ISO-INERTIAL MEASUREMENT OF MUSCULAR STRENGTH: AN ASSESSMENT ALTERNATIVE

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INTRODUCTION

Success in many sporting activities is dependent on strength and power. Sport scientists, coaches and athletes need reliable and valid tests to monitor changes in strength and power in order to maximise performance. These tests need to be simple, nonexhaustive and quick, without contributing to the potential for overtraining (Garhammer, 1993).

Isokinetic testing remains one of the more popular methods of strength assessment, both for the clinician and researcher, yet it may not be an appropriate method of assessment. When one considers that the assessment typically occurs in non-weight bearing, open-kinetic-chain positions, as opposed to the more functional closed-kinetic-chain position common to most everyday activities (Perrin, 1993). Isokinetic assessment is also normally confined to isolated muscle groups moving limbs through the cardinal planes of movement (Perrin, 1993), and is not suitable for assessing the multijoint movements which are common to many sports (Sale, 1991). The fixed velocity of movement utilised during isokinetic testing is also not characteristic of most land-based sporting activities, and the test velocity is often well below that of functional sporting movements. Angular velocity at the knee joint may exceed 800°/s during a vertical jump movement (Gregoire et al., 1984), whereas only one of the commercially available dynamometers allows testing at an angular velocity greater than 500°/s (Sale, 1991). Another major disadvantage of isokinetic testing is the high cost of the equipment (Davies, 1987).

Murphy et al. (1994) use the term iso-inertial to reflect the fact that the assessment involves a constant mass, which more closely approximates normal human movement. It would appear that the term iso-inertial more accurately reflects the type of testing apparatus that is often referred to as isotonic. This paper presents a low cost and simple iso-inertial device which can be used to determine a wide range of valuable strength and power measures.

METHODOLOGY

A simple apparatus has been designed in order to determine strength and power of the knee extensor/hip extensor complex during a leg press movement in either a supine or seated position. The force is measured using a force plate under the feet. The movement of the seat is measured by a DC generator which acts as a velocity transducer. A data logging system samples both transducers 1000 times a second and saves the data for further processing. The force plate and generator have been calibrated using criterion measures of force and velocity.

First, the subjects one repetition maximum (1RM) is determined using the method described by Baker etal. (1994). The subject then performs maximal leg press movements at 40%, 60% and 80% of the 1RM. Data is also collected for a maximal isometric leg press. The rest interval between each movement is 2 minutes, and the movement commences without muscle pre-tension at a knee angle of 90°.

The force and velocity data which is collected during each leg press movement is processed to determine peak force and power, and mean force. Time to peak force and rate of force development during various time intervals can also be determined from this data. Computer analysis can be used to determine the point of maximum rate of force development (RFD) on the force curve over a small, specified interval (Sale, 1991). It may also be important to determine the RFD both early and later in the force/time curve as different qualities may be important in different sports. The method of RFD analysis described by Siff and Verkhoshansky (1994) is used to determine the starting-strength (the muscles ability to develop force at the start of the movement) and acceleration-strength (the ability to rapidly develop maximal external force at the beginning of a dynamic contraction).

RESULTS

Table 1 shows the results of iso-inertial testing collected for one subject on the leg press apparatus. This data describes certain force, power and RFD qualities of the leg press movement. The quantification of these different functional qualities will allow accurate monitoring of the subject's performance over time.

Table 1. Various Iso-inertial measures of strength for Subject CP

	40% IRM	60% IRM	80% IRM
Peak Force (N)	1568	1693.4	1939.9
Mean Force (N)	961.3	985.5	1147.9
Peak Power (Watt)	6341.9	4828.7	4493.1
Peak Velocity (m/s)	4.56	3.09	2.48
Time to Peak Force (s)	0.56	0.6	0.6
Maximum RFD (N/s)	14538.4	13155.2	13125.8
Starting Strength (N/s)	5872.9	5625.1	5967.8
Acceleration Strength (N/s)	2629.1	2923.4	2823.0

The force/velocity relationship for the leg press movement at four different loads is shown in figure 1. While this relationship is not the same as that demonstrated in isolated muscle, this relationship would be useful in assessing changes in neuromuscular performance over time.

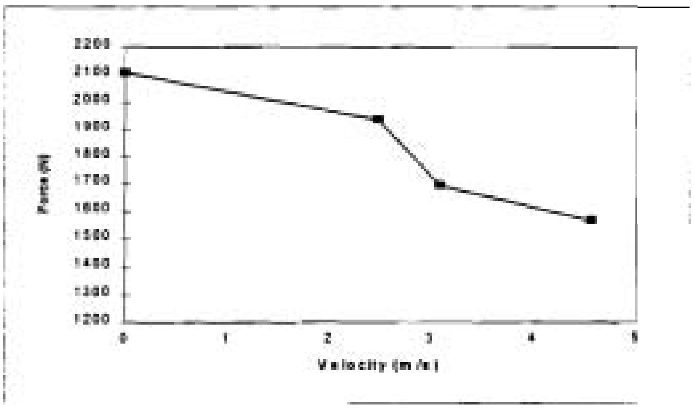

Fig 1. Force velocity characteristics for subject CP during a leg press movement at 40%, 60% and 80% of the 1RM. The isometric test result is also shown.

The force/time curves for the leg press movement at three different workloads are shown in figure 2. Despite the different workloads, the initial components of force are superimposed upon each other. This special characteristic of the neuromuscular apparatus was described earlier as the starting strength, and is independent of the external resistance (Siff and Verkhoshansky, 1994).

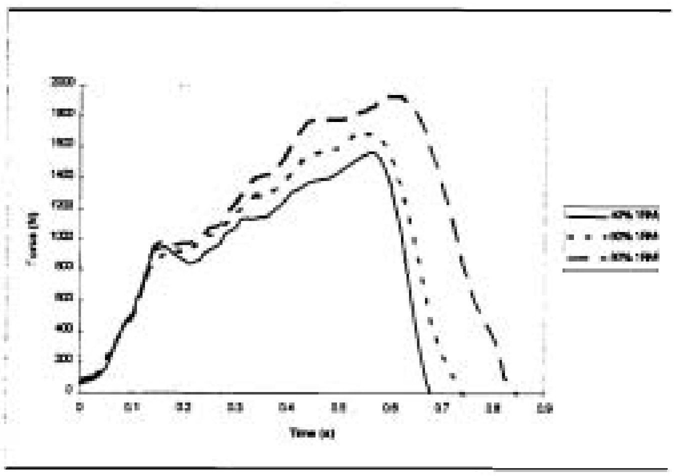

Fig 2. Force/time curves for subject CP during a leg press movement at 40%, 60% and 80% of the 1RM.

CONCLUSION

The limited availability of the most appropriate equipment, and the high cost of equipment often result in compromises being made in the testing of athletes. The athletes are often assessed using knee extension and flexion on isokinetic dynamometers when the required leg press or squat testing equipment was not feasible (Sale, 1991).

This iso-inertial assessment device provides a relatively low cost, relevant and easy method of assessing various measures of strength and power. It is an improvement over isokinetic testing devices because the leg press testing procedure more closely replicates iso-inertial activities such as running and jumping than does the typical, single joint, isokinetic testing procedure. Iso-inertial testing more closely approximates non-isokinetic, multi-joint activities which are characterised by accelerations and decelerations of a constant mass (Murphy et al., 1994). This test also has advantages over traditional iso-inertial leg strength tests, such as the vertical jump test, as the knee and hip angles are controlled at the commencement of the test, the test can be safely executed with maximal workloads, and detailed force/power results are obtained at various workloads.

The various neuromuscular qualities which are assessed during this test may be of far greater value to the athlete and coach than the isokinetic measurements of peak torque, mean torque, power and work. The ability to apply force rapidly is an important quality in many sporting activities. The RFD can be assessed at various points in the movement by using computerised iso-inertial assessment apparatus. Changes in these specific qualities of force development can then be quantified over time, and appropriate changes can be made to the athletes training programme to ensure continued improvements in performance over time. Standardisation of these various RFD measures would help ensure the universal acceptance of this form of measurement by coaches and sport scientists.

As the market for sport-specific testing equipment is smaller than the market for exercise rehabilitation equipment, further developments in this area will depend on sport scientists convincing coaches, athletes and sport-governing bodies on the need for specific iso-inertial equipment and the funding thereof (Sale, 1991).

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