Relationship between Selected Physical Characteristics and Functional Capacity in the Anterior Cruciate Ligament-Insufficient Athlete

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Traditionally, clinicians have utilized various physical characteristics as criteria to assess the functional status of anterior cruciate ligament (ACL)-insufficient athletes without validating the efficacy of such assessments. The primary purposes of this study were to determine the relationship between traditionally used physical characteristics and functional capacity of individuals with an ACL insufficiency and to compare functional results of two groups of ACL-insufficient athletes. Forty-one subjects were tested for strength and power on an isokinetic device, anthropometric characteristics, and function using three functional performance tests (FPT). Results revealed that conventional physical characteristics correlated poorly ($r = .01$ to $r = .42$) with the functional tests. Additionally, athletes who were able to return to preinjury levels of activity performed significantly ($p < 0.05$) better on the FPT than those who were unable to return to preinjury activities. Based on the results of this study, use of such traditional physical characteristics for predicting function in the ACL-insufficient athlete may be inappropriate, and the functional performance tests designed for this study appear to be the most valuable assessment of the athlete's functional capacity.

Key Words: *ACL insufficient, assessment, function*

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Little research has examined the relationship between physical characteristics such as strength, joint laxity, range of motion, muscular girth, and functional capacity of the anterior cruciate ligament (ACL)-insufficient knee (4, 5, 10, 12). This dearth of literature has contributed to inconsistencies in both evaluation and rehabilitation, while adversely affecting the determination of the functional capacity of the athlete with an ACL insufficiency. Because incomplete data exist regarding the relationship between these physical characteristics and functional capacity, the efficacy of the various protocols currently employed for the management of the condition is uncertain. Moreover, without guidance from the literature, controversy regarding the variables that influence functional disability most has resulted in inconsistencies in management for the ACL-deficient athlete (1, 6, 7, 17, 18, 20–22, 24).

Several factors confound a clear understanding of the relationship between function and strength, laxity, range of motion, and thigh girth. First, assessment of joint laxity has heretofore been limited to manual examinations having varying levels of accuracy and reliability. Second, documentation of muscular performance characteristics of the ACL-insufficient knee is limited. Finally, definitions of adequate "function" of the ACL-insufficient knee have been limited to patient self-assessment, using criteria that are subjective and often inappropriate due to their lack of sensitivity to the functional demands of an athlete (12, 16, 17, 22).

Relative to subjects with ACL-deficient knees, the purposes of this study were to: *1*) compare the involved and uninvolved knees using selected physical impairment variables; *2*) determine the relationship between involved/uninvolved physical impairment deficit measures and five different functional tests; and *3*) compare the functional test results between one group of athletes who were able to return to competition and another group of athletes who were not.

METHODS

Subjects

Forty-one subjects (32 male, 9 female) participated in the study. Subjects were selected to participate in the study from the University of Pittsburgh Sports Medicine Program and the Sports Medicine Institute of Presbyterian University Hospital, Pittsburgh, PA. Criteria for subject selection included the following: *1*) the injury had occurred within the previous 10–36 months, *2*) an orthopaedic surgeon had made assessment of a positive Lachman and pivot shift tests as described by Katz et al (10), and *3*) the involved knee had to possess >5 mm of anterior knee joint laxity compared to the uninvolved knee as determined with a KT-1000. Additional criteria for participation in the study included absence of medial or lateral laxity, absence of surgery, completion of a consistent rehabilitation program, and attempt by the subject to return to preinjury levels of athletic activity. All subjects were in a subacute injury stage when tested. All subject testing occurred during a 1-week period, and only subjects meeting the aforementioned inclusion criteria were included in the study.

The subjects' ages ranged from 16 to 32 years (mean = 22.7 yrs), and the mean postinjury time was 26.5 months. Twenty-one of the subjects reported that they had experienced a recurrent injury to the knee, while 29 subjects reported that they had returned to a preinjury level of activity. Subjects were subgrouped into a Return ($N = 29$) group if they indicated they had returned to preinjury levels of activity and an Unable to return ($N = 12$) group if they were unable to return to preinjury levels of activity.

Procedure

Data collection for each subject occurred over a successive 2-day period; 1 day involved the measurement of the selected physical characteristics, and the next day an evaluation was made of functional performance. The variables measured included anterior knee joint laxity, quadriceps and hamstring muscle-group peak torque, torque acceleration energy, peak torque ratios of the quadriceps/hamstrings at 60 and 270 °/sec, knee joint range of motion, and circumferential thigh girth measurements. Function was assessed via the Iowa Athletic Knee Rating Scale (IAKS) (22) and three functional performance tests designed exclusively for this study.

> ***Several factors confound a clear understanding of the relationship between function and strength, laxity, range of motion, and thigh girth.***

Measurement of Laxity

Anterior knee laxity was measured using the instrumented knee joint arthrometer MEDmetric Arthrometer Model KT-1000 (MEDmetric Corporation, San Diego, CA). The purpose of this measurement was to quantitatively measure the anterior knee joint laxity of the ACL-insufficient knee. The test protocol described by Daniel et al was used for measurement of joint laxity (2). Laxity was measured under 20 lbs of anterior force. The KT-1000 has been reported to be 90% accurate for ACL diagnosis, with sufficiently high test-retest reliability (2, 23).

Measurement of Muscular Strength and Power

Quadriceps and hamstring muscle-group peak torque, torque acceleration energy (TAE), and reciprocal muscle group ratios were obtained with a Cybex II isokinetic dynamometer (Lumex, Inc., Ronkonkoma, NY) at speeds of 60 and 270 °/sec, respectively. The TAE is defined as the work performed in the first 1/8 second of muscle contraction (8) and has been shown to be highly related to traditional power measurements (11). The isokinetic device was calibrated prior to testing.

Subjects were seated in the standard and upright positions and stabilized by securing straps at the mid-thigh, waist, and chest (3, 8). A dual-pad Cybex anti-shear device was employed to decrease the shearing or anterior translation of the tibia, which is associated with isokinetic knee extension in the ACL-insufficient knee (9). Each subject performed six trial repetitions (three submaximal and three maximal) at 60 and 270 °/sec, followed by six maximal test repetitions. The order of testing was randomized with respect to involved and uninvolved limbs. Peak torque, TAE, and reciprocal muscle-group ratios were determined with a Cybex Data Reduction Computer (CDRC) (Lumex, Inc., Ronkonkoma, NY).

Measurement of Thigh Circumference

Thigh girth measurements of both extremities were obtained using a standard circumferential measurement tape while the subjects were nonweight bearing (14). Measurements of circumference were taken 4 and 9 in proximal to the medial joint line. The purpose of these thigh circumference measurements was to determine if any thigh muscular atrophy existed in the subject's involved extremity.

Measurement of Knee Joint Range of Motion

Active knee joint flexion and extension were assessed through standard goniometry (14). Both flexion and extension were measured with the subject in the prone position.

Rating of Activity Status

The IAKS was used to assess each subject's activity status (Table 1). The test consisted of two separate assessments totaling 100 points. A 60-point questionnaire was employed that explored subjective symptoms of pain, swelling, instability, giving way, and activity status. An objective orthopaedic examination was performed, and points were assigned (40 total) based on laxity, pain, swelling, and joint ROM (22).

The IAKS was devised to provide a stringent measurement of function (22). Therefore, the scale was sensitive to a wide variation of total scores determined by the degree of functional incapacity experienced by each subject. Even the slightest functional incapacity was detected because a perfect score of 100 could only be obtained if the athlete was functioning without any disability at a professional level (22).

Measurement of Functional Performance

The functional performance tests (FPT) were used to obtain an objective measurement of function by reproducing the activities required to perform common sports skills (12). The tests included a cocontraction semicircular maneuver, a carioca maneuver, and a shuttle run. The tests were designed to produce rotational forces at the knee, tibial subluxation, and acceleration and deceleration, respectively (12). Test-retest reliability values for these tests range from $r = .92$ to $r = .96$ (12).

The cocontraction test (Figure 1) was performed by securing a Velcro® belt around the athlete's waist. The belt was attached to a heavy 122 cm length of rubber tubing with an outer diameter of 2.54 cm (Rehab Tubing, Pro Orthopedic Devices, Inc., Tucson, AZ). The tubing was anchored to a metal loop that was secured on a wall 154 cm above the floor. A semicircle was painted on the floor, which had a radius of 244 cm from the metal loop. The subject stood facing the wall with the toes of his/her feet on the line. This stretched the tubing 122 cm beyond its recoil length. The cocontraction test required each subject to complete five wall-to-wall lengths of the 180° semi-circle, with the tension applied to the overstretched rubber tubing. The subjects began the test on the right side of the semicircle and moved in a side-step or shuffle fashion to complete the five lengths (three lengths right-to-left, two lengths left-to-right) in the minimum amount of time possible.

There was a lack of any strong correlation between the involved extremity physical characteristics and the functional tests.

Parameter	Total Points
SUBJECTIVE	
Symptom	
Pain	10
Swelling	10
"Instability"	10
Symptom total	30
Activity status	
Athletic	10
Work	20
Activity status total	30
OBJECTIVE	
Physical examination	
Laxity	21
ROM	2
Synovitis	3
Crepitus	3
Hamstring control	11
Physical exam total	40
TOTAL	100

TABLE 1. *Iowa Athletic Knee Rating Scale.*

FIGURE 1. *Cocontraction test. The athlete moves in a side-step or shuffle fashion around the periphery of the semicircle.*

The carioca test (Figure 2) required the subjects to move laterally with a cross-over step. The test was performed over two lengths of a 12-m distance. The subject began moving from left to right and reversed direction following the first 12-m length, thus performing the test moving a total of 24.5 m in the minimum amount of time possible.

The shuttle run test was performed by the athlete running four lengths of 6.1 m. Subjects ran 6.1 m, touched a line on the floor with their foot, reversed direction, returned to the starting point, touched the line, and repeated the process. The complete test covered 24.4 m with three changes in direction.

The criterion measurement for all three tests was elapsed time, which was measured using a handheld stop watch. Each subject performed three trials on all tests, and the fastest time was recorded as the score for each of the three tests. The sum of the best time on each test was the total FPT score.

Analysis

Analysis of the data included computation of mean values for laxity, strength, girth, and range of motion. To examine for statistically significant differences between involved and uninvolved measurements, the data were then analyzed using analysis of variance (ANOVA). To establish the relationship among physical characteristics and functional capacity, the data were next analyzed using a Pearson product moment correlation coefficient. The final purpose of the statistical analysis included determining if differences existed in the functional performance tests and IAKS between subjects who had returned to a preinjury level of competition and those who had been unable to return. Subjects were assigned to either a "Return" group or to an "Unable to return" group. A one-way ANOVA was then computed to determine significant differences on both the functional performance tests and the IAKS for the two groups.

FIGURE 2. *Carioca test. The athlete moves laterally using an alternating cross-over step.*

RESULTS

Bilateral comparisons for all isokinetic strength, joint laxity, circumferential, and range of motion measurements are presented in Table 2. The analyses revealed significant involved extremity deficits for several comparisons, including quadriceps extension and hamstring flexion peak torque (60 and 270 °/sec). Involved extremity reciprocal muscle group peak torque ratios were significantly higher than uninvolved ratios at 60 °/sec. Statistically significant differences were not found for TAE between involved and uninvolved sides during knee extension and flexion at either speed. Differences in anterior knee joint laxity were significant, with the involved extremity displaying greater laxity than the uninvolved extremity on passive anterior tibial displacement of 20 lbs.

There was a lack of any strong correlation between the involved extremity physical characteristics and the functional tests (Table 3). The highest correlations were observed between the shuttle run test and several involved extremity measurements, including knee extension (quadriceps) peak torque at 60 ($r = -.42$, $p < .05$) and 270 °/sec ($r = -.41$, $p < .05$), knee extension TAE at 270 °/sec ($r = -.38$, $p < .05$), and knee flexion (hamstrings) TAE at 270 °/sec ($r = -.34$, $p < .05$). Other significant correlations were observed between involved extremity knee (hamstring) flexion TAE at 270 °/sec and the shuttle run ($r = -.42$, $p < .05$), the cocontractions test ($r = -.33$, $p < .05$), and the total FPT ($r = -.32$, $p < .05$). Finally the IAKS correlated significantly with the total FPT ($r = -.49$). No significant correlations were observed between any of the functional tests and any of the bilateral deficits (Table 4).

To examine for differences in function between those who were able to return to preinjury levels of activity and those who were not, subjects were assigned to one of two groups (Return, $N = 29$; Unable to return, $N = 12$). Table 5 reveals the differences between the Return and Unable to return groups for each

Characteristic	Extremity	
	Involved	Uninvolved
Hamstring peak torque (60°/sec)	105.90 ± 27.12	114.18 ± 33.76†
Quadriceps peak torque (60°/sec)	187.13 ± 50.17	211.40 ± 55.19‡
Hamstring peak torque (270°/sec)	71.60 ± 21.70	75.53 ± 23.19*
Quadriceps peak torque (270°/sec)	103.60 ± 34.98	108.07 ± 32.82*
Hamstring TAE (60°/sec)	5.70 ± 2.44	6.51 ± 2.85
Quadriceps TAE (60°/sec)	7.86 ± 2.98	8.81 ± 3.53
Hamstring TAE (270°/sec)	29.97 ± 8.41	31.59 ± 9.09
Quadriceps TAE (270°/sec)	38.65 ± 12.75	40.68 ± 10.98
Quad/Ham peak torque (60°/sec)	81.22 ± 29.29	75.26 ± 25.51*
Quad/Ham peak torque (270°/sec)	99.53 ± 27.26	95.73 ± 20.34
Anterior joint laxity	8.6 ± 2.8	2.5 ± 2.0†
Thigh circumference (10 cm)	39.6 ± 3.9	40.0 ± 3.9
Thigh circumference (23 cm)	51.7 ± 4.7	52.3 ± 4.2
Knee extension ROM	2.4 ± 2.8	1.4 ± 1.8
Knee flexion ROM	126.5 ± 6.2	126.5 ± 6.9

Peak torque values are mean (Nm) ± SD. Torque acceleration energy (TAE) values are mean (Nm) ± SD. Quadricep/hamstring peak torque values are mean (%) ± SD. Anterior joint laxity values are mean (mm) ± SD. Thigh circumference values are mean (cm) ± SD. Knee flexion and extension values are mean (°) ± SD.

* $p < .05$.

† $p < .01$.

‡ $p < .001$.

TABLE 2. *Isokinetic strength and joint laxity values for involved and uninvolved extremities.*

	Physical Characteristics										
	H PT 60°/sec	Q PT 60°/sec	Q TAE 60°/sec	H TAE 60°/sec	Q/H PT 60°/sec	H PT 270°/sec	Q PT 270°/sec	Q TAE 270°/sec	H TAE 270°/sec	Q/H TAE 270°/sec	Laxity
Shuttle run†	−.23	−.42*	−.30	−.10	.23	−.28	−.41*	−.38*	−.34*	.20	−.23
Carioca†	−.22	−.30	−.17	−.11	.09	−.19	−.27	−.25	−.27	.12	−.27
Cocontraction†	−.16	−.20	−.19	−.01	.07	−.20	−.30	−.27	−.33*	.19	−.21
Total FPT‡	−.20	−.29	−.20	−.06	.11	−.21	−.32	−.29	−.32*	.18	−.26
Iowa Athletic Knee Rating Scale†	.17	.15	.26	.24	−.04	.09	.13	.23	.22	−.10	.14

*$p < .05$.
† *Criterion measurement is 100 total points.*
‡ *Criterion measurement is time.*
Hamstring (H). Quadriceps (Q). Peak torque (PT). Torque acceleration energy (TAE). Functional performance tests (FPT).

TABLE 3. *Correlation coefficients between involved extremity physical characteristics and functional tests and Iowa Athletic Knee Rating Scale.*

	H PT 60°/sec	Q PT 60°/sec	H TAE 60°/sec	Q TAE 60°/sec	H PT 270°/sec	Q PT 270°/sec	H TAE 270°/sec	Q TAE 270°/sec
Shuttle run†	−.09	.05	−.14	−.32	.03	.08	.01	.20
Carioca†	−.02	.05	−.06	−.20	.04	.03	−.06	.17
Cocontraction†	−.19	−.14	−.14	−.31	.31	.12	−.07	.05
Total FPT†	−.11	−.03	−.11	−.27	.07	.02	−.06	.14
Iowa Athletic Knee Rating Scale*	−.28	−.23	−.04	−.10	−.25	−.01	−.32	−.07

* *Criterion measurement is 100 total points.*
† *Criterion measurement is time.*
Hamstring (H). Quadriceps (Q). Peak torque (PT). Torque acceleration energy (TAE). Functional performance tests (FPT).

TABLE 4. *Correlation coefficients between physical characteristic deficits and functional tests.*

Functional Test	Group	
	Return	Unable to Return
Total FPT (sec)	31.03 ± 5.50	47.83 ± 28.75†
Iowa Athletic Knee Rating Scale (100 pts)	80.17 ± 7.48	62.65 ± 8.71‡
Shuttle run (sec)	7.45 ± .82	9.67 ± 3.18†
Carioca (sec)	8.54 ± 1.93	17.31 ± 14.33†
Cocontraction (sec)	14.96 ± 4.48	20.70 ± 12.42*

Return group (N = 29). Unable to return group (N = 12).
*$p < .05$.
†$p < .01$.
‡$p < .001$.
Functional performance tests (FPT).

TABLE 5. *Scores on functional performance tests for subjects returning to competition and those unable to return post ACL injury.*

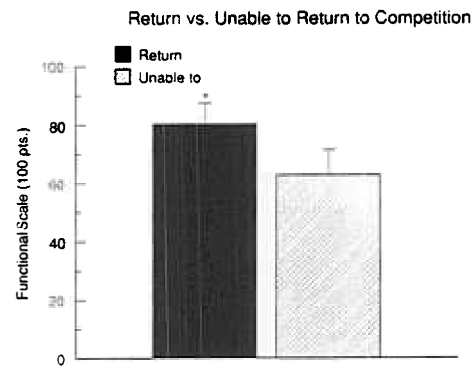

FIGURE 3. *Functional Scale Scores for Return and Unable to return activity groups. Asterisk denotes significant ($p < 0.05$) differences. T denotes SD.*

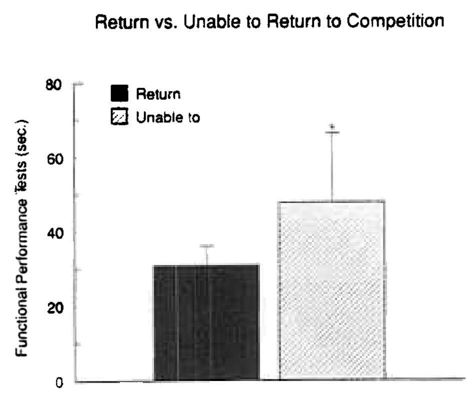

FIGURE 4. *Functional Performance Test for Return and Unable to return to activity groups. Asterisk denotes significant ($p < 0.05$) differences. T denotes SD.*

functional measure. The Return group scored significantly better on the IAKS and on all the functional performance tests. Figures 3 and 4 illustrate the group mean differences for the IAKS and the FPT between the Return and Unable to return groups.

There were no significant differences observed between male and female subjects for the variables assessed. Of the nine females in the study, six were in the Return group while three were in the Unable to return group.

DISCUSSION

The isokinetic peak torque deficits in the ACL-insufficient extremity during both knee extension and flexion at both testing speeds were consistent with the findings of Tibone et al (21). Furthermore, Giove et al (7) and McDaniel and Dameron (13) both stated that deficits in strength must be overcome for successful return to preinjury levels of function. As a result, many currently employed rehabilitation protocols focus on the attainment of bilateral strength equivalency as criteria for return to competition. Based on the peak torque deficits identified in this study, such rehabilitation objectives are reasonable. However, clinicians should realize that peak torque deficits are not necessarily related to an athlete's functional capacity. The data presented suggest that neither hamstring nor quadriceps peak torque deficits were highly related to functional performance. Therefore, bilateral peak torque measurements used exclusively as criteria for return to activity in the ACL-insufficient athlete are inadequate. More appropriately, the strength deficits should be addressed during rehabilitation but should not be used solely for the assessment of the athlete's functional level. Rather, the assessment of the athlete's functional level should also include functional tests specific to the athlete's sport.

Although the anterior knee joint laxity was significantly higher on the involved knee in the subjects in this study, these deficits were not found to be related to the functional capacity of the athlete. This finding suggests that the capacity to dynamically compensate for the ACL insufficiency is not necessarily related to the amount of static laxity present in the knee.

The subjects did not present significant differences between involved and uninvolved extremity range of motion measurements. Furthermore, there were no differences in thigh circumference measurements. Thus, thigh circumference deficits were not related to deficits in peak torque in these subjects, and the use of bilateral circumferential measurements as a criterion for assessing bilateral strength equivalence would be inappropriate in these subjects.

Consistent with Walla et al, relatively poor relationships were observed between the selected physical characteristics and the functional measurements that were assessed (22). The poor relationship between the selected physical characteristics and function suggests that these variables did not influence the functional capacity of subjects participating in this study. The role of the thigh musculature in dynamic stabilization of the knee has been suggested previously by Giove et al (7) and McDaniel and Dameron (13). However, the results of this investigation may suggest otherwise. On the other hand, the poor relationships observed in this study may be attributed to the manner in which the assessments of muscular characteristics have been obtained. Isokinetic testing occurs in an open kinetic chain system with muscular assessment from a nonweight-bearing state (15). It is suggested that the use of such instrumentation is inappropriate to assess the compensatory role of this musculature due to the inability to reproduce tibial-femoral translation when the athlete is not in a closed kinetic chain system or weight-bearing state. Furthermore, the assessment of muscular characteristics using an open kinetic chain isokinetic device in this study was limited to isokinetic concentric assessments only. The dynamic compensation of the ACL-insufficient knee occurs, presumably, with the musculature functioning isometrically and eccentrically, as well as concentrically. Therefore, in order to accurately assess the compensatory effects of the thigh musculature, development of an instrument that more closely simulates the activities in which the compensation occurs would seem indicated.

This study suggests that the strengthening objectives of rehabilitation and the existing criteria used to return the athlete to competition are not necessarily synonymous.

Consistent with previous statements regarding the open kinetic chain isokinetic assessments, the Medmetric K-T 1000 instrumented arthrometry values were similarly obtained. Additionally, these assessments of static laxity were made with near complete muscular relaxation. The static laxity assessments provide a quantitative measure of the amount of anterior tibial-femoral translation but fail to assess the role of the secondary restraints. Furthermore, the role of the musculature in dynamically controlling tibial-femoral subluxation in the ACL-insufficient athlete remains in question.

The mean quadriceps and hamstring reciprocal muscle group peak ratios for both the involved and uninvolved extremities were found to be consistent with previous studies that reported the ratios to range from 43 to 90% in normal nonathletic populations (16). Furthermore, the quadriceps and hamstring reciprocal muscle group peak torque ratios for both the involved and uninvolved sides were consistent with reports on normal football players averaging 54% at the test speed of 60 °/sec and 66% at the test speed of 240 °/sec (19). While little research exists regarding the reciprocal muscle-group peak torque ratios in the ACL-insufficient athlete, Giove et al stated that hamstring muscular strength equal to quadriceps strength of the involved extremity allowed athletes to return to higher levels of sport participation (7).

The data presented here suggest

that the quadriceps/hamstring reciprocal muscle group peak torque ratios were not highly related to the functional capacity of the subjects and, therefore, may have little influence on ability to return to activity. As stated previously, the true compensatory effects of the hamstring musculature are not assessed while the athlete is in a nonweight-bearing state. Therefore, the recommendations suggesting the development of a substantially high quadriceps/hamstring strength ratio cannot be discarded when the objective is dynamic control of anterior translation of the tibia in the ACL-insufficient athlete.

The three FPT were intended to provide an objective instrument for the clinician to assess functional capacity in the ACL-insufficient athlete. The FPT attempted to simulate stresses about the knee commonly encountered during athletic participation. Thus, high levels of performance in these tests should be related to a return to preinjury levels of activity. The results of this investigation substantiate this expectation. Subjects who returned successfully to athletic competition scored significantly higher on the FPT than those who were unable to return to preinjury levels of competition. Thus, it is suggested that the clinician implement these FPT in establishing criteria for return to competition. The FPT allow the clinician to objectively quantify performance while also visually assessing factors such as running gait, compensation, and apprehension.

Questionnaires such as the IAKS have been designed to assess function of an athlete in a subjective manner. While the IAKS relies predominantly on a subjective assessment of function, it was nonetheless found to relate closely to actual functional capacity. Subjects who returned to preinjury levels of competition scored significantly higher on the IAKS than subjects who were unable to return. The IAKS was also highly related to the FPT. These findings suggest that an athlete's perception of functional capacity is an important component of the overall criteria for return to activity.

There continues to be inconsistency in the prescription of therapeutic exercise for the athlete suffering from an ACL insufficiency. In addition to these discrepancies, inconsistency exists with regard to criteria for return to activity. McDaniel and Dameron suggest that dynamic muscular control is necessary for return to functional levels (13). However, little research has established the efficacy of functional performance testing in the assessment of adequate dynamic muscular stability. Giove et al suggested that one criterion for return to activity is that the injured extremity hamstring strength be at least equal to the quadriceps muscle group strength (7). Somewhat similarly, Walla et al suggested that a "hamstring reflex" is necessary in order to function at high levels of activity (22). The recommendation of Walla et al seems reasonable, but this assessment is subjective in nature and occurs in an open kinetic chain, which does not assimilate the stresses placed on the knee while competing.

This study suggests that the strengthening objectives of rehabilitation and the existing criteria used to return the athlete to competition are not necessarily synonymous. The objective of regaining normal thigh muscular strength, particularly of the hamstring muscle group, is a reasonable goal. Previous research has found these strength deficiencies in ACL-insufficient athletes. Furthermore, a fundamental understanding of the role of the hamstring musculature in controlling anterior tibial translation is clear. However, this study failed to establish a relationship between involved extremity peak torque deficits and functional capacity.

CONCLUSION

Based on the findings of this investigation it has been proposed that a combination of functional performance tests and an athlete self-assessment of readiness to return to competition be used as the criteria for return to activity. The IAKS was found to be highly related to ability to return to preinjury levels of activity. The test included a number of assessments, such as subject signs and symptoms due to the insufficiency, perception of functional capacity, and an orthopaedic assessment of physical status. The combination of the IAKS and the FPT designed for this study seemed to best represent an athlete's capacity to return to competition.

As a result of the findings in this study, the use of peak torque, laxity, thigh circumference, and various other nonfunctional criteria are not recommended as the primary criteria in determining an ACL-insufficient athlete's readiness to return to competition. Once normative values have been established for the functional performance tests and the IAKS specific to the various sports, the clinician will have resources available to objectively assess the functional capacity of the athlete utilizing tests that reproduce the stresses placed upon the knee which the ACL-insufficient athlete must compensate for during competition.

JOSPT

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