Do Current Methods of Strength Testing for the Return to Sport After Injuries Really Address Functional Performance?

ABSTRACT


Key Words: Strength Testing, Return to Sport, Sports Injuries, Functional Performance

Evaluation of muscle strength is frequently used to monitor the effectiveness of rehabilitation programs for the return to sport after injuries. However, the relationship between tests of muscle strength and functional performance is still unclear. Despite this, tests of strength are often used to monitor training-induced changes in performance. Currently, isokinetic, isometric, and isoinertial dynamometry are the most commonly used techniques to assess muscle strength. Each form of assessment has its advantages and drawbacks.

Since the introduction of the isokinetic concept, most rehabilitation studies reporting quantitative instrumental measures used this form of exercise to assess strength, which has been thought to be a valuable and safe tool. Isokinetic strength is the torque that can be exerted through a range of motion in which the limb is moving at a constant angular velocity. The main advantages of isokinetic assessment are (1) it gives the possibility to isolate muscle groups, (2) it collects quantifiable data for analytic evaluation, (3) it allows building the torque-velocity relationship at certain submaximal velocities (up to about 40% of maximal velocity), and (4) it has high reproducibility if gravity correction and patient set-up are properly considered. However, isokinetic movements do not reflect everyday activity where individuals have to work against a constant mass rather than a constant velocity. Moreover, maximal speed of isokinetic devices (about 400 degrees/s) is too low with respect to the maximum that can be achieved during “unloaded” movements of human limbs (estimated at 832 degrees/s, as reported by Perrine), which limits the measure of power above these values of speed. In addition, evaluation occurs primarily from non-weight-bearing open-kinetic chain positions, even if many isokinetic dynamometers can be used also in a closed-kinetic chain fashion. In addition, the results of Greenberger and Paterno support the belief that isokinetic strength does not correlate strongly with functional tasks.

A lower number of rehabilitation studies assessed muscle function by measuring maximal isometric strength, that is, the maximal force that can be exerted against an immovable object, which corresponds to the maximum that can be measured in humans. The main advantages of isometric assessment...
are as follows: (1) it has a high test-retest reliability, (2) it is easily administered and requires little skill involvement, and (3) it is relatively inexpensive. The main argument against isometric assessment is that isometric tests bear little resemblance to the dynamic nature of most sporting activities. Isometric literally means “constantly resistant to motion,” and it reflects the constant external load that is accelerated and decelerated during a weightlifting task. The common term “isotonic,” which literally means with constant tension, is not correct because the tension developed during a weightlifting task is not constant throughout the movement as a result of acceleration and deceleration of the weight and changes in joint angle. The two major advantages of isoinertial with respect to isokinetic testing are (1) it allows the most natural pattern of movement of the human limbs, which apply force to an external load that is accelerated, and (2) it allows the achievement of all ranges of velocities. These conditions are more specific to human physical performance than isokinetic or isometric assessment. In addition, a special sled apparatus has been built ad hoc to study the stretch-shortening cycle activity, which is a feature of the most natural human activities such as walking and running. Authors against isotonic assessment tend to emphasize poor reliability and objectivity caused by intersubject, intertrial, and interlaboratory variations. For years, clinicians have given priority to measuring muscle strength in the rehabilitation context, whereas more recently, many authors have commented on the particular relevance of muscle power, which is the product of strength and speed of movement, for the assessment of muscle function. A number of studies documented that muscle power is more strongly correlated than strength per se to functional abilities, such as stair climbing or rising from

**FIGURE 1** Schematic representation of the force-velocity and power-velocity relationships obtained using an isoinertial load device. The solid line (—) represents the force-velocity relationship, and the dotted line (—) represents the power-velocity relationship, calculated from the force-velocity curve (power = force × velocity). The arrows represent the optimal force (\(F_{\text{opt}}\)) and velocity (\(V_{\text{opt}}\)) on the F-V curve where maximal power output occurs. \(F_{\text{max}}\), maximal force; \(V_{\text{max}}\), maximal velocity.

**FIGURE 2** Isoinertial test performed during a leg press maneuver on a weight training machine. A linear encoder (A) was connected to the weight stack of the machine for the measurement of time and displacement. Velocity, acceleration, and average power were calculated using a computerized muscle function measuring system (B).
a chair, and sport performances, such as jumping or throwing. It is therefore a challenge for the world of rehabilitation medicine to shift from the traditional practice of measuring muscle strength for assessing functional performance toward the novel approach of measuring muscle power, which relates to function to a greater extent than strength per se. Isoinertial dynamometry appears to be more appropriate than isokinetic dynamometry for estimating muscle power for two main reasons: (1) limb movements are closer to those of real life, in that the individuals have to accelerate external loads, and (2) higher speeds of movement can be achieved, thus allowing to draw a full force-velocity curve and calculate the optimal combination of force and speed at which peak power is reached (Fig. 1). Encoders measuring the load displacement of any machine using gravitational loads as external resistance (e.g., leg press, dips, pull down, barbells) are now commercially available, such as Muscle Lab (Bosco System Technologies, Rieti, Italy), which allows the calculation of muscle power during dynamic movements (Fig. 2). In addition, isoinertial dynamometry appears to be the most appropriate assessment tool for patients in postoperative conditions, such as after anterior cruciate ligament reconstruction, because muscle power can be safely measured using only light loads.

Finally, it should be pointed out that, regardless of the techniques used for assessing strength and power, a number of practical recommendations have to be implemented to obtain valid measurements: (1) at least three trials should be carried out, and the best performance should be selected; (2) a resting interval between trials of at least 3–5 mins should be observed; (3) visual feedback on a computer screen should be given to the subjects together with verbal encouragement to achieve their best performance. This might be problematic in a clinical environment because of time pressure to obtain the results quickly, but efforts should be made to act according to the best practice.

REFERENCES