25 Functional Progression of Exercise During Rehabilitation

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There is consensus in the literature that there needs to be an evaluation and a systematic progression of any patient through a rehabilitation program.[1–6] How to perform this systematic progression is elusive, however, and there are as many methods and techniques as there are clinicians. Furthermore, there are few articles in the literature that describe specific methods or provide precise guidelines with objective documentation for functional progression of exercise during rehabilitation. Numerous descriptions of techniques exist to assess patients' performance,[7–22] but few articles have integrated all techniques into a systematic process. The purpose of this chapter is to provide a systematic, objective functional testing algorithm that is based on published research, empiric guidelines, and over 25 years of clinical experience using a similar format.

FUNCTIONAL TESTING ALGORITHM

We[23–26] have developed a functional testing algorithm (FTA) as one method to assess a patient in a systematic manner and to base the functional progression of exercise during a rehabilitation program. The FTA is discussed in a whole-part-whole system. We discuss the specific details of how the FTA is used in the evaluation and progression of a patient from postinjury or postsurgery through the rehabilitation program and back to functional activities and sports. An overview (whole) of the FTA is illustrated in Figure 25–1.

The FTA testing strategies are based on the principles of progression and "control." Each test in the progressive testing sequence increases different types of stresses to the patient with less clinical control. Early in the rehabilitation process and subsequent testing, the FTA is based on maintaining careful clinical control of the stresses imposed on the patient, and as time goes on, to gradually introduce controlled progressive stresses. Each test in the FTA increases stress to the patient with less clinical control. Progression to the next higher level of testing difficulty is predicated on passing each test in the FTA sequence. The patient must pass a minimum level of performance on one level to progress to the next higher level in the FTA sequence.

The criteria for the progression through the FTA are currently based on limited research published in the literature, many years of clinical experience, and our empirically based clinical guidelines. Correlation research by other authors is in progress. In addition, a paper was submitted for publication that contains statistical correlations between many of the tests used in the FTA.[27] Table 25–1 provides the current empiric guidelines for clinical decision-making regarding the functional progression of exercise during rehabilitation.

The following information describes each stage of the FTA with emphasis on the empiric guidelines and rationales for their inclusion.

BASIC AND FUNDAMENTAL MEASUREMENTS

The basic and fundamental measurements consist of the various findings in the history, the subjective examination, and the objective physical examination of the patient. The various parts of the basic and fundamental measurements are listed in Table 25–2. Examples of how the basic and fundamental measurements can be used in the functional progression of exercise during rehabilitation is presented in the following sections.

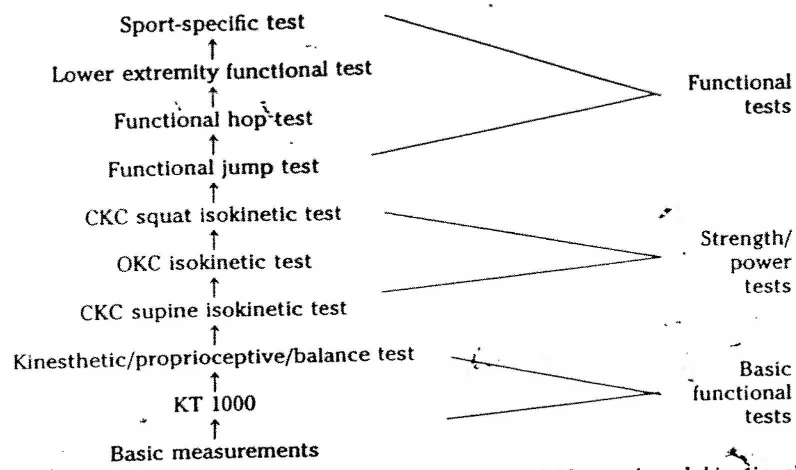

Figure 25–1. Functional testing algorithm (FTA), lower extremity. CKC = closed kinetic chain; OKC = open kinetic chain.

Subjective Examination

The patient's subjective symptoms are evaluated at rest, with activities of daily living, with vocational activities, and with avocational activities. A visual analog scale is used to assess the patient's response to different types of stress loading. The visual analog scale we use ranges from 0 (no pain) to 10 (worst pain). The clinician's experience and familiarity with the patient now become invaluable when trying to cause progression of a patient through a functional rehabilitation program. (What is one patient's pain may be another patient's pleasure.) Our present standard is for the patient to have no pain at rest and pain with activity at less than 1 or 2 on the visual analog scale before progressing to more exercises.

One of the reasons for this constraint is that pain produces a reflex inhibition resulting in muscle "weakness." In addition, the location of the symptoms and the specific anatomic structures involved often dictate the progression in the rehabilitation program. If pain is significant, discussion with the patient's physician or surgeon is recommended and progression is placed on

Table 25–1. **Empiric Guidelines for Patient Progression in the Functional Testing Algorithm**

Tests	Empiric Guidelines
Sport-specific testing (SST)	
Lower extremity functional test (LEFT)	Female <2:00 min; Male <1:30 min
Functional hop test (FHT)	<15% bilateral comparison and norms
Functional jump test (FJT)	<20% compared with body height and norms
Closed kinetic chain (CKC) (standing)	<20% bilateral comparison
Open kinetic chain (OKC)	<25% bilateral comparison
Closed kinetic chain (CKC) (supine)	<30% bilateral comparison
Balance test	<30% bilateral comparison
KT 1000	<3 mm bilateral comparison
Basic measurements	<10% bilateral comparison
Subjective	Pain < 3 (analog pain scale: 0–10)

Table 25–2. **Functional Testing Algorithm (FTA): Basic/Fundamental Measurements**

- History and subjective examination
- Objective examination
  - Observation/posture
  - Vital signs
  - Gait evaluation
  - Anthropometric measurements
  - Leg length measurements
  - Referral/related joints
  - Palpation
  - Neurologic examination
    - Sensation
    - Reflexes
  - Balance/proprioception/kinesthesia
  - Manual muscle testing
  - Active range of motion
  - Passive range of motion
  - Flexibility tests
  - Special tests
  - Medical tests

hold. As a general clinical guideline, criteria for the progression of a patient to the next level of testing in the FTA include parameters within 10 percent in a bilateral comparison or relative to normative data and clinical experience and judgment.

KT 1000 Testing

If the patient has had an anterior or posterior cruciate ligament injury, evaluation of knee stability is performed with the KT 1000.[28] If surgery has been performed, ideally the difference between the uninvolved and the involved knee would be 3 mm or less. If a greater than 3 mm difference exists between the sides, medical discretion is used to determine whether the patient is ready to progress and be tested at the next stage of the FTA. If a patient has a KT 1000 reading that is greater than 3 mm early in the postoperative course, we try to protect the graft by protected weight-bearing, bracing, and modification of the rehabilitation program.

Balance, Kinesthesia, and Proprioception Testing

Measurement of balance, kinesthesia, and proprioception should be included as part of the FTA.[29–32] Both static and dynamic balance are measured. For many years, we used a digital balance evaluator, which was a single-plane balance board that had microswitches and counted the number of touches and time out of balance in a 30-second test protocol. During the last several years, however, we have used a FASTEX computerized neuromuscular assessment system. This allows us to measure both static and dynamic balance simultaneously. The current test protocols are described in Figures 25–2 and 25–3.

Limited information has been published on normative values for balance, kinesthesia, and proprioception. We therefore have our own internally generated testing data as empiric guidelines for the evaluation and progression of the patient in the FTA. Johnson-Stuhr (unpublished research, 1997) completed a test-retest reliability study on the FASTEX and found that it was a reliable device for measuring balance within the limitations of the study. If, during testing, a patient's score is higher than the established norm, kinesthetic exercise for neuromuscular control is emphasized in his or her rehabilitation program. Variables are based on the specific pathologic condition and test scores. Retesting for progression takes place at a later date.

MUSCULAR STRENGTH AND POWER TESTING

Closed Kinetic Chain Isokinetic Testing Semisitting or Supine Position

With the increased emphasis on closed kinetic chain (CKC) exercises in many rehabilitation protocols, the need to test for CKC functional performance becomes an important part of the FTA. A concern is how to test safely with CKC exercises early in rehabilitation without iatrogenically creating more problems. It is often contraindicated to test using 1 repetition maximum or 10 repetition maximums too soon following injury or surgery because it may cause inappropriate stresses to the injured area or healing tissue structures.[33]

Historically, the reasons quoted for incorporating CKC exercises into the rehabilitation program are that (1) CKC exercises are functional,[34, 35] (2) CKC exercises are more effective in improving function, (3) the CKC position increases the joint compressive forces, increasing knee stability,[36–42] (4) CKC exercises promote co-contractions of the quadriceps and hamstrings to provide dynamic stability to the knee joint,[43–54] and (5) CKC exercises minimize translatory stresses to the ligaments, particularly the anterior cruciate ligament (ACL).[55] Interestingly, many of these reasons have been questioned.

As an example, one study using a prospective randomized controlled clinical trial series demonstrated that using only aggressive CKC exercises as the primary mode of rehabilitation for patients following ACL reconstruction did not normalize their quadricep function with gait.[56] Yet another study[57] demonstrated that in an unloaded bilateral squat, there was minimal electromyographic hamstring activity and minimal electromyographic gastrocnemius activity. This causes

Name ______________________ DOB ________ Gender M/F
GC # ______________________ PT ________ MD ________
Injury/Surgery ______________________ DOS/DOI ________

Procedure

1. Patient stands on uninvolved leg facing away from the computer, with head and eyes looking straight forward focusing on an object.
2. Non–weight-bearing knee is flexed to approximately a 90-degree angle, and the shin is held parallel to the floor.
3. NWB knee is abducted and not touching opposite leg.
4. Hands are clasped behind the back.
5. Allow one practice test for 20 seconds.
6. Each test is 20 seconds.
7. Repeat the test 3 times with a 20-second rest period in between each test.
8. Record the total stability index for each trial.
9. Repeat 1 to 8 on involved leg.

DATE	UNINVOLVED L/R	INVOLVED L/R	% DEFICIT
Trial 1			
Trial 2			
Trial 3			
Average			
DATE	UNINVOLVED L/R	INVOLVED L/R	% DEFICIT
Trial 1			
Trial 2			
Trial 3			
Average			
DATE	UNINVOLVED L/R	INVOLVED L/R	% DEFICIT
Trial 1			
Trial 2			
Trial 3			
Average			

Figure 25–2. Static balance test protocol and data collection sheet.

a question about the co-contraction loading to provide dynamic stability theory.

Nevertheless, accepting all the indications to do CKC testing and exercises as well as many of the limitations, we incorporate CKC testing at this point in the FTA. We use a Linea (Loredan Biomedical), which is a lower extremity computerized isokinetic/isotonic testing and rehabilitation system. We test the patient in a semisitting to supine position with CKC isokinetics. Davies and Heiderscheit[58] have published the results on the reliability of the Linea that demonstrates the intraclass correlation coefficients to be from .85 to .94, which demonstrates good to excellent test-retest reliability.

We begin the CKC testing in the semisitting or supine position for control of weight-bearing and range of motion. This testing position controls the stresses delivered to the knee and prevents varus-valgus and rotational forces. It is considered safe for operative and nonoperative patients early in rehabilitation.

Although the Linea provides numerous modes of testing (isometrics, isotonics, isokinetics), different muscle actions, including isometric, concentric, and eccentric, different patterns of testing, such as reciprocal lower extremity patterns or coupled or tandem symmetric leg press patterns, and a variety of speeds (0–30 inches per second), we primarily employ the following test protocol. The testing protocol has a CKC isokinetic reciprocal because it simulates the functional movements of gait or running. We use the isokinetic mode because of the safety afforded by the accommodating resistance and the ability to sample the muscle's performance through the velocity spectrum.

Name ______________________ DOB __________ Gender M/F
MH # ______________________ PT __________ MD __________
Injury/Surgery ______________________ DOS/DOI __________

Procedure

1. Patient stands on both legs.
2. Patient jumps side to side between two platforms, with the arms left free.
3. Allow one set of submax (easy side to side) warm-ups.
4. Each set consists of 20 jumps, with a 20-second rest period in between each set.
5. The objective is for the patient to complete the 20 jumps as quickly as possible.
6. The patient completes 3 sets of 20 jumps for the test. For each set the total elapsed time is recorded.

DATE	TOTAL ELAPSED TIME
Trial 1	
Trial 2	
Trial 3	
Average	

DATE	TOTAL ELAPSED TIME
Trial 1	
Trial 2	
Trial 3	
Average	

DATE	TOTAL ELAPSED TIME
Trial 1	
Trial 2	
Trial 3	
Average	

DATE	TOTAL ELAPSED TIME
Trial 1	
Trial 2	
Trial 3	
Average	

DATE	TOTAL ELAPSED TIME
Trial 1	
Trial 2	
Trial 3	
Average	

DATE	TOTAL ELAPSED TIME
Trial 1	
Trial 2	
Trial 3	
Average	

Figure 25–3. Dynamic balance test protocol and data collection sheet.

Many times, patients have normal function at one speed (such as slower speed) but then have a significant deficit at a faster speed. In these cases, it indicates that patients have a power deficit and the inability to produce the forces quickly that are necessary for functional activities. Research by Wojtys et al. has also illustrated the functional importance of the quadricep and hamstring and the power deficits or muscle reaction times.[59–62]

At the present time, the empirically based guidelines that we use to produce patient progression to the next stage of the FTA and to a higher level of functioning (increased stresses with less clinical control) are a bilateral comparison of less than 30 percent in peak force, total work, total work/body weight, average power, and average power/body weight. If the patient has greater than a 30 percent deficit in bilateral comparison, we incorporate open kinetic chain (OKC) exercises along with the CKC program. The reason for the integrated OKC is to obtain isolated strengthening of the involved area without allowing other muscle groups to compensate and mask potential deficits. The emphasis is on motor re-education and power and endurance training before we retest the patient's status.

Open Kinetic Chain Testing

As mentioned, OKC exercises are part of the total rehabilitation program so that no isolated muscle strength deficits are allowed to exist.[63] Although many practitioners believe that certain knee pathologies are contraindications to OKC testing, they also believe that it has an important place in evaluating recovering patients. Examples of conditions that would contraindicate OKC testing include limited joint range of motion, significant effusion, patellofemoral chondrosis and pain, tendinitis leading to pain with exertion, and insufficient soft tissue healing time since the surgery or injury. These conditions may change over time and the contraindication may be lifted.

Clinical controls that are inherent in OKC testing to improve its safety include the following:

1. No varus, valgus, or rotation applied during testing if the unit is properly applied.[50, 51]
2. A proximally placed tibial pad that helps reduce anterior translation of the tibia. (An important consideration for patients with ACL-deficient knees to prevent stretching the secondary restraints as well as with ACL reconstructions to prevent placing extra stresses on the healing or maturing ligament.)[64, 65]
3. Controlled speeds. (Faster speeds decrease the amount of anterior tibial translation.)[65, 66]
4. No applied compressive force during testing for joints with chondral abnormalities. (An exception exists across the patellofemoral joint.)
5. Precise control of range of motion. (By limiting range of motion, anterior tibial translation can be controlled.)[64, 65]
6. Isolation of the muscle to be tested so that results are "pure" for that muscle. (Also assesses the neural system's ability to "drive" the isolated muscle group and assess the muscle's power.)[67, 68]

Several authors[69, 70] have described and demonstrated the need for isolated joint testing. Furthermore, Nicholas et al.[71] and Gleim et al.[72] have demonstrated the need for creating a composite score of total leg strength. Davies[73] has documented the importance of performing isolated joint testing (OKC) in conjunction with CKC testing for patients with various knee pathologies. Rosenthal et al.[74] also compared OKC with CKC testing.

When performing the OKC testing, velocity spectrum testing is used[75] so that the muscle's performance can be sampled at different speeds.[76–78] Often, muscle deficits show up only at particular velocities.[79–82]

Research by Wojtys and colleagues reinforces the importance of evaluating isolated muscle function to identify the "weak link" in the kinetic chain.[59–62] Most studies employ isolated isokinetic testing to evaluate for deficits in peak torque production. Wojtys et al. and other investigators,[83–86] in contrast, demonstrated that the most important source of deficits is the neuromuscular timing and recruitment. Kannus et al. have extensively demonstrated the significance of measuring muscle power in an OKC test.[87–90]

The concept of muscle power or the ability to produce force or torque quickly is the basis of functional performance testing. It really does not matter how much force a muscle can produce in unlimited time.[91, 92] Real significance is placed on a muscle's ability to generate force quickly, which leads to functional dynamic stability of an adjacent joint. This ability can be measured as force development quickness, time rate of torque development, or torque acceleration energy.[83] Davies et al. have discussed the significance of this muscle contraction characteristic and its importance to functional performance since 1980.[75, 79, 80, 93–98] Furthermore, because more injuries occur in fatigued conditions, the status of muscle endurance is another parameter that should be assessed.[99]

The need certainly exists for more research in this area to determine the most significant muscle assessment parameters and how they correlate with functional performance. Admittedly, a patient and muscle group do not function in an isolated manner. There are numerous studies that demonstrate a correlation between OKC testing and functional performance,[100–107] and a few that dispute this association.[108, 109]

Data analysis involves many components, including bilateral comparison, unilateral ratios of agonist to antagonist, and peak torques to body weight, among others.[23, 81] The clinically based empiric guideline used for progression of the patient to the next level of the FTA is a bilateral comparison of less than 25 percent upon OKC testing. If the patient has a deficit in a particular isolated muscle, such as the quadriceps, greater than 25 percent (isolated weak link of the kinetic chain), then an integrated rehabilitation program utilizing both OKC and CKC exercises facilitates normal functional motor patterns (Table 25–3).

Closed Kinetic Chain Weight-Bearing Squat Position Isokinetic Testing

The next step is to move the patient from the OKC or partial CKC testing position to the actual weight-bearing position.[9, 27, 36, 110–113] In this test position, the Linea is placed in the upright position and the patient is tested in the CKC squat position using two legs. Then the patient can also progress to unilateral squat testing. With the single-leg squats, a bilateral comparison of the extremities is evaluated. We expect patients to have less than 20 percent bilateral deficit to go to the functional testing position. If the patient has greater than a 20 percent deficit, the rehabilitation program emphasizes single-leg concentrated training with integrated OKC and CKC techniques (Table 25–4).

FUNCTIONAL TESTING

At this time, there is a major change in the emphasis of the testing sequence. The focus of testing is now on functional activities. There is no longer clinical control superimposed on the patient. The patient's knee is now subjected to progressive varus-valgus and rotational stresses. Furthermore, speed, range of motion, and eccentric decelerative loading forces are no longer limited by the testing, as was done earlier in the sequence.

Table 25–3. **Comparison of Open and Closed Kinetic Chain Isokinetic Testing with Body Weight**

The peak torque to body weight (BW) for the quadriceps with OKC was	
slow speed	60°/sec: ≈ 1 × BW
medium speed	180°/sec: ≈ ⅔ × BW
fast speed	300°/sec: ≈ ½ × BW
The peak force to body weight (BW) for the leg extensors with CKC was	
slow speed	25.4 cm/sec: ≈ 3 × BW
medium speed	50.8 cm/sec: ≈ 2½ × BW
fast speed	76.2 cm/sec: ≈ 2 × BW

BW = body weight; CKC = closed kinetic chain; OKC = open kinetic chain.

Functional Jump Test

We begin the functional testing sequence with a functional jump test (FJT), which is a simultaneous two-leg jump.[114] The purpose of the FJT is to measure simultaneous functional bilateral leg power. To prevent the segmental contributions of the arm, neck and trunk,[115, 116] we have the patient clasp the hands behind the back to minimize the neck and trunk movements. The patient performs four gradient submaximal to maximal warm-up jumps (25, 50, 75, and 100 percent effort). It is important to have the patient perform at least one maximal jump to create a positive transfer of learning from a warm-up activity to the actual test activity. If the patient performs only submaximal warm-ups and is then asked to perform a maximal effort in the testing, it creates a negative transfer of learning.

Moreover, this is an excellent test to assess the patient's readiness to perform "uncontrolled functional test activities." The patient then performs three maximal volitional effort jump tests. The distance the patient jumps is averaged and then normalized to the patient's height (distance is recorded as a percentage of patient height) to make it relative to the patient. We normalize the data to the patient's height because the absolute distance values provide limited usefulness in data analysis and interpretation, since patients vary in gender and body size. As an example, if a patient jumps 102 cm, 112 cm, and 107 cm in the three maximal test repetitions, is that excellent, good, fair, or poor performance? The normative data allow a standard for performance to be set and used for functional progression.

The descriptive normative data collected over the years at this center are listed in Table 25–5. Healthy recreational or competitive athletes under 40 years of age are expected to achieve the numbers listed in Table 25–5. The criterion for the patient to progress to the next level of the FTA is that the patient achieve scores with less than a 15 percent deficit compared with the descriptive normative data. If the patient has greater than a 15 percent deficit based on the normative data, then we continue the functional rehabilitation program with emphasis on bilateral lower extremity CKC exercises.

Table 25-4. **Lido Linea Closed Kinetic Chain Computerized Isokinetic Testing Compared with Cybex Open Kinetic Chain Computerized Isokinetic Testing***

Cybex Test	% Deficit	Linea Test	% Deficit
PT 60 degrees/sec quadriceps U - 142 ft-pounds I - 101 ft-pounds	29	PT 25.4 cm/sec U - 208 kg I - 189 kg	9
PT BW 60 degrees/sec quadriceps U - 95% I - 66%	31	PT % BW 25.4 cm/sec U - 134 kg I - 120 kg	11
PT 180 degrees/sec U - 99 ft-pounds I - 78 ft-pounds	21	PT 50.8 cm/sec U - 168 kg I - 149 kg	11
PT BW 180 degrees/sec U - 64% I - 48%	25	PT % BW 12.7 cm/sec U - 108 kg I - 97 kg	11
PT 300 degrees/sec U - 80 ft-pounds I - 64 ft-pounds	20	PT 76.2 cm/sec U - 137 kg I - 114 kg	16
PT BW 300 degrees/sec U - 51% I - 41%	20	PT % BW 76.2 cm/sec U - 87 kg I - 77 kg	11

*N = 250 patients (different knee injuries).
BW = body weight; I = involved side; PT = peak torque; U = uninvolved side.

Functional Hop Test

The functional hop test is a unilateral hop test that compares the normal with the involved extremity.[117] This test, which is recommended by the International Knee Documentation Committee, is a major progression in the FTA because uncontrolled stresses are placed exclusively on the involved extremity. This is also an important "psychologic readiness test" on the part of the patient. Often, even though the patient has passed all the tests prior to this stage of the FTA, the patient is not "psychologically" ready to take this test. The patient exhibits apprehension, hesitation, or unwillingness to perform the test. In some cases, the patient can concentrically hop off the involved leg but cannot land with the eccentric deceleration on the involved leg.[67, 118–120] Many times the patient hops off the involved leg but keeps landing on both feet. This demonstrates that the patient is not ready, whether psychologically or physiologically, to progress further in the FTA at this point, and the emphasis must be placed on a continued rehabilitation program to correct the patient's deficits. There are several reliability studies that demonstrate that this is an excellent test.[121–124]

We use guidelines for the functional hop test similar to those already described for the FJT. The techniques for testing are as follows: the patient's hands are clasped behind the back and the head and trunk movements are minimized for the reasons previously described relative to the FJT. Four gradient submaximal to maximal warm-ups are used prior to the three maximal volitional tests being performed. The data are analyzed as a bilateral comparison, as recommended by the International Knee Documentation Committee; however, these data are also normalized to the patient's height, similar to the FJT. This practice allows comparison with the general population of athletes and not simply side-to-side comparisons.[125, 126]

With the involved leg, the patient should hop within 10 percent bilateral comparison of the involved to the uninvolved side. Moreover, the patient should hop within 10 percent of the descriptive normative data de-

Table 25-5. **Functional (Relative/Normalized) Jump and Hop Test Data for Males and Females**

	Males (%/Ht)	Females (%/Ht)
Jump test (R + L)	90–100	80–90
Hop test (U)	80–90	70–80
Hop test (I)	80–90	70–80

Ht = patient's height.

scribed in Table 25–5. If the patient has greater than a 10 percent deficit in either data analysis or interpretation, functional rehabilitation exercises are continued. The emphasis of the rehabilitation is on single-leg CKC and OKC exercises as well as on the eccentric loading component of various activities. Once the patient performs and passes the test, then he or she progresses to the next level of the FTA.

Lower Extremity Functional Test

When the patient reaches the terminal phases of the rehabilitation program and is being considered for discharge from ongoing treatment, a lower extremity functional test (LEFT) is administered. The LEFT has evolved from several years of attempting to replicate numerous functional sporting activities into one practical test. It meets the criteria of being a test that can be performed within the constraints of the size of a clinical setting, requires minimal equipment to perform, takes a short time to administer, and is valid and reliable. A study by Negrete and Brophy[27] demonstrated the validity or correlation of the LEFT with other tests to measure performance.

The specific dimensions of the LEFT were designed based on in-clinic space constraints. The floor dimensions are in a diamond shape 30 feet in length and 10 feet in width (Fig. 25–4).

The test is designed to create progressively more demanding functional movement patterns to the lower extremity. The sequence of activities of the LEFT are described in Table 25–6.

When the patient performs the LEFT, the clinician evaluates the quantity of the performance (time required to complete the test) as well as the quality of the performance. Considerations regarding the quality of the performance come back to the "psychologic readiness" and willingness to put out during the test, any hesitation in performing the various maneuvers of the test, and any limping that may result during the test. The quality of the performance by the patient is an empiric assessment by the clinician. The tester's clinical judgment is important in determining whether the patient passes this stage of the FTA. On rare occasions, a patient may be able to complete the LEFT in a reasonable time but has poor quality of performance. Both components of the evaluation of this test are important in deciding whether the patient returns to limited practices, scrimmages, and so on. If the quality of the performance is poor, it may mean that the patient is still "favoring" the injured extremity and may be more vulnerable for reinjury, even though he or she has passed many of the prior objective tests.

The quality of the performance (time to complete the LEFT) for objective documentation is also recorded. The descriptive normative data collected at this center are described in Table 25–7.

There are certainly many considerations in evaluating a patient's performance during the LEFT. The analysis and interpretation of the results may take into consideration many factors, including age, sex, somatotype, physical fitness level, sport, and position within the sport. Each of these factors can certainly influence one's performance in this test. A need exists to develop patient-specific norms based on many of the aforementioned criteria. This massive undertaking is in its early stages.

An example of the need for these patient-specific norms is if we were testing a 15-year-old, 230-pound endomorphic wrestler who had injured his knee and was being assessed for possible return to practice. Most likely, this patient would score poorly on the test, not just because of the injury, but also because of age, size, condition, and so on. Consequently, the norms in Table 25–7 would have to altered. Furthermore, the interpretation of any patient's test performance relative to descriptive normative data is performed with caution. Good clinical judgment is not applied to poor research data (if the norms are not really inclusive of the particular patient's unique characteristics).

The LEFT is a very stressful test for the anaerobic cardiovascular system. Consequently, if the individual being tested has poor cardiovascular conditioning, it must also be considered in the interpretation. If cardiovascular limitations are noted, generalized training and specific cardiovascular training techniques through cross-training can help improve this component without causing further stress to the injured area.

If the patient does not pass the LEFT, both quantitatively and qualitatively, the focus of the rehabilitation is then on the areas of the

Patient Name: ______________________ GC # ________ DOB ________
MD ______________________ PT ______________ DOS/DOI ________
Diagnosis ______________________________________ Gender M/F
Dominant L/R Involved L/R Height ________ in Weight ________ lb

Procedure

1. Forward sprint (A-C-A)
2. Retro sprint (A-C-A)
3. Side shuffle right—face in (A-D-C-B-A)
4. Side shuffle left—face in (A-B-C-D-A)
5. Cariocas right—face in (A-D-C-B-A)
6. Cariocas left—face in (A-B-C-D-A)
7. Figure 8s right (A-D-C-B-A)
8. Figure 8s left (A-B-C-D-A)
9. 45° Cuts right—plant outside foot (A-D-C-B-A)
10. 45° Cuts left—plant outside foot (A-B-C-D-A)
11. 90° Cuts right—plant outside foot (A-D-B-A)
12. 90° Cuts left—plant outside foot (A-B-D-A)
13. Crossover 90° cuts right—plant inside foot (A-D-B-A)
14. Crossover 90° cuts left—plant inside foot (A-B-D-A)
15. Forward sprint (A-C-A)
16. Retro sprint (A-C-A)

Data

Date ________ Time ________ sec	Date ________ Time ________ sec	Date ________ Time ________ sec
Date ________ Time ________ sec	Date ________ Time ________ sec	Date ________ Time ________ sec

NORMS	
Males	Females
90 sec–good	120 sec–good
100 sec–average	135 sec–average
125 sec–below average	150 sec–below average

Figure 25–4. Lower extremity functional test (LEFT) dimensions.

test where the patient did not perform well. As an example, if the patient had no problems with the straight-ahead running or gradual cutting maneuvers, but only had pain or disability during the sharper cutting motions, the emphasis in the rehabilitation program is on the sharper cutting motions. The problematic areas are analyzed and broken down into the component parts to try to determine as precisely as possible where the problematic areas were in the activity. The component parts are then addressed in the rehabilitation program. Slow submaximal activities may be performed initially, and the intensity of the effort, the speed of the activity, and the angle of the cut may all be gradually improved to obtain the adaptation response required to allow the patient to perform the activity with no limitations. Goals for the patient to achieve are to be within the range of the descriptive normative data in Table 25–7. If a surgical patient

Table 25–6. Sequence of the Lower Extremity Functional Test (LEFT)

1. Sprint (frontward)
2. Sprint (retro-run)
3. Side shuffles (both ways)
4. Cariocas (both ways)
5. Figure-of-eights (both ways)
6. 45-degree angle cuts (outside foot) (both ways)
7. 90-degree angle cuts (outside foot) (both ways)
8. Crossover step (both ways)
9. Sprint (frontward)
10. Sprint (retro-run)

Table 25–7. Lower Extremity Functional Test (LEFT) Descriptive Normative Data

	Norms (seconds)
Males	90–125 100 average
Females	120–150 135 average

is unable to achieve these goals and consistently has difficulty with this particular test, discussion of the deficit with the patient's surgeon is important. Once the patient performs in a satisfactory manner based on the established criteria, however, the patient progresses to the next level of the FTA.

Sport-Specific Testing

The final stage of the FTA is sport-specific testing. Often, because of the space limitations, equipment limitations, simulated environment, appropriate testing methodology, and so forth this cannot be performed in the clinical setting. Ideally, there is a health care team approach in which the functional "field" testing can be performed by members at the respective competitive venues. These would include certified athletic trainers, certified strength and conditioning specialists, physical therapists, and so forth. Ideally, a consultation takes place between the "field" professional and the clinical therapist regarding the patient's status and the eventual disposition of the patient.

Figure 25–5 illustrates how the FTA (whole) provides the foundation for a precise (based on the test results from the FTA), progressive rehabilitation program that can be performed safely and efficiently to progress through the process to discharge and return to activities.

Most articles on ACL outcome studies are

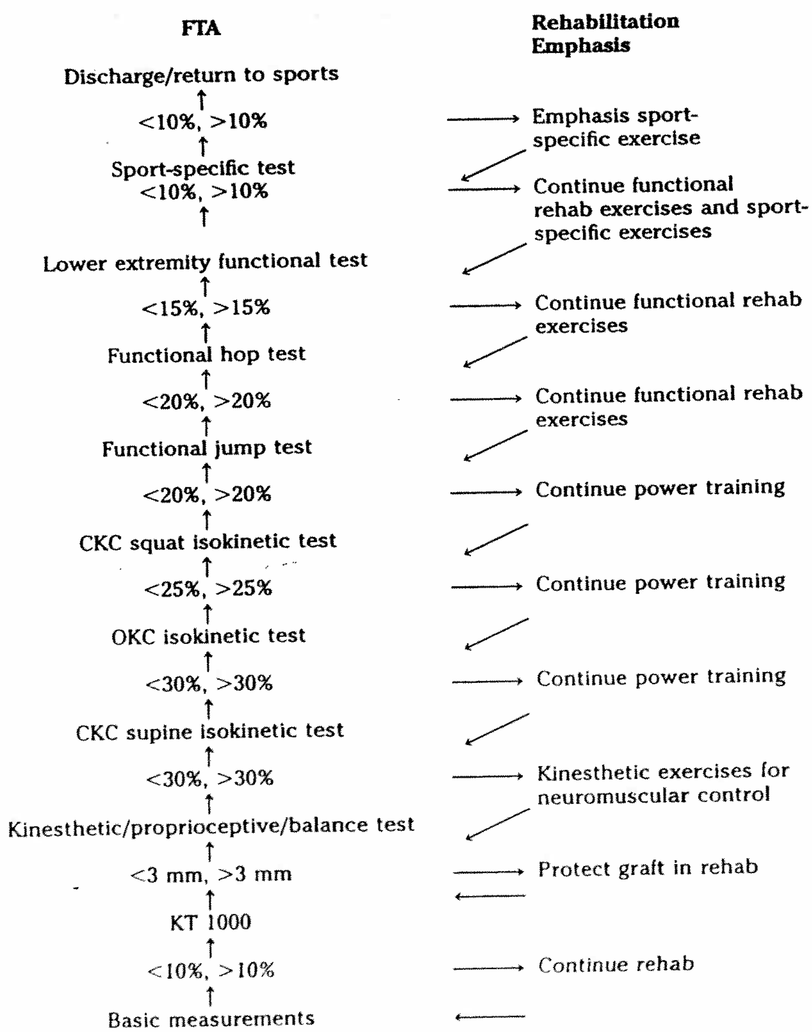

Figure 25–5. Functional testing algorithm as the foundation for a progressive rehabilitation program.

based on retrospective descriptive chart reviews.[127] Perhaps a comprehensive systematic FTA as described will facilitate more prospective randomized controlled clinical trial studies.

To those unaccustomed to this approach, the FTA may correctly seem long and impractical. In practice, it actually helps a patient to progress more quickly through a rehabilitation program. The primary reason is that patients are always being tested and monitored to know exactly where they are and what their status is. Instead of following the protocol or having patients continue with the generic home program, they are placed on specific in-clinic rehabilitation activities based on their test results and their deficits. Furthermore, their home program is also designed to specifically address the problematic area to complement the clinical program.

The functional progression can be explained to coaches and even to parents in the field by certified athletic trainers so that they develop a better understanding of where in the recovery phase their athlete is. Visual demonstration of progression can also be provided by using the algorithm (see Fig. 25–1).

Another important point about this treatment approach is how it works with managed care and limited numbers of physical therapy visits. The physical therapists' first goals after injury or surgery are to decrease pain and swelling, increase range of motion, and achieve muscle control. The treatments and home programs are thereafter based on test results. The patient's progression can then be more goal oriented, more efficient, and less time consuming.

SUMMARY

The FTA is a systematic, objective, progressive sequence that forms the scientific and clinical foundation for testing a patient to determine his or her status and then uses the results to guide the appropriate rehabilitation program. This approach has been effective in highly motivated individuals. It may prove less useful to focus on deficits in less goal-oriented individuals. However, in less goal-oriented patients, continuing to emphasize the positive progression and improvement through the FTA can still serve as a motivational tool to help them return to their desired activity levels.

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