION/ NON-INTERVENTION	TEST 1 (INCEPTION) Nm ± S.D	TEST 2 (6 WEEKS ISOKINETIC TRAINING) Nm ± S.D.	TEST 3 (12 WEEKS POST-TRAINING) Nm ± S.D.
Q con	Controls	Int	507.10 ± 132	566.00 ±117*	524.30 ± 104*
	Controls	Non-Int	464.40 ± 102	450.33 ± 129	462.20 ± 115
	Cricketers	Int	508.70 ± 68	586.20 ±109*	551.90 ± 91*
	Cricketers	Non-Int	527.30 ± 92	488.40 ± 53	487.40 ± 67
Q ecc	Controls	Int	597.50 ± 107	797.50 ±233*	708.90 ± 185*
	Controls	Non-Int	626.20 ± 169	614.20 ± 157	605.80 ± 134
	Cricketers	Int	548.90 ± 98	783.60 ±138*	746.00 ± 153*
	Cricketers	Non-Int	683.90 ± 107	655.20 ± 60	638.00 ± 63
H con	Controls	Int	324.70 ± 53	371.10 ± 47*	358.60 ± 55*
	Controls	Non-Int	325.80 ± 63	324.80 ± 81	336.70 ± 68
	Cricketers	Int	332.70 ± 53	371.00 ± 79*	362.60 ± 48*
	Cricketers	Non-Int	349.90 ± 67	362.00 ± 54	358.60 ± 55
H ecc	Controls	Int	404.40 ± 85	487.20 ± 85*	426.00 ± 95*
	Controls	Non-Int	422.00 ± 123	437.80 ± 167	422.00 ± 140
	Cricketers	Int	375.00 ± 98	495.50 ±138*	445.50 ± 121*
	Cricketers	Non-Int	477.80 ± 105	427.40 ± 76	421.10 ± 71

There were no significant differences for the Q con; Q ecc; H con; H ecc at inception (Test 1) for the various groups, controls with non-intervention (NI); controls with intervention (I); cricketers with non-intervention (NI) and cricketers with intervention (I).

Friedman test for repeated measures revealed that the absolute strength values (Q con; Q ecc; H con, H ecc) improved significantly in both training groups (intervention groups) after the 6week training period ($p < 0.05$).

A significant decrease was observed in both training groups between the test after the 6 week period and the final post-training test ($p < 0.05$).
The absolute strength values were not maintained when the training groups (intervention groups) did not perform isokinetic strength training between 6wk and 12wk.

4.3.2 Shoulder Data

A table of the absolute strength values for the shoulder data are shown in the table below (Table 4.3B).

Table 4.3B : Details of Absolute strength values

Shoulder Data (IR con; IR ecc; ER con; ER ecc) * P < 0.05

VARIABLE	GROUP	INTERVENTION/ NON-INTERVENTION	TEST 1 (INCEPTION) Nm ± S.D	TEST 2 (6 WEEKS ISOKINETIC TRAINING) Nm ± S.D.	TEST 3 (12 WEEKS POST-TRAINING) Nm ± S.D.
IR con	Controls	Int	188.70 ± 45	311.10 ± 32*	203.80 ± 55*
	Controls	Non-Int	191.70 ± 47	206.60 ± 52	202.50 ± 53
	Cricketers	Int	202.70 ± 45	230.90 ± 42*	211.20 ± 42*
	Cricketers	Non-Int	206.10 ± 40	211.50 ± 32	208.10 ± 24
IR ecc	Controls	Int	225.60 ± 67	265.40 ± 80*	233.70 ± 78*
	Controls	Non-Int	227.70 ± 589	232.60 ± 46	227.40 ± 38
	Cricketers	Int	219.10 ± 52	270.30 ± 44*	227.70 ± 38*
	Cricketers	Non-Int	236.60 ± 31	239.90 ± 41	236.50 ± 26
ER con	Controls	Int	103.10 ± 29	114.50 ± 27*	110.40 ± 31*
	Controls	Non-Int	105.50 ± 36	106.10 ± 37	108.60 ± 38
	Cricketers	Int	100.70 ± 28	124.70 ± 28*	114.80 ± 26*
	Cricketers	Non-Int	104.90 ± 22	102.90 ± 19	100.70 ± 22
ER ecc	Controls	Int	122.00 ± 22	135.90 ± 39*	125.60 ± 33*
	Controls	Non-Int	127.40 ± 41	134.30 ± 38	132.70 ± 36
	Cricketers	Int	116.20 ± 35	146.00 ± 39*	134.30 ± 54*
	Cricketers	Non-Int	130.70 ± 14	133.90 ± 24	132.80 ± 19

There were no significant differences for the IR con; IR ecc; ER con; ER ecc at inception (Test 1) for the various groups, controls with non-intervention (NI); controls with intervention (I); cricketers with non-intervention (NI) and cricketers with intervention (I).

Friedman test for repeated measures revealed that the absolute strength values (IR con; IR ecc; ER con; ER ecc) improved significantly in both training groups (intervention groups) after the 6 wk training period ($p < 0.05$).

A significant decrease was observed in both training groups between the test after the 6wk period and the final post-training test ($p < 0.05$).

The absolute strength values were not maintained when the training groups (intervention groups) did not perform isokinetic strength training between 6 wk and 12 wk.

4.4 DETAILS OF CONVENTIONAL H/Q RATIOS

A table of Conventional H/Q ratios are shown in the table below (Table 4.4).

Table 4.4: Details of Conventional H/Q ratios

(H/Q ratios) * p < 0.05

VARIABLE	GROUP	INTERVENTION/ NON-INTERVENTION	TEST 1 (INCEPTION) Nm ± S.D.	TEST 2 (6 WKS. ISOKINETIC TRAINING) Nm ± S.D.	TEST 3 (12 WKS. POST-TRAINING) Nm ± S.D.
H/Q ratio	Controls	Int	0.67 ± 0.14	0.67 ± 0.09	0.70 ± 0.12
	Controls	Non-Int	0.71 ± 0.10	0.74 ± 0.11	0.74 ± 0.09
	Cricketers	Int	0.65 ± 0.08	0.63 ± 0.10	0.67 ± 0.12
	Cricketers	Non-Int	0.66 ± 0.06	0.74 ± 0.06	0.75 ± 0.08*

The H/Q ratio ranged from 0.63 to 0.75. The H/Q ratio remained constant in the intervention and non-intervention control groups throughout the trial. The H/Q ratio remained constant in the intervention cricket group but there was a significant increase in the non-intervention cricket group (p<0.05).

Mann-Whitney test revealed a significant difference between H/Q ratios between the cricketers with non-intervention (NI) and cricketers with intervention (I) (p<0.05).

This would indicate that that nature of cricket results in differential development of agonist and antagonist muscle groups. The H/Q ratio in the final test for the non-intervention cricket group indicated moderate quadriceps weakness relative to hamstring strength according to the norms for the normal population. This imbalance could predispose cricketers to knee injuries, or could be interpreted as being the norm following cricket training.

The H/Q ratios were within normal limits for the intervention and non-intervention control groups and the intervention cricket group.

4.5 DETAILS OF FUNCTIONAL H ecc/Q con RATIOS

A table of the Functional H ecc/Q con ratios are shown in the table below (Table 4. 5).

Table 4. 5: Details of Functional H ecc/Q con Ratios

(H ecc/ Q con ratios) * $p<0.05$

VARIABLE	GROUP	INTERVENTION/ NON-INTERVENTION	TEST 1 (INCEPTION) Nm ± S.D.	TEST 2 (6 WKS. ISOKINETIC TRAINING) Nm ± S.D.	TEST 3 (12 WKS. POST-TRAINING) Nm ± S.D.
H ecc/Q con ratio	Controls	Int	0.79 ± 0.15	0.88 ± 0.17	0.81 ± 0.10
	Controls	Non-Int	0.91 ± 0.22	0.96 ± 0.16	0.92 ± 0.25
	Cricketers	Int	0.74 ± 0.17	0.85 ± 0.22	0.82 ± 0.24
	Cricketers	Non-Int	0.92 ± 0.17	0.88 ± 0.16	0.87 ± 0.13

The H ecc/Q con ratio ranged from 0.74 to 0.96. The ratios of the intervention control group and intervention cricket group at the inception test were poor functional ratios (0.79 ± 0.15 control grp; 0.74 ± 0.17 cricket grp); however when they performed the other post-training tests, they achieved good functional ratios which were maintained.

If these two groups had not undergone training to improve their functional ratios, they may have been predisposed to knee injuries, according to conventional teaching. The functional ratios for the non-intervention control group and non-intervention cricket group were within normal limits.

4.6 DETAILS OF CONVENTIONAL ER/IR RATIOS

A table of the Conventional ER/IR ratios are shown in the table below (Table 4. 6).

Table 4. 6: Details of Conventional ER/IR ratios

(ER/IR ratios) * p<0.05

VARIABLE	GROUP	INTERVENTION/ NON-INTERVENTION	TEST 1 (INCEPTION) Nm ± S.D.	TEST 2 (6 WKS. ISOKINETIC TRAINING) Nm ± S.D.	TEST 3 (12 WKS. POST-TRAINING) Nm ± S.D.
H/Q ratio	Controls	Int	0.55 ± 0.10	0.54 ± 0.05	0.53 ± 0.09
	Controls	Non-Int	0.55 ± 0.10	0.50 ± 0.08	0.53 ± 0.12
	Cricketers	Int	0.50 ± 0.09	0.55 ± 0.11	0.54 ± 0.06
	Cricketers	Non-Int	0.51 ± 0.07	0.49 ± 0.07	0.48 ± 0.09

The ER/IR ratios ranged from 0.48 to 0.55. The ER/IR ratios remained constant in the intervention and non-intervention control groups and the intervention and non-intervention cricket groups.

The conventional ratios indicated moderate to severe external rotator weakness relative to internal rotator strength for both groups according to norms for the normal population. This imbalance could predispose cricketers to shoulder injuries.

4.7 DETAILS OF FUNCTIONAL ER ecc/IR con RATIOS

A table of the Functional ER ecc/IR con ratios is shown in the table below (Table 4.7).

Table 4. 7: Details of Functional ER ecc/IR con ratios

(ER ecc/IR con) * $p<0.05$

VARIABLE	GROUP	INTERVENTION/ NON-INTERVENTION	TEST 1 (INCEPTION) Nm ± S.D.	TEST 2 (6 WKS. ISOKINETIC TRAINING) Nm ± S.D.	TEST 3 (12 WKS. POST-TRAINING) Nm ± S.D.
ER ecc/IR con ratio	Controls	Int	0.67 ± 0.14	0.64 ± 0.09	0.62 ± 0.09
	Controls	Non-Int	0.66 ± 0.13	0.65 ± 0.07	0.66 ± 0.08
	Cricketers	Int	0.58 ± 0.13	0.63 ± 0.11	0.64 ± 0.24
	Cricketers	Non-Int	0.65 ± 0.10	0.64 ± 0.10	0.64 ± 0.11

The ER ecc/IR con ratios ranged from 0.58 to 0.66. The ER ecc/IR con ratios remained constant in the intervention and non-intervention control groups and the intervention and non-intervention cricket groups.

These functional ER ecc/IR con ratios are poor functional ratios for both groups. The shoulder's external rotators' eccentric contraction is essential during deceleration of shoulder rotation and a poor functional ratio could predispose cricketers to shoulder injuries.

CHAPTER FIVE

DISCUSSION AND CONCLUSION

This study compares concentric and eccentric knee and shoulder muscle strength between agonist and antagonist muscles groups.

In this study we have tried to set the groundwork on the relationship of muscle strength ratios to injury in professional cricketers and for the national gathering of ratios that will be sport specific.

Dominant and Non-dominant limbs

The extensor and flexor knee muscles showed no significant differences in mean torque between dominant and non-dominant legs of cricketers for either concentric or eccentric contractions.

This coincides with findings by Gilliam et al (1979) and Holmes and Alderink (1984). However, a number of studies have demonstrated significant differences between dominant and non-dominant limbs, Goslin and Chateris (1979) and Wyatt and Edwards (1981). These discrepancies may result from the definition of dominance by various authors. Some researchers define it as the leg preferred for kicking, others describe it as the stronger limb, and some do not specify how dominance was determined.

Holmes and Alderink (1984) suggest that consistent definitions of dominance should be established to make future research findings meaningful.

Internal rotator muscles showed no significant difference in mean torque between dominant and non-dominant shoulders of cricketers for either concentric or eccentric contractions.

This coincides with findings by Sirota et al (1997), Alderink and Kuck (1986) and Wilk et al (1993) who also found no significant differences in concentric internal rotational torques in pitchers.

External rotator muscles showed no significant differences in mean torque between dominant and non-dominant shoulders of cricketers for either concentric or eccentric contractions.

This coincides with findings by Sirota et al (1997),Alderink and Kuck (1986) and Hinton (1988) who also found no significant differences in concentric peak torque values between dominant and non-dominant shoulders for external rotator muscles in their studies of pitchers. However , Wilk et al (1993) found a trend toward increased strength in the non-dominant shoulders of professional baseball pitchers.

This similarity of strength between dominant (throwing) and non-dominant (non-throwing) shoulder is somewhat surprising, although consistent with literature.

Absolute strength values

The absolute strength values for the extensor and flexor knee muscles (Q con; Q ecc; H con; H ecc) improved significantly in both training groups (intervention groups) after the 6 wk training period.

The concentric contraction of the extensor (quadricep) muscles showed a 12% increase in the control group and a 15 % increase in the cricket group.

The eccentric contraction of the extensor (quadricep) muscles showed a 33% increase in the control group and a 43% increase in the cricket group.

The concentric contraction of the flexor (hamstring) muscles showed a 14% increase in the control group and 12% increase in the cricket group.

The eccentric contraction of the flexor (hamstring) muscles showed a 20% increase in the control group and 32% increase in the cricket group.

The absolute strength values for the internal and external rotator muscles (IR con; IR ecc; ER con; ER ecc) improved significantly in both training groups (intervention groups) after the 6 wk training period.

The concentric contraction of their internal rotator muscles showed a 65% increase in the control group and 14% increase in the cricket group.

The eccentric contraction of the external rotator muscles showed an 18% increase in the control group and 23% increase in the cricket group.

The concentric contraction of the external rotator muscles showed an 11 % increase in the control group and 24% increase in the cricket group.

The eccentric contraction of the external rotator muscles showed an 11% increase in the control group and a 26% increase in the cricket group.

Isokinetic training for 6 wks produced significant increases in peak concentric and eccentric torque measurements for the knee extensor and flexor muscles and shoulder internal and external rotator muscles.

A significant decrease was observed in both training groups (intervention groups) between the test after the 6 wk training period and the final post-training test. The strength gains were not maintained when the training groups did not perform isokinetic strength training between 6 wk and 12 wk.

Our data suggest that isokinetic strengthening regimens of 6 weeks will produce significant gains in muscular strength.

Conventional H/Q ratios

The H/Q ratios ranged from 0.67   0.70 for controls with intervention and 0.71   0.74 for controls with non-intervention.

The H/Q ratios ranged from 0.63 0.66 for cricketers with intervention and 0.66 0.75 for cricketers with non-intervention.

These ratios coincide with other findings (Prentice, 1994, Scudder, 1980, Wyatt and Edwards, 1981, Holmes and Alderink, 1984).

However, numerous studies reveal different hamstring to quadricep ratios. The differences in the literature regarding H/Q ratios may be attributed to investigators testing at different velocities.

Coplin (1971) and Kellis and Baltzopoulos (1995) suggest that a ratio of 0.60 is needed to maintain a normal balance around the knee.

The H/Q ratio remained constant in the intervention and non-intervention control groups and the intervention cricket groups throughout the trial. However, there was a significant increase in the non-intervention cricket group (0.66 0.75). This would indicated that the nature of cricket results in differential development of agonist and antagonist muscle groups, with a ratio of approximately 0.75.

With reference to athletes; there is other data that suggest sport-specific ratios may exist. Hockey players exhibited a ratio of 0.85 at 180 deg/sec (Smith et al, 1981) and professional football players had a ratio of approximately 0.77 at 180 deg/sec (Davies et al, 1981). A study of elite track and field athletes (Coetzee et al, 1992) at 30 deg/sec found ratios of 0.60 for jumpers and sprinters, 0.61 for throwers, 0.62 for middle distance runners and 0.59 for long distance runners.

Future isokinetic research should be conducted using consistent testing velocity protocols and large sample sizes of athletes so meaningful comparisons can be made between groups.

<u>Functional H ecc/Q con ratios</u>

A functional H/Q strength ratio was calculated by expressing eccentric hamstring muscle strength relative to concentric quadriceps muscle strength (H ecc/Q con).

The H ecc/Q con ratios ranged from 0.79 0.88 for controls with intervention and 0.91 0.96 for controls with non-intervention. The H ecc/Q con ratios ranged from 0.74 – 0.85 for cricketers with intervention and 0.87 0.92 for cricketers with non-intervention.

To date there is minimal published normative data for functional ratios. Comparison with other studies is difficult because of the limited studies on functional ratios and the different testing velocities and isokinetic testing systems.

Our data coincides with finding by Aagaard et al (1998) who had H ecc/Q con ratios for slow knee extension (30 deg/sec) of 0.60; 0.80 and 1.00 based on 50°; 40° and 30° moments. Preliminary evidence suggests that the expected functional H ecc/Q con ratio should be 0.80 1.00 (Aagaard et al, 1998).

The ratios of the intervention control group and intervention cricket group at the inception test were poor functional ratios (0.79 ± 0.15 control grp. 0.74 ± 0.16 cricket grp); however when they performed the isokinetic training, they achieved good functional ratios, which were maintained. If these two groups had not undergone training to improve their functional ratios, they may have been predisposed to knee injuries, according to conventional teaching.

Further studies are needed to demonstrate if there is a clear relationship between poor functional ratios for knee extension and muscle injury.

<u>Conventional ER/IR ratios</u>

The ER/IR ratios ranged from 0.53 0.55 for controls with intervention and 0.50 0.55 for controls with non-intervention. The ER/IR ratios ranged from 0.50 0.55 for cricketers with intervention and 0.48 0.51 for cricketers with non-intervention.

Our ER/IR ratios were lower than those found for previous studies for the same testing velocity (Ivey, 1985, Davies, 1992, Sirota et al, 1997). Our results may be different from those of previous studies because of the differences in isokinetic testing equipment. Wilk et al (1987) demonstrated significant differences between various isokinetic testing systems. The differences in testing methods is another factor that may account for differences. Many studies reported on concentric testing only, our study involved alternating concentric and eccentric repetitions for each muscle group and therefore may yield different results.

The lower ER/IR ratios indicated a relative decrease in external rotator strength compared with internal rotator strength. This ratio identifies the selective concentric strength development of the internal rotators in throwing athletes without concomitant increase in the external rotators.

The conventional ratios indicate moderate to severe external rotator weakness relative to internal rotator strength for both groups according to the norms for the normal population.

A sport injury questionnaire (Appendix D) which was given to the cricketers during the season, revealed that 40% of the cricketers with non-intervention experienced shoulder injuries. The imbalance of the external rotator weakness relative to the internal rotator strength could predispose cricketers to injury.

Research evaluating the ER/IR ratio is required to identify the critical value where the throwing athlete is clearly at risk of injury.

<u>Functional ER ecc/IR con ratios</u>

A functional ER/IR strength ratio was calculated by expressing eccentric external rotator muscle strength relative to concentric internal rotator muscle strength (ER ecc/IR con).

The ER ecc/IR con ratios ranged from 0.62 0.67 for controls with intervention and 0.65 0.66 for controls with non-intervention. The ER ecc/IR con ratios ranged from 0.58 0.64 for cricketers with intervention and 0.64 0.65 for cricketers with non-intervention.

Comparison with other studies is difficult because of the limited studies on functional ratios.

The functional ER ecc/IR con ratios are poor functional ratios for the intervention and non-intervention control and cricket groups.

The shoulder's external rotator eccentric contraction is essential during deceleration of shoulder rotation and a poor functional ratio could therefore predispose cricketers to shoulder injuries. A sport injury questionnaire, which was given to the cricketers during the season, revealed that 40% of the cricketers with non-intervention experienced shoulder injuries. Further studies are needed to determine the role of eccentric shoulder testing in the prevention and rehabilitation of shoulder injuries.

CONCLUSION

In summary, these data suggest that:

(i) There is no significant difference between dominant and non-dominant extremities of the extensor and flexor knee muscles and internal and external shoulder rotator muscles in professional cricketers.

(ii) There is a significant difference between the intervention and non-intervention trials in both groups.

(iii) Isokinetic training for 6 wks will produce significant increases in peak concentric and eccentric torque measurements.

(iv) The knee extensor to flexor strength relationship put forward for the normal population is significantly different from provincial cricketers.

(v) The shoulder internal rotator to external rotator strength relationship indicated moderate to severe external rotator weakness relative to internal rotator strength for both groups, this imbalance could predispose cricketers to shoulder injuries.

Future isokinetic research should be conducted using consistent testing velocity protocols; isokinetic testing equipment and testing procedures so that meaningful comparisons can be made between different groups.

Research evaluating the conventional and functional ratios is required to identify if there are critical values where the athlete is clearly at risk of injury and for the national gathering of ratios that will be sport specific.

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APPENDICES

PAGE

APPENDIX A : SUBJECT'S PERSONAL DETAILS

PHYSIOLOGY DEPARTMENT

UNIVERSITY OF NATAL MEDICAL SCHOOL

The determination of unilateral ratios, (knee and shoulder muscle strength), of Provincial Cricketers.

Personal Details

Name : ______________________________

Contact Address : ______________________________

____

____

____

Contact Tel No's : ______________________________

____

Age : ______________________________

Date of Birth : (Day/Month/Year)

Height : ______________m

Body Mass : _kg

Body Composition : Triceps______________ Calf______________

Suprailiac______________ Abdomen

Thigh______________ Subscapularis __ __ __

Sum of skinfolds ________

% Body Fat _

APPENDIX B : INFORMED CONSENT

PHYSIOLOGY DEPARTMENT

UNIVERSITY OF NATAL MEDICAL SCHOOL

TITLE OF PROJECT:

The determination of unilateral ratios (knee and shoulder muscle strength), of provincial cricketers.

EXPLANATION OF TESTS

You will be tested isokinetically on the Kin-com. You will perform three isokinetic tests and some subjects will be randomly selected for 6wks of isokinetic training.

The test will involve repeated bouts of extending and flexing both the right and left leg to determine the strength of the quadriceps and hamstrings.

The test will involve repeated bouts of internally rotating and externally rotating both the right and left shoulder to determine the strength of the internal rotators and external rotators. You will be tested eccentrically and concentrically at a pre-test velocity of 60 degrees per second.

You will be unable to perform the exercise tests if you have severe pain at joints, extreme limited range of motion, severe swelling unstable joint, acute sprain or strain.

RISKS AND DISCOMFORTS

Muscle soreness is unlikely as the resistance is accommodating throughout the range of motion. You may experience muscle soreness 24-48 hours after testing when tested eccentrically. If muscle soreness occurs, appropriate stretching exercises to relieve this soreness will be demonstrated.

EXPECTED BENEFITS FROM TESTING

Your knee extensor to flexor strength relationship, and shoulder internal rotator to external rotator strength relationship will be determined.

An awareness of the correct sport specific strength ratios would help Biokineticists tailor strength training programmes to give the relevant muscle groups sufficient strength to cope with the activities they would be involved in. This would also help reduce the likelihood of injury and also improve performance.

INQUIRIES

Questions about the procedures used in isokinetic testing are encouraged. If you have any questions or need additional information, please ask us to explain further.

FREEDOM OF CONSENT

Your permission to perform these tests is strictly voluntary. You are free to deny consent if you so desire.

I have read this form carefully and I fully understand the test procedures. I consent to participate in these tests.

________________________ SIGNATURE __________________________DATE

APPENDIX C : ISOKINETIC TEST RESULTS

PHYSIOLOGY DEPARTMENT

UNIVERSITY OF NATAL MEDICAL SCHOOL

The determination of unilateral ratios (knee and shoulder muscle strength), of provincial cricketers.

	Test 1 (Inception) nm		Test 2 (6 wks) nm		Test 3 (12 wks) nm	
	Dom Limb	Non- Dom Limb	Dom Limb	Non- Dom Limb	Dom Limb	Non- Dom Limb
Knee Data						
Q con						
Q ecc						
H con						
H ecc						
H/Q ratio						
H ecc/ Q con ratio						
Shoulder Data						
IR con						
IR ecc						
ER con						
ER ecc						
ER/ IR ratio						
ER ecc/ IR con ratio						

APPENDIX D: SPORT INJURY QUESTIONNAIRE

PHYSIOLOGY DEPARTMENT

UNIVERSITY OF NATAL MEDICAL SCHOOL

The determination of unilateral ratios (knee and shoulder muscle strength), of Provincial Cricketers

DATE : ______________________

NAME: ____

SPORTING HISTORY: __ __________ ___________________________

____

____

MEDICATION : ____

PHYSICIAN : _________________ ________TEL NO:________________

USE OF PROTECTIVE EQUIPMENT:
1. MOUTHGUARD __ __
2. ANKLE TAPE/BRACE ______________
3. HELMET _______________ _____
4. OTHER BRACE/SUPPORT _________

MUSCULOSKELETAL SYMPTOMS	RIGHT	LEFT
NECK	______	______
SHOULDER	______	______
ELBOW	______	______
WRIST	______	______
HAND	______	______
CHEST AND THORAX	______	______
LOW BACK	______	______
BUTTOCKS	______	______
GROIN/ HIP	______	______
THIGH	______	______
KNEE	______	______
SHIN/ CALF	______	______
ANKLE	______	______

DETAILS: ____

____

____

Has pain gotten: ____ Better __ Worse ____ Stayed the same

Type of pain : ______Dull __ Ache ______ Burning ______Sharp _ Shooting

When does pain occur? _ After training _ Middle of training ____ As soon as start

___ Daily activities _ All the time

Is pain: _ Consistent ____ Irregular

How long does pain last? ____ ______ __ ______ ____ ___________

What has made pain worse? __ ________________ ____________________

What have you tried to help pain? ____ __ ________________ _____

What effect does injury have on your workouts? ____ ______ ______ ____

Have you had any other injuries? ______ ____ ______ __ __________ __

Do you stretch regularly? ______ __ ________ ____ __________ ____

Running gait: ______ __ __ ____ ______ __ __ ______ ___

Walking gait: __ ________ ____ ____ __________ __ ____ ___

Shoes: ____

Orthotics: ____

Preferred dominant side:

Hand/ Arm	Right/ Left
Foot/ Leg	Right/ Left