CHAPTER 5: RESEARCH METHOD

5.1 INTRODUCTION

Although a wide variety of possible and viable isokinetic test protocols exist, the author attempted to utilize well-recognized protocols that are accepted by various other researchers. The protocol included essential components like warm-up, rest periods, test velocity, number of repetitions, encouragement, visual feedback and precise positioning of the subject, as described by Perrin (1993) in his authoritive work ***"Isokinetic Exercise and Assessment"***. All the testing took place from 08h00 to 13h00 and the same sequence was followed in order to keep the tests reliable and to allow the present researcher to compare the results from day to day.

5.2 APPARATUS

The following apparatus was used:

- skinfold calliper (Harpenden John Bull, British Indicators Ltd., England);
- non-stretch anthropometrical measuring tape;
- spreading calliper;
- medical scale (Richter Scale KA-10, Kubota Company, Japan);
- stadiometer; and

- Cybex 340 isokinetic dynamometer (Cybex, Division of Lumex, Inc., 2100 Smithtown Avenue, Ronkonkoma, New York).

5.3 SUBJECTS

Four hundred and forty three (n=444) South African males, between the ages of 16 and 29 years, were used as subjects. These subjects volunteered for the project as they were in a selection process of applying to become pilots in the South African Air Force (SAAF). These individuals were mostly civilians and thus not under any obligation to conduct tests against their will.

The following pre-selection criteria was used:

- passed higher grade Mathematics in standard 9 (grade 11);
- between 165 cm and 195 cm;
- between 55 kg and 100 kg;
- excellent physical health; and
- uncorrected vision.

5.4 MEDICAL SCREENING AND INFORMED CONSENT

Before the isokinetic testing took place, a medical doctor examined all the subjects to exclude any subjects with orthopaedic injuries and/or other serious medical conditions (for example, diabetes mellitus or hypertension). Before the body composition analysis and isokinetic testing, each subject was again briefed on the testing procedure and made aware of the physical exertion required for the testing. Only subjects without any medical conditions and those who completed an informed consent participated in the study.

5.5 COLLECTION OF ANTHROPOMETRICAL DATA

Personal and anthropometrical data, including age, dominance, body mass, height, skinfolds, bone widths, and limb circumferences were obtained before the isokinetic testing commenced.

Body mass was determined to the nearest 100 grams. Subjects were all dressed in running shorts without shoes. Height/stature was determined to the nearest 5 millimetres.

The skinfold thickness of the triceps, subscapula, supraspinale, abdominale, thigh, and medial calf were determined according to the method of Carter (1982). All anthropometrical measurements were performed prior to any exercise. The "MOGAP" skinfold method was used to calculate percentage body fat of each subject (Carter, 1982).

Bone widths were determined to the nearest millimetre and circumferences of the tensed upper arm and relaxed calf muscle, were determined to the nearest millimetre. The "Heath-Carter" method was used to calculate the somatotype of each subject (Carter, 1982).

All anthropometrical measurements were taken on the subject's right side apart from the abdominal skinfold, which was taken 5 centimetres left of the umbilicus. However, the limb circumferences and bone widths were taken on the subject's dominant side (Carter, 1982).

5.6 WARM-UP PROCEDURE

Some researchers (Johnson & Siegel, 1978) found that three sub-maximal and three maximal isokinetic warm-up repetitions were necessary to obtain reliable and stable knee extension torque values. Kues *et al.* (1992) even advocated one or two days of familiarization training to enhance the reliability of isokinetic testing. However, the author's clinical experience over 10 years indicated that four to five progressive repetitions were adequate to familiarize young adult male subjects with isokinetic testing. The imposed time restraints and limited access to the test subjects precluded any familiarization days.

The isokinetic testing procedure was further preceded by a general warm-up that consisted of light jogging for five minutes and static stretching. Before each movement pattern, four (4) familiarization contractions were performed as part of the specific warm-up. The first two warm-up repetitions were performed at a perceived 50% of maximum, the next repetition at 75% and the last repetition at 100% of perceived maximum. Krüger (1992) utilized five sub-maximal repetitions and one maximal repetition for familiarization purposes.

5.7 ISOKINETIC TESTING PROTOCOL

Each subject was positioned and stabilized according to the Cybex User Manual (Cybex, A division of Lumex, Inc., 2100 Smithtown Avenue, Ronkonkoma, New York). A damping value of two (2) was used during all the tests and the Cybex was calibrated after every fourth session of testing. After the warm-up/familiarization, five maximum efforts were performed on each subject's non-dominant side, using the Cybex 340 isokinetic dynamometer. Perrin (1993) recommended using three to four test repetitions when evaluating maximum torque. The author selected to evaluate the non-dominant side of each subject for the following reasons:

Time constraints prevented bilateral testing of the seven different movement patterns on one single day (an average of 12 to 15 subjects had to be evaluated per day according to the predetermined schedule of the SAAF). Also, although

Cahalan *et al.* (1991) found a significant difference during shoulder flexion (at 180°/s and 300°/s) and shoulder internal rotation (at 0°/s, 180°/s and 300°/s) between the torque values of the dominant and non-dominant side for men, Ivey *et al.* (1985) found no significant difference for shoulder torque values at 60°/s and 180°/s. Simoneau (1990) also reported no significant differences between the dominant and non-dominant limb for the ankle's evertors and invertors. Hall & Roofner (1991) reported a high correlation between the left and the right leg when considering knee flexion and extension values between 60°/s and 500°/s. Since the author utilized **slow testing velocities** (30°/s or 60°/s), it was decided to test the non-dominant limb only. Although the expected difference between the dominant and non-dominant side is approximately 5% for the lower limbs when conducting "slow" isokinetic testing, larger differences could be expected in the upper limbs, or when testing at higher velocities (User's Guide: Norm testing and rehabilitation system, 1996).

In developing possible norms for subjects in this specific age group, the author thought it wise to evaluate the "weaker" of the two sides in order for the norms to be realistic for both sides of the body, especially in individuals recovering from injury. It may however be an option to add 5% to 10% to the eventual norms of the author when considering a possible norm for a subject's dominant side (Perrin, 1993). However, according to Constain & Williams (1984) and Lucca & Kline (1989), there was no significant difference between knee peak torque values of the dominant and non-dominant limb in their subjects. Lucca & Kline (1989) reported an average difference between the left and right knee torque of approximately 3% in their study of 54 student subjects (19 males & 35 females); they also reported no significant relationship between hand preference and foot preference.

Some researchers advise against **verbal encouragement** during the isokinetic test (Perrin, 1993), while others allowed for a standardized encouragement routine (Figoni & Morris, 1984; Krüger *et al.*, 1992). Due to the fact that the present study utilized a group-testing format, and because of spontaneous peer encouragement, the author had to use verbal cues to ensure that each repetition was performed correctly. However, it was impractical to utilize a set verbal routine during encouragement and coaching cues, since some subjects were not able to grasp what was expected of them following the first explanation given.

Subjects in the present study were permitted to receive **visual feedback** of their efforts. It is thought to improve maximum voluntary contraction, especially at slow isokinetic velocities (Baltzopoulos *et al.*, 1991). Increases as great as 12% at 15°/s have been reported by Figoni and Morris (1984) as a result of visual feedback during isokinetic testing. The effect of feedback on high speed isokinetics is still unclear. Figoni and Morris (1984) and Baltzopoulos *et al.* (1991) reported no beneficial effect at 180°/s and 300°/s, respectively, while greater peak torque values were reported at 180°/s by Hald & Bottjen (1987).

Each subject was allowed to **rest** for at least five minutes between the testing of the different movement patterns, which is five times longer than the 60-second guideline set by Perrin (1993). Thus it was postulated that more than adequate recovery time was given to each subject between consecutive testing efforts. Since the ATP-PC stores are thought to be replenished within two to four minutes following intense muscle contractions (Houglum, 2001), this rest period should have been adequate to enable subjects to achieve their maximum torque values for each movement pattern tested. According to Sinacore *et al.* (1994), it takes approximately four minutes for a muscle to recover to 90% to 95% of its initial torque levels following an **exercise bout to fatigue**. However, the biggest recovery takes place in the first 30 seconds to 90 seconds. After 90 seconds the rate of recovery declines slightly. After four minutes another rate change takes place and recovery is very gradual; full recovery may take more than 40 minutes (Houglum, 2001).

If any subject expressed the view that he was not able to achieve his maximum effort, due to unfamiliarity with the testing protocol for instance, the subject was allowed to rest for five minutes, before resuming the test. If subjects experienced discomfort during any of the tests, or if they decided not to complete the testing session, they were excused and excluded from the experiment.

An angular velocity of 60°/s was used for all the movement patterns of the shoulder, elbow, and knee joint, but a velocity of 30°/s was used for testing the ankle and forearm joint.

5.7.1 Shoulder flexion and extension

Subjects were positioned supine on the upper body exercise bench (UBX), perpendicular to the dynamometer head. The grip was positioned in 90° of forearm pronation and the elbow had to be straight. The subject's feet were positioned on the footrest in such a way that the knees formed an angle of approximately 90°. The hips were in approximately 45° of hip flexion. Each subject was stabilized by a Velcro strap, which was positioned over the pelvis (just above the anterior superior iliac spines), and over the chest (just below the nipple line). The subject was allowed to grip the contra-lateral handgrip, provided with the UBX, but were not allowed to lift the head, back, pelvis or feet from the UBX (Perrin, 1993).

The dynamometer's axis of rotation corresponded with the axis of rotation of the gleno-humeral joint of the subject. The ROM was preset to range from 0° of shoulder flexion to 180° of shoulder flexion. Any further movement was eliminated, by using mechanical ROM stops. Thus the total ROM was 180°.

Each subject completed five reciprocal maximum repetitions at an angular velocity of 60°/s, after the five warm-up repetitions (see 5.5).

5.7.2 Shoulder horizontal abduction and adduction

The supine position was utilized on the UBX, with the subject positioned parallel to the dynamometer's axis of rotation. The grip position utilized was 90° of forearm pronation, and the elbow was in 0° of elbow flexion. The subject's feet were positioned on the footrest in such a way that the knees formed an angle of approximately 90°. The hips were in approximately 45° of hip flexion. Each subject was stabilized by a Velcro strap, which was positioned over the pelvis (just above the anterior superior iliac spines), and over the chest (just below the nipple line). The subject was allowed to grip the contra-lateral handgrip, provided with the UBX, but were not allowed to lift the head, back, pelvis or feet from the UBX (Perrin, 1993).

The dynamometer's axis of rotation corresponded with the subject's glenohumeral axis of rotation. ROM ranged from full horizontal adduction (45° on average), through anatomical zero, to 90° of shoulder horizontal abduction. Thus the average total ROM was approximately 135°. No mechanical ROM stop was used for horizontal adduction, but a mechanical ROM stop was positioned at the 90°-position of horizontal abduction.

A testing velocity of 60°/s was used, and each subject completed five maximum repetitions, after five warm-up repetitions.

5.7.3 Shoulder internal- and external rotation

The subject assumed a supine position on the UBX, perpendicular to the axis of rotation of the dynamometer head. The tested limb was positioned in 90° of elbow flexion and 90° of shoulder abduction. The handgrip position was in anatomical zero (0° of forearm pronation/full supination). The subject's feet were positioned on the footrest in such a way that the knees formed a 90° angle and the hips were in approximately 45° of hip flexion. Each subject was stabilized by a Velcro strap, which was positioned over the pelvis (just above the anterior superior iliac spines), and over the chest (just below the nipple line). The subject was allowed to grip the contra-lateral handgrip, provided with the UBX, but were not allowed to lift the head, back, pelvis or feet from the UBX (Perrin, 1993).

The dynamometer's axis of rotation corresponded with the subject's longitudinal axis through the humerus. ROM was from 90° of shoulder external rotation, through anatomical zero, to approximately 70° of shoulder internal rotation. Thus the total ROM was approximately 160°.

After a 5-repetition warm-up, five reciprocal maximum repetitions were performed in immediate succession, at an angular velocity of 60°/s.

5.7.4 Elbow flexion and extension

The subject was positioned supine on the UBX at an angle of approximately 45° with the dynamometer head, so that the subject's head was closer to the dynamometer than his feet. The tested limb was positioned in approximately 45° of shoulder abduction. The subject's feet were positioned on the footrest in such a way that the knees formed an angle of approximately 90° and the hips were in approximately 45° of hip flexion. Each subject was stabilized by a Velcro strap, which was positioned over the pelvis region (just above the anterior superior iliac spines), and over the chest (just below the nipple line). The subject was allowed to grip the contra-lateral handgrip, provided with the UBX, but was not allowed to lift the head, back, pelvis or feet from the UBX (Perrin, 1993).

The dynamometer's axis of rotation corresponded with the longitudinal axis through the humerus of the subject. The ROM utilized, ranged from full extension to the position of maximal flexion, with total ROM of approximately 165° on average.

Following five repetitions of warming up, five maximum repetitions were performed in immediate succession, at an angular velocity of 60°/s.

Two handgrip positions were utilized, and therefore **two sets of data** were collected:

- with the first handgrip position, the forearm was in the **anatomical zero position (AZ)**; and
- with the second handgrip position, the forearm was in **90° of pronation**.

5.7.5 Forearm pronation and supination

The subject was seated on the UBX, facing the dynamometer. The forearm rested in the stabilization device and was fastened with a Velcro strap, to limit unwanted movements of the upper extremity. The elbow was held in 90° of elbow flexion. The subject was not allowed to use his upper body or to lift his buttocks off the UBX during the test (Perrin, 1993).

The dynamometer's axis of rotation corresponded with the subject's longitudinal axis through the forearm. The ROM utilized, ranged from full supination to full pronation (thus the average ROM was approximately 135°). No mechanical ROM stops were utilized.

Isokinetic testing (five consecutive repetitions) took place at an angular velocity of 30°/s, following five repetitions of warming up.

5.7.6 Knee flexion and extension

Although Krüger *et al.* (1992) utilized a hip flexion angle of 90° the results of other researchers (Selkowitz, 1985; Ferguson *et al.*, 1989; Snyder-Mackler, 1989) prompted the author to use a hip flexion angle of 70°. The subject was seated with the hip joint in 70° of flexion and the torso of each subject was stabilized with the seatbelt provided. The upper thigh of the test limb was stabilized with a Velcro strap, which was fastened just proximal to the superior border of the patella. Since Patteson *et al.* (1984) found no significant difference in knee torque values between stabilized or non-stabilized contra-lateral limbs at 60°/s and 180°/s, the contra-lateral limb of each subject was stabilized at approximately 90° of knee flexion with the standard stop provided. The dynamometer's axis of rotation corresponded with the subject's lateral epicondyle (Perrin, 1993). Subjects were not allowed to hold onto the grips provided by the manufacturers of the Cybex 340, but were instructed to grasp the shoulder strap during testing. This was done to ensure isolation of the thigh musculature and to avoid accessory movements. Kramer (1990) reported no significant difference between grasping the test table and grasping the pelvic strap when testing the knee's flexion and extension torques.

No mechanical ROM stops were used and the ROM ranged from full possible flexion (approximately 100° to 110° of knee flexion) to full knee extension (0° of knee flexion). The ROM was thus approximately 100°.

Krüger (1992) utilized a 60-second rest period between familiarization and testing. In the present study, the five maximal repetitions were performed at an angular velocity of 60°/s, directly following the 5-repetition warm-up. The author's warm-up routine did not lead to muscular fatigue, and therefore no rest period was used following the warm-up.

5.7.7 Ankle plantar- and dorsiflexion

The subject was positioned prone on the Cybex, which was positioned flat (with the backrest in 0° of hip flexion). The subject was prone with the hip and knee joints in 0° of flexion. The dynamometer's axis of rotation was aligned with the medial maleoli of the subject. In each case, the lower leg of the subject was stabilized using a Velcro strap. The strap was positioned approximately 10 cm to 15 cm proximal to the malleoli (Perrin, 1993).

No ROM stops were used and ROM ranged from full dorsiflexion to full plantar flexion (with an average ROM of approximately 50° to 70°).

After a five repetition warm-up, isokinetic testing took place with five maximal repetitions at an angular velocity of 30°/s.

5.8 INTERPRETATION OF ISOKINETIC DATA

The peak torque of each subject was determined and expressed in Newton metres (Nm), and relative to body mass (% BM). Each agonist/antagonist ratio was also calculated and expressed as a percentage (%). Bandy & Timm (1992) found significant correlation coefficients between peak torque and both work and power of the knee flexors and extensors, in their study of 77 subjects, and thus the present study only focussed on peak torque values.

None of the results were corrected for the effect of **gravity**. This was done for the following reasons: Firstly, the author had to test large groups of subjects within a specified **timeframe**, and correcting for gravity for five joints per subject, would have taken too much time (between 10 and 20 subjects had to be tested within five hours). Secondly, the author hypothesized that **errors** made during the process of correcting for gravity, could pollute the data and subsequent calculations/interpretations. The author thus viewed the testing of raw, gravitation-uncorrected torque values as a more accurate test, when faced with a large group of subjects, and when utilizing different test personnel (more than one biokineticist).

5.9 STATISTICAL ANALYSIS

The group average, minimum, maximum, standard deviation, and normal distribution tests were calculated for each movement pattern. Percentile tables were also constructed to serve as normative values for biokinetic rehabilitation and sport science testing. It was decided to focus on the relative torque values rather than the absolute ones, to improve comparisons between individuals with differing body mass values. Every fifth percentile, the mean, median, and mode was presented in the respective normative tables.