Functional Outcome Measures for Knee Dysfunction Assessment

Douglas R. Keskula, PhD, PT, ATC; Jewell B. Duncan, MD; Virginia L. Davis, MEd, PT, ATC; Paula W. Finley, PT

ABSTRACT: Maximizing the functional abilities of the individual is the primary objective of any therapeutic intervention. Functional outcome data are valuable to those involved in the care of the athlete because such data provides information that helps facilitate the clinical decision-making process and, therefore, helps insure a safe and efficient return to athletics. Functional outcome measures also provide useful data for assessing therapeutic intervention efficacy. The clinician/researcher must consider various factors when selecting an appropriate outcome measure, such as: the patient population, pathology, specific test parameters, psychometric properties, and practicality of the measure. The primary purpose of this paper is to provide the reader with guidelines for either assessing existing measures or developing new measures of functional outcomes for use in clinical practice and research.

The purpose of health care intervention is to restore the functional abilities of the individual within the limits imposed by injury or disease. Functional limitation or dysfunction represents the individual's inability to perform specific tasks and activities otherwise considered normal.[11] A functional outcome is a predicted result of care that is meaningful and practical to the athlete and sustainable beyond the rehabilitation environment.[20,21] In the athletic population, treatment goals are directed toward safely and efficiently returning the individual to participation in athletics.

Functional outcome data is important to health care consumers, providers, and insurers for several reasons. First, improvement in impairments such as range of motion and strength do not always lead to functional improvement.[20,21] Athletes must meet criteria to progress through the rehabilitation program. However, success during an early phase of rehabilitation does not insure that the athlete will successfully participate in functional activities. The only way to determine the athlete's ability is to conduct a functional trial. The clinical decision-making process must include a mechanism to assess and report functional outcomes to insure safe return to athletic participation.

Functional outcome measures provide data to assess treatment outcomes. The continual evolution of health care delivery and reimbursement requires greater justification for third party payers. Stewart[21] suggests that functional outcome is the key to justification of treatment and successful reimbursement. Functional outcome data may also facilitate the assessment of the efficacy of therapeutic intervention, leading to more efficient and more effective treatment. Functional outcomes not only assess benefits but also provide cost-benefit data.[9]

Douglas R. Keskula is an Assistant Professor of Physical Therapy at the Medical College of Georgia in Augusta, GA 30912.
Jewell B. Duncan is an Assistant Professor of Orthopedic Surgery and Director at The Medical College of Georgia Center for Sports Medicine.
Virginia L. Davis is a clinical supervisor and **Paula W. Finley** is a staff physical therapist at The Medical College of Georgia Center for Sports Medicine.

Rehabilitation of the lower extremity is frequently encountered in sports medicine. There are several assessment tools available to the clinician/researcher to measure and report change in the status of an individual with lower extremity dysfunction. Tegner et al[23] categorized these dimensions as patient symptoms, clinical exam, activity grading, and performance testing. There are advantages and limitations to each measure used independently or in conjunction with other measures. Determination of the appropriate outcome measure(s) may be contingent on the patient population, pathology, specific test parameters, psychometric properties, and practicality of the measure.

The purpose of this paper is to provide the reader with guidelines for the assessment of existing or development of new measures of functional outcomes for use in clinical practice or research for the assessment of knee dysfunction. Suggestions for the documentation of functional outcomes in sports medicine are presented.

CONSIDERATIONS IN THE SELECTION OF FUNCTIONAL OUTCOME MEASURES

The clinician/researcher must consider the psychometric properties of the measurement tool when selecting a functional outcome measure. Reliability and validity are important considerations in the selection of a clinical test. These attributes applied to data acquisition serve to facilitate the clinical decision-making process. Additional considerations for test selection include the practicality of the measure.

Reliability is the degree to which a measure is consistent and free from error. Clinicians need to be concerned with the reliability of measures with respect to time and the evaluator. The assumption is that variations between measures are attributed to changes in the variable being measured. However, random measurement error may contribute to this variation, reducing the reliability of the test. There are several sources of measurement error that diminish the reliability of testing. These factors may include flaws with the measurement tool, inherent instability of the variable being measured, and errors made by the examiner.[16] There are limited reports of reliability of functional measures for the lower extremity.[4,15,19]

A reliable measure is not necessarily a valid one. The validity of a test examines whether the test measures what it is supposed to measure. In addition, the clinician must consider if the test is valid for the intended purpose. An outcome measure designed for patients with a total knee replacement may have questionable validity for patients with anterior cruciate ligament (ACL) reconstruction. There are several reports addressing the validity of functional measures for ACL patients[17,24] and total hip and knee replacement patients.[15,19]

A test should possess the ability to discriminate between the presence or absence of problems. The ability of a test to determine a positive test when the problem is present (true positive) is defined as sensitivity.[16] A negative test, when the problem is absent (true negative), is defined as specificity.[16] Both of these dimensions are desirable characteristics of a test. However, there is an inverse relationship between the two dimensions (sensitivity increase results in specificity decreasing). The dimension of the test should reflect the consequences of decisions made based on the test data. Combining several tests to assess function may serve to minimize any trade-offs between specificity and sensitivity.[16]

The practicality of functional outcome measures employed in the clinical/research setting is an important consideration. Jette[10] describes the following factors: the method of administration, time required to administer the tests, equipment required, special training for the examiners, and the nature of the scoring system. Selection or development of an evaluative tool will depend on all these factors. In addition, the intended purpose of the data should be considered. Whether the data will be used primarily for clinical or research purposes may influence the decision to select a functional measure. For example, comparison of data across several investigators or clinical sites requires the use of standardized assessment tools to create valid comparisons.

FUNCTIONAL OUTCOME MEASURES

A variety of measures have been established for a range of lower extremity problems. Oberg et al[15] provides a comprehensive review of instruments across a range of dysfunctions. Many authors describe activity rating scores[8,13,22] and performance testing[2,12,23] for use in assessing lower extremity dysfunction following knee ligament injury. Activity rating scales solicit qualitative and quantitative subjective information from the patient such as functional/recreational abilities, pain, swelling, instability, and level or intensity of activity. Performance tests are objective measures of unilateral, bilateral, and sport-specific activity.

Activity Rating

Activity grading scores may be used to compare several points in time (ie, preop to postop or pretreatment to posttreatment). Draper and Ladd[6] used the Lysholm scale to assess knee function and activity levels of patients with ACL-reconstructed knees. The athlete/patient responds to items on a questionnaire. Scores are calculated and recorded. The following examples are representative of activity rating scales used in the sports medicine literature to assess knee dysfunction resulting from ACL injury and/or surgery. The reader is encouraged to consult original reports for specific information.

Lysholm Score.[22] Patients/athletes rate eight dimensions and are assigned point values with a possible total score of 100 points. The dimensions assessed and maximal point values are as follows: limp (5 points), support (5 points), locking (15 points), instability (25 points), pain (25 points), swelling (10 points), stairs (10 points), and squatting (5 points). Quality dimensions for each category generally range between no problem to consistent limitation. For example, the range of points for stair climbing and squatting is 0 points for impossible and a maximal point value of 10 points for no problem with activity.

Activity Score.[22] Patients/athletes rate activity level on a scale of 0 to 10. Levels 6 through 10 describe recreational to competitive sports participation in activities requiring acceleration/deceleration and cutting (ie, soccer, basketball, hockey, and tennis). Levels 3 through 5 identify heavy vocational requirements and competitive recreational activities requiring straight plane activities (ie, cycling, jogging, and cross-country skiing). Levels 0 through 3 describe sick leave or disability pension secondary knee problems through light work/ambulatory requirements.

Subjective Knee Score Questionnaire. Wilk et al[24] used a questionnaire adapted from the work of Noyes et al[13] to study patients with ACL-reconstructed knees. Patients responded to questions regarding symptoms and sport activities pertaining to their knee. Categories along with maximum point values included: pain (20 points), swelling (10 points), stability (20 points), overall activity level (20 points), walking (10 points), stairs (5 points), running (10 points), and jumping and twisting activities (5 points). Levels within each category are based on scales with a range of abilities. For example, in the running category, 10 points are awarded for normal, unlimited, and fully competitive running, while 2 points are awarded for severe problems with only a few steps. Patients also rated their overall knee function on a scale of 1 to 100.

Several dimensions contribute to the construct defined as function. Factors that impact functional performance may include overall endurance, sport-specific skill, and psychological elements, in addition to the specific knee impairments. These factors may be hard to assess in the structured clinical setting and require the actual participation of the activity. Tegner and Lysholm[22] suggested that activity rating scores provide a good overall picture of knee function without restriction. Seto et al[18] reported that activity scores of patients with an ACL reconstruction were positively correlated with the ability to participate in sports. Activity scales provide both the clinician and the athlete the opportunity to assess the spectrum of knee performance in an unstructured environment. This data is an important component of the functional abilities of the individual.

The activity rating scales listed are based on scales with a range of abilities. For example, the Lysholm scale has four levels to describe the swelling dimension: none (10 points), on severe exertion (6 points), on ordinary exertion (2 points), and constant (0 points). The range of responses increases the sensitivity of the scale. The implications of swelling on severe exertion are different from swelling that is constant. Properly designed scales may provide qualitative and quantitative data about several aspects of knee function. Activity scales provide useful information regarding the functional status of the individual related to knee problems. The clinician must consider the level or intensity of the activity. Performance of certain functional abilities may suggest no limitations in the capabilities of the knee. However, the activity level may be decreased when compared to premorbid abilities, hiding the knee limitations.[13,22] Comparisons of functional status must be made at comparable levels of activity to be valid.

The appropriate selection of activity scales may be determined by the stage of the rehabilitation program. Risberg and Ekeland[17] reported high functional performance as determined by the Lysholm Score. However, 55% of the ACL patients tested had limitations performing strenuous activities. Data obtained from the Lysholm Scale appears to have limited ability predicting performance of activities such as running, jumping, and twisting. Based on this finding, the authors recommend the use of the Lysholm Score in the early phase of the rehabilitation program. Any scale should be examined for content validity before implementation; ie, it should contain the dimensions you wish to assess.

Performance Tests

Lower extremity dysfunction may be evaluated using unilateral and/or bilateral performance tests. Contrasts between the involved/uninvolved extremity, pretreatment/posttreatment, or normative data are possible. The following examples are representative of performance tests used in the sports medicine literature to assess knee dysfunction resulting from ACL injury and/or surgery. Summaries are presented and the reader is encouraged to consult the original reports for specific information.

Single-Leg Hop for Distance.[2,12] The athlete stands on one limb, hops as far as possible, and lands on the same limb. The distance obtained for each extremity is measured and used for comparison.

Timed Hop.[2,12] The athlete stands on one limb and then hops a distance of 6 m. The time is measured for each extremity and used to determine the symmetry index.

One-Legged Vertical Jump.[2] The athlete's bilateral standing reach is determined. The athlete performs a vertical jump and lands on the same extremity. The height is measured and recorded.

Triple Hop for Distance.[12] The athlete stands on one limb and performs three consecutive hops, landing on the same foot. The distance is measured for each extremity and used to determine the symmetry index.

Cross-over Hop for Distance.[12] The athlete hops three times on one limb over a 15-cm-wide center strip. The distance for each extremity is measured and used for comparison.

Bilateral lower extremity performance tests provide baseline data to assess change between test sessions. Normative data may also be available for contrast. Comparisons between uninvolved and involved limbs may be possible by considering the leg on which the athlete pivots to change direction. The following are some examples of bilateral functional measures for the lower extremity.

Shuttle Run.[2] The athlete completes two laps running around cones placed 6 m apart with the uninvolved leg on the inside. The test is repeated with the involved leg on the inside. In a variation of this test, the athlete runs, then stops, pivots on the uninvolved limb, and returns to the starting point. The same procedure is followed for the involved lower extremity. For both tests, Barber et al[2] recommends two laps with the time recorded in seconds and comparisons made.

Running in a Figure Eight.[17,23] The athlete runs in a figure eight of a predetermined distance. Tegner et al[23] employed a 20-m course, while Risberg and Ekeland[17] used circles with a diameter of 4 m. The time is recorded in seconds.

Running Up and Down a Staircase.[23] The athlete runs up and down a staircase one time, one step at a time. The time is recorded in seconds. Risberg and Ekeland[17] reports a variation of this, referred to as the stairs hopple test. This test is modified to be a unilateral test. The athlete hops up and down a staircase on the uninvolved, followed by the involved, lower extremity. The time for both tests is recorded in seconds. The stair hopple test allows comparisons between uninvolved and involved extremities.

All tests listed have minimal equipment needs and space requirements. The equipment required for the tests outlined are a stopwatch, cones, and tape. Space and surface requirements vary with the desired test and outcome. More complex systems interfaced with computers designed to assess functional performance are being used in the clinic and in research. One example is the CYBEX Fastex System (Division of Lumex, Jericho, NY), which enables the clinician to objectively assess a variety of unilateral and bilateral lower extremity parameters, such as reaction time, ground force time, transit speed stabilization time, ground time, and total movement time.

Functional or performance tests provide objective assessment of components of the athlete's ability in a structured, controlled setting. Skills assessed may include running, jumping, and cutting activities. The clinician must consider the stage of rehabilitation, status of the patient, surgical restrictions, and measurement outcome when selecting various tests. Data from the tests may then be used to identify problems or limitations. Patient goals are determined and the plan is designed to address appropriate goals. Data may be used to augment the decision about return to activity. To be valid, performance tests should correspond with the functional demands during rehabilitation through return to activity.

The clinician has the option of unilateral and bilateral lower extremity tests. Generally, the athlete's ability to perform unilateral tests is limited in the early phase of rehabilitation. Risberg and Ekeland[17] examined unilateral and bilateral tests to assess functional demands of patients with ACL-reconstructed knees. The bilateral tests (figure eight and stair running) were correlated with the daily life function and the unilateral tests (triple jump and stair hopple test) correlated with the strength and stability function. The daily life function represents the early phase of the rehabilitation sequence. The Lysholm score correlated with the bilateral tests supporting the ability of bilateral tests to assess the daily life function.[17]

Tegner et al[23] reported that several bilateral tests (turn-running component of the figure eight, stair running, and slope running) place greater demands on the knee. The authors reported only 35% to 46% of ACL-deficient patients were able to perform normally on these activities when compared to uninjured subjects. No difference was present in the straight-running segment or single-leg hopping. Methodological differences in the performance of the figure eight places different demands on the knee. A lazy figure eight (large diameter circles) does not require cutting as in a less circular pattern, thereby placing less demands on the knee.

The figure eight may be an appropriate assessment tool at different stages of the rehabilitation program. Progression of activities from a lazy figure eight with no cutting may be useful in the early phase of rehabilitation. Performance on a course with less of a circular (tear drop pattern) requires the athlete to quickly pivot and turn. This activity is a common component of many sport skills and is appropriate in the later stages of rehabilitation.

The clinician must be concerned with substitution and compensatory actions during the measurement of clinical parameters. Data obtained when the athlete substitutes may be of limited value in defining functional limitations. Barber reported that ACL-deficient patients compensated during the shuttle run by running at half speed and guarding both lower extremities. The ability to detect functional limitations was diminished because of the compensation.

Unilateral lower extremity tests were highly correlated with strength and stability dimensions described by Risberg and Ekeland.[17] The sensitivity of the four tests used by Noyes et al[12] (single-leg hop for distance, timed hop, triple hop for distance, and crossover hop for distance) was not sufficient to detect specific components dysfunction. However, the tests were able to identify asymmetry between involved and uninvolved lower extremities. Unilateral test data serves to provide confirmatory information, enhancing the clinical picture.[12]

Unilateral leg tests provide the opportunity to compare the uninvolved and involved limbs. Time or distance data may be compared between uninvolved and involved lower extremities. The symmetry index provides a useful guide to determine abnormal limb symmetry.[2,12] To determine the symmetry index, the mean value for the involved extremity is divided by the mean for the uninvolved extremity and multiplied by 100. Barber et al[2] reported 91% to 92% of normal subjects tested (the single-leg hop for distance and the one-leg hop for distance) obtained symmetry index scores of 85%. A symmetry index less than 85% may be considered abnormal.[2,12] The ability of performance tests to determine abnormal lower extremity symmetry does not appear to be affected by gender or limb dominance.[2]

Barber et al[2] and Noyes et al[12] reported a higher percentage of abnormal scores when two unilateral tests were combined compared to a single test (60% vs 42% to 50%) when assessing athletes with ACL-deficient knees. Wilk et al[24] reported similar percentages in ACL-reconstructed patients performing three similar tests. Noyes et al[12] assessed combinations of four tests (single-leg hop for distance, timed hop, triple hop for distance, and crossover hop for distance) and reported no difference in abnormal scores between the combinations. The clinical implications are that any combination of a minimum of two unilateral tests are necessary to determine lower extremity asymmetry.

Performance tests are performed in a controlled environment with minimal distractions. A limitation of performance tests is that the data do not provide a comprehensive picture of the athlete's overall abilities or limitations. Barber et al[2] reported that over half of ACL-deficient patients had normal scores on the one-leg hop test but reported limitations with sport activities. Athletes with normal performance test results may be at risk for limitations in performing more complex activities in an uncontrolled setting. Data from the clinical exam and activity rating scores should be combined to provide a comprehensive picture of the functional status of the athlete.

Intrarater and/or interrater reliability of data obtained from performance tests is an important consideration for the clinician. Booher et al[4] examined the reliability of three single-leg hop tests (hop for distance, 6-m hop for time, and 30-m agility hop) on 18 healthy subjects. Intraclass correlation coefficients (ICCs) ranged from .77 to .99, suggesting good reliability within this investigation. Oberg et al[15] reported gamma coefficients for interrater reliability ranging from .99 to 1.0 for total knee and hip patients. Shields et al[20] reported intratester reliability coefficients of .79 to .90 and intratester reliability coefficients of .48 to .78 for total hip and knee patients. However, reliability is specific to examiners and patient population. Examiners must adhere to the basic principles of test administration to maximize reliability.

Several sources of error can be controlled, thereby improving reliability of functional outcome performance tests. Appropriate calibration and maintenance of the equipment may serve to minimize measurement error due to mechanical problems. If the measure of interest is error-prone, a decision may be made as to the value of its use.[16] Careful planning, clear operational definitions, and standardization of test procedures can minimize the effect of additional sources of measurement error.[16] For example, appropriate practice/test trials and rest intervals must be established.

Based on research, there are several useful tests to assess components of function in ACL patients. Performance measures may be employed throughout the rehabilitation program based on abilities and goals of the patient. An example of a sequence over a rehabilitation program is as follows: 1) low-level bilateral test such as walking, lazy figure eight, and straight running; 2) unilateral activities such as single-leg hop for distance, timed hop, triple hop for distance, and crossover hop for distance; and 3) sport-specific skills that may include cutting, pivoting, and running at full speed.

The clinician/researcher must obtain a variety of information to accurately identify patient problems and set realistic goals. Data will enable the clinician to progress the athlete safely and efficiently through a rehabilitation program. Various assessment tools are available to the clinician. Careful selection of the appropriate dimensions to measure provides a clear and accurate clinical picture. It is beyond the scope of this paper to discuss all aspects of the clinical exam. Due to the emphasis on return to function, several components of the clinical exam are discussed in the context of the relationship with functional outcomes.

THE RELATIONSHIP BETWEEN IMPAIRMENTS AND FUNCTION

The Nagi[11] conceptual scheme for disability would classify symptoms and clinical signs as impairments that contribute to fictional limitations. Impairments such as pain, instability, or decreased range of motion and strength may contribute to the inability of the athlete to run, cut, jump, or perform other task-oriented activities. The primary concern of the athlete, coach, and parents is not specific to impairments, but rather "can they play?" Several reports in the literature describe the relationship between impairments and functional parameters.[1,3,7,14,17,18,23,24] The relationship between conventionally assessed impairments and function are briefly discussed below.

Stability

The relationship between functional abilities and knee joint stability is not clearly defined. Risberg and Ekeland[17] reported that the triple jump and the stair hopple test were correlated to instability determined by knee arthrometer measurements. Other researchers report that data obtained from clinical assessment of knee joint laxity does not reliably predict functional stability.[2,7,14,18,23] Noyes et al[14] suggests that the forces placed on the knee during a clinical exam are less than forces acting on the knee during activity. The data obtained from the clinical exam may not represent in vivo stability, thereby limiting validity of the measure to infer functional stability. Several researchers have supported this hypothesis.

Harter et al[7] examined ACL-reconstructed patients and concluded that patients' postoperative perceptions of function were not strongly correlated with elements of the clinical exam (instrumented measurement of ligamentous laxity, knee joint position sense, orthopedic clinical exam, isokinetic muscle testing). Seto et al[18] reported no significant relationship between objective instability and functional activity score in patients with an ACL-reconstructed knee. Barber et al[2] reported no significant relationship between arthrometer measurements and five functional tests (one-legged hop for distance, one-legged timed hop, one-legged vertical jump, shuttle run with pivot, and shuttle run without pivot). Assessment of knee laxity provides information related to the integrity of the ligament. However, clinical laxity tests may be limited in their ability to assess functional stability of the knee. The clinician must limit inferences about function with absence of additional data.

Isokinetic Testing

Isokinetic dynamometers are frequently employed in the clinical/research setting. The data derived from isokinetic testing provides reliable, objective assessment of a variety of parameters indicative of muscle performance. The relationship between isokinetic test data and functional performance is not clear. Several researchers report no relationship between isokinetic testing and sport skills.[1,5] Others report correlations between isokinetic data and functional test performance.[2,12,18,24]

Several researchers reported significant relationships between concentric quadriceps peak torque obtained at 60°/s and the single-leg hop test.[2,12] Seto et al[18] reported a significant correlation between quadriceps/hamstring concentric peak torque (obtained at 120°/s and 240°/s) and an activity rating scale in patients with intra-articular ACL reconstructions. Wilk et al[24] reported a significant, positive correlation between concentric peak torque of the quadriceps at test speeds of 180°/s and 300°/s and functional testing. Activity rating scales also correlated with isokinetic measures of quadriceps performance. There did not appear to be a relationship between hamstring peak torque and function.[18,24]

The method of isokinetic data acquisition is an important consideration. Data obtained through reciprocal testing protocols provides appropriate neural input to the lower extremity.[24] Based on the results of this and other studies, measures of quadriceps peak torque obtained through reciprocal testing at test speeds of 180°/s and 300°/s may provide the most valid indicators of functional performance. Measures of acceleration and deceleration may provide additional information.

Additional measures of proprioception[3] and girth[17] have been reported in the literature. Measures of impairments may provide meaningful data about functional status. However, the construct of function is multifaceted and requires assessment across several dimensions to allow valid inferences to be made about functional status.

DOCUMENTING FUNCTIONAL OUTCOMES

Functional outcome reporting should include information that identifies the tolerance of the individual to the activity, endurance considerations, and the level of desired performance.[21] There are several ways to document functional outcomes related to performance test or specific skill requirements. The following example involving a basketball player returning from ACL reconstruction will illustrate the reporting of functional outcomes at different periods during the rehabilitation process. The functional assessment is presented along with a corresponding goal: a) Single-leg hop for distance: unaffected side 40 inches and affected side 32 inches with pain in the affected knee during landing (symmetry index: $32/40 \times 100 = 80\%$). An example of a 2-week goal could be that the athlete will reach 36 inches (symmetry index: 90%) with the affected extremity while performing the single-leg hop for distance with no pain. b) Figure-eight run: performed an 8-m figure eight with minimal guarding during cutting to the affected side in 10 seconds. An example of a 2-week goal could be that the athlete will perform two consecutive figure eights with no guarding during turning to the affected side in 18 seconds. The basic concepts of documenting functional outcomes and determining appropriate goals may be applied to sport-specific skills. An example of assessment of a basketball layup: limitations and guarding during jumping and landing phase with the involved lower extremity for a single layup. An

Structure of an Outcome Oriented Clinical Report: An Example of a Program for Post-Op ACL Reconstruction Patients

Strategic program outcomes	Independent ambulation with no deviations in gait on level surfaces and stairs Return to recreational/vocational activities ROM and strength within normal limits
Program-specific data base	Stability (KT-1000, clinical exam) Isokinetic test Performance tests Unilateral +/or bilateral tests as appropriate Sport-specific tests Activity rating scales Functional and sport level
Generic screening data	A/PROM and strength lower extremities—bilateral Gait: Level surfaces and stairs Strength of bilateral upper extremities Skin and soft tissue Pain

example of a 3-week goal could be the athlete will perform 10 consecutive layups with the involved lower extremity with no limitations or guarding. An example of the organizational structure of a functional outcome report for an ACL reconstruction patient is presented in the Table.

CONCLUSIONS

There does not appear to be a universal measure of function for athletes with lower extremity dysfunction. The clinician should consider choosing tests that assess meaningful, practical, and sustainable functional measures in reliable and practical ways. Functional outcome measures provide the clinician with significant data that contribute pieces of meaningful information to the complex patient puzzle. Functional outcome data, a careful history, thorough physical examination, and consideration of the athlete's goals and expectations are all components of the clinical decision-making process to assure a safe and expedient return to athletic participation.

REFERENCES

1. Anderson MA, Gieck JH, Perrin D, Weltman A, Rutt R, Denegar C. The relationships among isometric, isotonic, and isokinetic, concentric and eccentric quadriceps and hamstring force and three components of athletic performance. *J Orthop Sports Phys Ther.* 1991;14:114–120.
2. Barber SD, Noyes FR, Mangine RE, McCloskey JW, Hartman W. Quantitative assessment of functional limitations in normal and anterior cruciate ligament-deficient knees. *Clin Orthop.* 1990;255:204–214.
3. Barrett DS. Proprioception and function after anterior cruciate reconstruction. *J Bone Joint Surg Br.* 1991;73B:833–837.
4. Booher LD, Hench KM, Worrell TW, Stikeleather J. Reliability of three single-leg hop tests. *J Sport Rehabil.* 1993;2:165–170.
5. Delitto A, Irrang JJ, Harner CD, Fu FH. Relationship of isokinetic quadriceps peak torque and work to one-legged hop and verticle jump in ACL reconstructed knees. *Phys Ther.* 1993;73:S85.
6. Draper V, Ladd C. Subjective evaluation of function following moderately accelerated rehabilitation of anterior cruciate ligament reconstructed knees. *J Athl Train.* 1993;28:38–41.
7. Harter RA, Ostering LR, Singer KM, James SL, Larson RL, Jones DC. Long-term evaluation of knee stability and function following surgical reconstruction for anterior cruciate ligament insufficiency. *Am J Sport Med.* 1988;16:434–443.
8. Insall JN, Dorr LD, Scott RD, Scott WN. Rationale of the knee society clinical rating system. *Clin Orthop.* 1989;246:13–14.
9. Jenkins CD. Assessment of outcomes of health intervention. *Soc Sci Med.* 1992;35:367–375.
10. Jette AM. Using health-related quality of life measures in physical therapy outcomes research. *Phys Ther.* 1993;73:528–537.
11. Jette AM. Approaches to determining and measuring functional limitations and disability. Presented at Design and Management of Outcomes/Effectiveness Research in Physical Therapy; Oct 1992:23–24. Alexandria, VA.
12. Noyes FR, Barber SD, Mangine RE. Abnormal lower limb symmetry determined by function hop tests after anterior cruciate ligament rupture. *Am J Sport Med.* 1991;19:513–518.
13. Noyes FR, Barber SD, Mooar LA. A rationale for assessing sports activity levels and limitations in knee disorders. *Clin Orthop.* 1989;246:238–249.
14. Noyes FR, Grood ES, Butler DL, Malek M. Clinical laxity tests and functional stability of the knee: biomechanical concepts. *Clin Orthop.* 1980;146:84–89.
15. Oberg U, Oberg B, Oberg T. Validity and reliability of a new assessment of lower-extremity dysfunction. *Phys Ther.* 1994;74:861–871.
16. Portney LG, Watkins MP. *Foundations of Clinical Research: Applications to Practice.* Norwalk CT: Appleton and Lange. 1993;53–67.
17. Risberg MA, Ekeland A. Assessment of functional tests after anterior cruciate ligament surgery. *J Orthop Sports Phys Ther.* 1994;19:212–217.
18. Seto JL, Orofino AS, Morrissey MC, Medeiros JM, Mason WJ. Assessment of quadriceps/hamstring strength, knee ligament stability, functional and sports activity levels five years after anterior cruciate ligament reconstruction. *Am J Sport Med.* 1988;16:170–180.
19. Shields RK, Enloe LJ, Evans RE, Smith KB, Steckel SD. Reliability, validity, and responsiveness of functional tests in patients with total joint replacement. *Phys Ther.* 1995;75:169–179.
20. Swanson G. Outcomes-oriented approach to physical therapy care. Presented at Managing Your Physical Therapy Practice: An Outcomes-Oriented Approach; July 21–22, 1995; Cambridge, MA.
21. Swanson G. Functional outcome report: the next generation in physical therapy reporting. In: Stewart DL, Abeln SH, eds. *Documenting Functional Outcomes in Physical Therapy.* St Louis, MO: Mosby-Year Book; 1993:101–134.
22. Tegner Y, Lysholm J. Rating systems in the evaluation of knee ligament injuries. *Clin Orthop.* 1985;198:43–49.
23. Tegner Y, Lysholm J, Lysholm M, Gillquist J. A performance test to monitor rehabilitation and evaluate anterior cruciate ligament injuries. *Am J Sport Med.* 1986;14:156–159.
24. Wilk KE, Romaniello WT, Soscia SM, Arrigo CA, Andrews JR. The relationship between subjective knee scores, isokinetic testing, and functional testing in the ACL-reconstructed knee. *J Orthop Sports Phys Ther.* 1994;20:60–73.