

ISOKINETIC TEST SYSTEM AND ASSESSMENTS

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1. Introduction

When isokinetic tests and exercise procedures are examined, it is seen that it has been used actively for approximately 30 years. Isokinetic devices, which were developed and started to be used in the early 1960s, began to be used more widely, especially in the 1980s-1990s. Isokinetic systems enable a physician, clinician or a performance monitor to evaluate muscle performance within safe and normal values. Objective ideas about muscle performance can be produced by performing tests at different procedures and speeds. In addition to these, the balance between agonist and antagonist muscle groups can also be measured by these systems (Feiring et al., 1990).

Isokinetic exercise systems also contain useful parts of exercises with isometric and dynamic weights. Maximum load can be achieved even at joint angles where muscle power is produced at a minimum. Therefore, the level of development achieved in the muscle is at the maximum level in all aspects of joint movement. Performing the movement with the same speed and maximum tension at all joint angles reveals isokinetic contraction. In some sports branches, this contraction type and its values are widely used (Pincivero et al., 1997). The purpose of the isokinetic test systems is to keep the speed of the performance exhibited by the contraction of the muscle at a certain level. The external resistance that can be applied to the skeletal muscles on this system is at unlimited levels. Therefore, the change of the current angular velocity of the muscle power is prevented by the device by automatically creating resistance and the power produced in this way is transformed into torque (Baltzopoulos and Brodie, 1989). In training with normal dynamic weights, the resistance on the muscle generally reaches its maximum level at the end of the angles in which the joint moves. In the middle of the joint range of motion, the load on the muscle due to the position is at the lowest level. In isokinetic contraction, different from this, more importantly, the muscle provides maximum tension at all angles in which the joint moves and creates resistance. While the load on the muscle is at the lowest level in the middle of the free weights range of motion, its speed is maintained in the same way at the middle angles in the isokinetic dynamometer (Pincivero et al., 1997).

In the isokinetic test evaluations, the joint motion angle where the muscle is weak during the measurement is determined and the necessary studies are planned to close this deficiency. Thanks to the tests performed in this system, data on the comparison of the two opposite sides of the body extremities, the comparison of agonist and antagonist strength levels and ratios, and the general capacity and endurance of the muscle can be obtained (Baltzopoulos and Brodie, 1989). Although the reliability of the isokinetic test system and the results obtained are at high levels, it is very important to control the factors that may affect the test. The selection of parameters whose value is curious, the positions of the subjects during the test and the measurement angles are the factors that can affect the test and test results.

2. Main Parts of Isokinetic Dynamometer

Dynamometer: It is the section that can adjust the desired contraction type, joint movement angle and speed, and measure torque.

Test chair and other support apparatus: It includes apparatuses that will provide a fixed seat and isolation and stabilization of the person in order to analyze different extremities or regions.

Computer: It is the part used for the preparation of the desired protocols for the measurements to be made with a dynamometer and for starting these applications, in addition to calculating various parameters and analyzing the results (Brown, 2000).

3. Factors Affecting Results Values in Isokinetic Tests

Personal characteristics

- Age
- Height
- Gender
- Body Weight (kg)
- Athlete History
- Dominant Side
- Injury or disease state (Brochu et al., 2002).

4. Test Movements and Features

Joint Angle: Due to the relationship between the length and the tension and the biomechanical feature of the joint, the force and power generation revealed during the test may have different values at different joint angles.

Muscle Movement: Thanks to this system, force production can be revealed both by concentric (concentric) in the muscle length and by eccentric contractions. In this way, analyzes can be made on force, work and power. When the results of the studies on this system were evaluated, it was concluded that eccentric contractions produced more power than concentric contractions. As the reason for this; During eccentric contraction, both contractile and non-contractile elastic components are involved in the production of force. In concentric contraction, only the contractile structures participate in the contraction (Brown and Whitehurst., 2003).

Test Type: With this system, 3 main contraction types can be measured. These are expressed as isometric, isotonic and isokinetic.

5. Variables for Isokinetic Tests

Isolation and Stabilization: In parallel with the meaning of the word isolation, it is the removal of any external factor that will affect the results of the muscle or muscle groups included in the test during the test. The simplest way to do this is to ensure that the subject, who is seated on the dynamometer, sits optimally based on the determined dimensions and personal

characteristics. This process is called stabilization. In this process, the angles of the measured joint and the dynamometer must be exactly compatible with each other. It should be fixed with the help of belts so that the joints and muscles involved in the test are not affected by other parts of the body. In summary, it is necessary to fix all the factors other than the muscles or muscle groups that we want to work or to measure and to eliminate the effect of the test results (Brown, 2000).

Movement Axis: There is a fixed lever arm in the dynamometers where the test is carried out. The torque produced by the joints and muscles is recorded and transmitted by this apparatus. Therefore, it is very important that this lever axis and the axis of the joint under test are aligned and at an angle. If this importance is ignored, invalid and meaningless torque values may occur in the results obtained (Brown and Whitehurst., 2003).

Gravity Effect: Gravity correction must be adjusted for movements to be performed against gravity. It occurs in knee extension and flexion movements. This effect needs to be reset. Resetting this effect is even more important in hamstring/quadriceps ratios, which is the reciprocal ratio (Kannus, 1994).

Range of Motion (ROM: Range of motion): While performing the test, a bit of physiological and total range of motion should be evaluated together on the dynamometer. Physiologically, range of motion refers to the angle between the beginning and end of motion of the joint. Total range of motion refers to the range of motion drawn during the physiological range of motion. It is necessary to determine the range of motion in the tests, since the differences that will occur on the joint will affect the work and strength in the tests performed (Brown and Whitehurst., 2003).

Information about the test: The information given to the people who are planned to be tested should be given to all subjects in the same way. It should be clearly stated how the person participating in the measurement should perform the test and what is expected of him/her, and adequate practice should be given to adapt to the dynamometer.

Repetitions: Determining and telling the number of repetitions beforehand is very important for the data to be obtained at the end of the test. In studies to be analyzed for peak torque power, 5 repetitions of tests and 15-25 repetitions of tests should be performed in studies that will analyze endurance (Chan, 2001).

Resting time: 30 seconds – 3 minutes rest periods can be used in all tests performed on the dynamometer. While some researchers state that the resting time should be around 60 seconds in rest intervals (Parcell et al., 2002), other researchers say that an average of 30 seconds of rest can be in the ideal interval (Bottaro et al., 2005).

Angular velocity in measurements: Angular velocity in isokinetic dynamometers has rates ranging from 0°/sec to 600°/sec. During the test, the speed is determined according to the measurement purpose. In previous studies, it was observed that speed protocols did not significantly affect the values of force variables, whose order was the test output.

Exceeding the angular velocity and torque upper limit: The arm or leg area included in the test goes through a phase of free movement before encountering the resistance created by the

dynamometer. In places where the leg or arm exerts pressure on the resistance of the device in the line of power and torque created by the angular movement performed, the increase in torque on the device, especially during the deceleration phase of the movement, causes an unexpected deviation under normal conditions. A similar bias can occur in the last part of the acceleration phase. It is stated that the deviation in this torque curve may be due to the oscillation of the elbow that integrates the arm or leg into the device. In fact, such data to express real muscle strength are encountered especially at very high angular velocity values. It is important to consider this situation when analyzing the data obtained from these tests (Crenshaw et al., 1995).

Loading intervals: As mentioned before, isokinetic movements consist of 3 different phases. In order to reach effective and logical data, it is necessary to distinguish the 3 stages from each other and to include the values in the isokinetic test loading ranges in the analysis.

Calibration: It is necessary to calibrate regularly in order to obtain accurate and reliable results from isokinetic tests. It is important to calibrate the device every time it is turned on for testing. In addition, it is necessary to calibrate once a month with fixed and known weights (Brown, 2000).

6. Parameters Evaluated in Isokinetic Tests

Peak torque: It is expressed as the highest possible amount of torque produced at the joint opening by the muscle or a certain muscle combination included in the measurement during the test. In other words, it is the peak value on the torque curve obtained after the measurement. It is expressed as the most commonly used value in isokinetic measurements and is determined as a unit of foot-pound (ft-lb) or Newton-meter (Nm) (Brown, 2000).

Average peak torque: It is the average value of the peak torque resulting from the movement performed during the measurement. In repetitive movements during the test, this value can be considered as a much more important variable than the single peak torque value (Horvat et al., 1997).

Angle-specific peak torque: It is the value in terms of torque obtained from any movement angle during the measurement.

Torque body weight: It is the proportional value of the peak force output obtained from the test to the weight. It ensures that the resulting force output becomes personalized. The specific interpretation of the peak torque value obtained from the test to body weights helps to create another and new dimension for analysis. Individual differences can also be analyzed by dividing the peak torque and other work and power data by the weights of the test subjects.

Total work: The work value obtained in isokinetic measurements is the portion under the torque-joint range of motion curve.

Average power: It is obtained by dividing the automatically calculated work by the time required to complete the work. Its unit is Watt.

Peak power: It is expressed as the maximum power value that can be generated at the angular velocity and time at which the peak torque is obtained in the test. The acceleration capacity of

the torque occurring in the test body is expressed as the amount of power resulting from the contraction of the muscle or any muscle group in a period of one-eighth of a second. Again, it appears as an important data in the analysis of isokinetic data.

Peak torque development process: It is the value at which the peak torque value obtained from the test is determined at which speeds it develops. It normally occurs in the first 1/3 of the torque curve. However, if such a development occurs in the middle or last parts of the torque curve, it refers to any pathology that prevents the development of the peak torque during contraction. In these cases, it should be understood that the patient included in the test is not yet suitable for resuming activities in normal life.

Power loss rate: It refers to the descending portion of the torque curve on the analysis page. Under normal conditions, the descending part of this curve must be flat or convex.

Velocity-specific data: The force that the subject can produce during the test may vary depending on the velocity. When the speed increases, there may be a decrease in force production.

Force Decrease Ratio: It defines the part of the torque curve where downward bending begins. It shows the degree to which the person can produce force from the beginning to the last part of the movement.

Reciprocal innervation time: It is expressed as the ratio between the activation of the opposite muscles and the activation of the agonist muscle. If the patient has an important pathology, delays may occur at this time.

7. Muscle Ratios in Isokinetic Measurements

Bilateral comparison: It is the comparison of one extremity with the other in the lower or upper region. As a result of the analysis, differences exceeding of 10-15% are considered as asymmetry. Evaluation of this result together with other parameters obtained from the test may give more accurate results.

Unilateral ratios (Agonist/Antagonist): It involves comparing the relationship between opposite muscle groups (eg, quadriceps and hamstring) on one extremity. In such comparisons, it is revealed whether there are strength differences between muscle groups.

Ipsilateral ratios: Comparison of agonist and antagonist muscle groups of muscles in the same extremity. For example, comparison of the ratios of the quadriceps muscle and the hamstring muscle on an extremity.

Concentric / eccentric ratios: This movement pattern is used during testing and especially during many activities. When the eccentric and concentric contraction rates of a muscle group are compared with each other, it is expected that the eccentric contraction will be 30% more than the other contraction. Low rates obtained during eccentric contraction may indicate that there is a muscular pathology in general.

Endurance rates: Accurate information about muscle fatigue and recovery can be obtained by choosing test protocols for endurance.

8. Reasons for Preferring Isokinetic Tests

Reliability; In this test system, valuable results can be obtained by making a qualitative measurement of musculoskeletal system performance. Thanks to the objective data obtained, the strength and power values of the person being tested can be followed or their development can be recorded periodically.

Security; The resistance applied by the dynamometer during the test is in the same proportion to the force created by the person during the movement. Therefore, during the test, the person's skeletal muscles do not face more force than they can withstand. In this context, the risk of damage from the test is very low. The possibility of increasing muscle pain after exercise is also low (Bogdanis and Kalapotharakos, 2016).

Effectiveness; During isokinetic contraction, the muscles show maximal contraction at every angle of joint range of motion. This type of exercise is very effective in terms of strengthening because the muscles are dynamically loaded.

When pain or fatigue occurs during testing and exercise on the device, the muscle can continue to contract in harmony with the device. The force produced by contraction begins to decrease due to pain. Therefore, the resistance rate applied by the device also decreases and the exercise is continued at a lower intensity. In exercises performed with free weights, the athlete has to stop working out when she feels pain. In this test system, since the range of motion of the joint where the muscle or muscle group is not at sufficient capacity can be detected, special force loads can be applied to the muscle at the desired angle of motion. Thanks to this test, it is possible to compare different extremity ratios, agonist and antagonist ratios. In addition, information is obtained about the work capacity of muscle groups and the variables related to endurance.

During the test, information about his/her own performance can be presented to the athlete or the patient verbally, as well as the necessary graphics can be displayed with the help of a monitor. Torque curves obtained from the tests may have certain characteristics determined for some diseases. It has a high degree of reliability and accuracy in determining the power and torque levels produced by the muscles (Dvir, 2004).

9. Joint Movements Measured in the Isokinetic Test

In our body, isokinetic measurements of the lower and upper extremities can be made at different angles and speeds. Lower extremity measurement options;

- Hip abduction and adduction
- Hip flexion and extension
- Hip internal and external rotation
- Knee flexion and extension (sitting or prone)
- Tibia internal external rotation
- Ankle dorsal and plantar flexion (prone or supine)

- Ankle inversion and eversion

Upper extremity measurement options;

- Shoulder flexion and extension
- Shoulder abduction and adduction
- Shoulder internal and external rotation (90° abduction, sitting, standing, 90° flexion)
- Shoulder horizontal abduction and adduction
- Elbow flexion and extension
- Wrist flexion and extension
- Forearm pronation and supination
- Wrist radial and ulnar deviation

10. Advantages of Isokinetic Tests

- The test can be repeated as many times as desired.
- Different protocols can be created with isokinetic equipment specific to the test procedure.
- It isolates the joints.
- Data can be stored for later use.
- Athletes can be motivated by using visual feedback during the test.
- Some parts and equipment of the device also allow eccentric tests.
- This device allows accurately determined maximum resistance in the whole range of motion.
- It offers the option of working at different speeds at the determined maximum resistances.

Disadvantages of Isokinetic Tests

- Less originality.
- The device and necessary equipment are economically costly.
- The device must be calibrated at certain times.
- Muscle movements performed during the test may not be specific to all sports branches.
- The rapid and sudden torque increases during the test may be related to different factors besides the strength and power of the athlete.
- Since only the speed is controlled in the tests during the study, the effort made is at the minimum or maximum level.

- It does not allow all of the joints to work at the same time. The whole body cannot be involved in the test or study at the same time.
- It can take a lot of time to adapt the athlete to the device for testing different joints or areas.
- The fact that the athlete cannot show real performance with his capacity affects the accuracy of the data obtained (Dvir, 2004).

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