

A New Rating Scale for the Rapid Evaluation of High-Level Sports Ability

Jiebo Chen,* MD, Eunshinae Cho,* BM, Caiqi Xu,* MD, and Jinzhong Zhao,*[†] MD

Investigation performed at the Department of Sports Medicine, Shanghai Jiao Tong University Affiliated Sixth People's Hospital, Shanghai, China

Background: Nearly half of patients with an anterior cruciate ligament (ACL) injury who have returned to sport after ACL reconstruction can return to sports activity at a competitive level, so emphasis should be focused not only on the timing of return to the sport but also on measuring the ability to participate in high-level sports activity.

Purpose: To develop and evaluate a new, self-administered rating scale for rapid evaluation of high-level sports ability among community-level athletes who return to sports after ACL reconstruction surgery.

Study Design: Cohort study (diagnosis); Level of evidence, 2.

Methods: We developed the new rating scale—the Knee Stability in Sports/Cutting-Pivoting Ability (KSS/CPA) scale—in 2 stages. Initially, we used a survey and roundtable discussion to achieve an expert consensus for the KSS/CPA scale from a group of independent orthopaedic experts. Next, 77 amateur athletes who underwent ACL reconstruction by a single surgeon were recruited for a background analysis of data to compare the new scale with results from the Marx activity rating scale, Tegner activity scale, International Knee Documentation Committee Subjective Knee Form, and self-assessment of overall knee function.

Results: The KSS/CPA scale was applicable and effective for evaluating the high-level sports ability of community-level athletes who had returned to their sport after ACL reconstruction. Statistical analysis confirmed the test-retest reliability of the new rating scale (intraclass correlation coefficient, 0.85/0.84 postoperatively) as well as its internal consistency (Cronbach alpha coefficient, 0.73 preoperatively and 0.89 postoperatively), construct validity (Spearman correlation coefficient, >0.35 postoperatively), excellent discriminant validity, acceptable responsiveness, and reasonable minimal detectable change (<25).

Conclusion: The KSS/CPA scale can act as a supplement to other clinical outcome measures for a more comprehensive evaluation of community-level athletes' cutting-pivoting ability and knee stability.

Keywords: rating scale; high-level sports; return to sport; anterior cruciate ligament; cutting-pivoting ability; knee stability

Anterior cruciate ligament (ACL) tears constitute >50% of all knee injuries.¹² Moreover, 40% of sports injuries are

attributed to noncontact mechanisms, including pivoting and cutting activities.^{11,19} Younger athletes are at higher risk of multiple injuries of the ACL mainly because they are more likely to return to high-level sports activities too soon.²⁶

Numerous knee-specific outcome measures have been reported²³ to evaluate the condition and function of the knee, including the Knee Injury and Osteoarthritis Outcome Score, International Knee Documentation Committee (IKDC) score, American Knee Society score, Lysholm score, Cincinnati Knee Rating System, ACL–Quality of Life questionnaire, Tegner activity scale, and Marx activity scale.^{3,23} Most of these scales cover several domains, such as symptoms, function, activities of daily life, sports activity, and physical examination. All of these measurements have been validated and are reliable, as described in previous studies.²³ Even 25 years after they were first introduced, the Lysholm and Tegner activity scales have proven to be acceptable for evaluating responsiveness after ACL treatment.²

In addition to pain relief and regaining of function, the ultimate anticipation for most patients after ACL injury or

[†]Address correspondence to Jinzhong Zhao, MD, Department of Sports Medicine, Shanghai Jiao Tong University Affiliated Sixth People's Hospital, 600 Yishan Road, Shanghai, 200233, China (email: jzzhao@sjtu.edu.cn).

*Department of Sports Medicine, Shanghai Jiao Tong University Affiliated Sixth People's Hospital, Shanghai, China.

J.C. and E.C. contributed equally to this work.

Final revision submitted May 16, 2020; accepted June 11, 2020.

One or more of the authors has declared the following potential conflict of interest or source of funding: This study was funded by the Western Medicine Guidance Project of Science and Technology Commission of Shanghai Municipality (grant 17411966400). AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

Ethical approval for this study was obtained from the Shanghai Sixth People's Hospital (approval No. 2016-96-1).

The Orthopaedic Journal of Sports Medicine, 8(12), 2325967120964883

DOI: 10.1177/2325967120964883

© The Author(s) 2020

surgery is their return to preinjury activity levels and sports participation.¹ Thus, measuring the readiness and ability of patients to participate in sports after surgery is particularly important. Return-to-sport criteria^{8,15,20,21,25} have been proposed so that athletes can safely return to their sport and can predict their future participation level.

During postoperative rehabilitation, several objective physical measurements—for example, strength and functional symmetry,⁴ single-leg hopping for distance,²⁶ and complicated video analysis¹⁰—have been used to assess athletes. Most of the physical tests, however, were developed to use on professional athletes rather than their amateur counterparts, who are also eager to return to their sport. Because nearly half of those with an ACL injury who have returned to sport after ACL reconstruction can return to sports activity at a competitive level,¹ emphasis should be focused not only on the timing of return to sport, but also on measuring the ability to participate in high-level sports activity.

Our study aimed to develop and evaluate a self-administered rating scale for rapid evaluation of high-level sports ability among community-level athletes with an ACL tear and those who had already returned to sports participation after ACL reconstruction surgery. We hypothesized that the new rating scale would present acceptable psychometric parameters as a supplement for other clinical measures.

METHODS

This study was approved by an institutional review board, and all patients gave informed consent to participate.

Data Collection

The study included patients ≥ 18 years of age with a unilateral ACL injury that occurred during participation in a competitive sport and who had undergone ACL reconstruction surgery performed by a senior surgeon (J.Z.) during 2017-2018. The exclusion criteria were the presence of multiligament injury, a history of prior surgery, or injury or workers' compensation. In all, 28 patients did not return to their sport and 8 patients failed to attempt to perform cutting and pivoting motion. Thus, 77 patients were available for the final analysis (Figure 1). The descriptive characteristics of the study patients are reported in Table 1.

Preoperatively and postoperatively, all participants completed the Knee Stability in Sports/Cutting-Pivoting Ability (KSS/CPA) scale. They also completed the Marx activity scale, IKDC Subjective Knee Form (sIKDC) (including symptom, function, and sport activities domains), and Tegner activity scale. Although the Marx and Tegner scales are ordinal, they were analyzed as continuous variables (Marx = 0-100; Tegner = 0-10).² In addition, patients provided an overall self-assessment evaluation of their knee function (0 = worst, 100 = best) preoperatively and postoperatively.

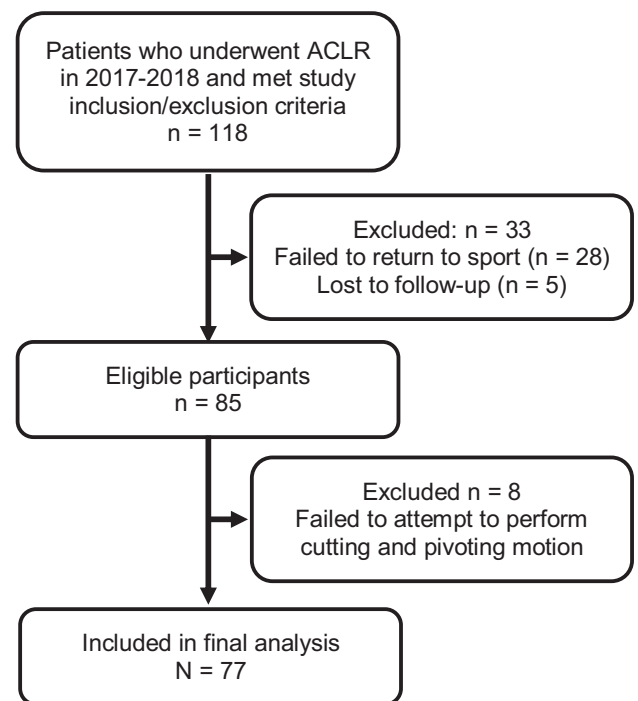


Figure 1. Flowchart for patient enrollment. ACLR, anterior cruciate ligament reconstruction.

TABLE 1
Patient Descriptive Characteristics (N = 77)

Characteristic	Value
Sex, male/female, n	64/13
Age at surgery, y, mean \pm SD	30.4 \pm 7.0
Body mass index, mean \pm SD	24.5 \pm 3.8
Follow-up time, mo, mean \pm SD	18.5 \pm 4.6

KSS/CPA Scale Description

The KSS/CPA scale (Appendix Figure A1) was established by a consensus of experts under the chairmanship of a senior surgeon of sports medicine (J.Z.). Validity was assessed by a group of independent experts in orthopaedics. The KSS section of the scale emphasizes the giving way sensation or instability in the knee during cutting-pivoting activities and linear activities (ie, running in a straight direction, including accelerating or decelerating), which comprise relatively lower level motions. The CPA section focuses on the ability and frequency of performing cutting-pivoting activities, as well as discomfort after performance. As it is clinically impossible for a patient who feels frequent knee instability during linear activities to perform cutting-pivoting activities without knee instability, we eliminated such occasions and simplified the options. The items are ultimately graded on a 5-point Likert scale, with response categories consisting of (A) normal, (B) near normal, (C) abnormal, (D) severely abnormal, and (E) dysfunctional (Appendix Table A1).

Scale Characteristics

Reliability. The measurements were completed via telephone contact initially at least 12 months after the operation and then twice within 4 weeks. The test-retest reliability was determined by the intraclass correlation coefficient (ICC). The internal consistency of the scale was evaluated using Cronbach alpha coefficient before and after the surgery. Values of >0.7 were considered acceptable and those >0.8 were considered good.¹⁴

Validity. Construct validity is defined as “compared with a gold standard.”¹⁴ However, no gold standard test has been established before and after ACL reconstruction for community-level patients engaged in cutting-pivoting activities. Because there was no such test, we tested the KSS/CPA scale by comparing it with the Marx and Tegner activity scales, the sIKDC, and an overall self-assessment score. The Marx and Tegner activity scales are widely used to evaluate activity level in sports, ranging from recreational sports to competitive sports, involving cutting-pivoting motions.²³ The sIKDC is validated as a tool to determine an athlete’s readiness to return to advanced-level activities.¹⁵

The community-level athletes were tested preoperatively and postoperatively through use of the Spearman rank correlation coefficient. The relationship was considered strong if the value was >0.5, moderate if 0.35-0.5, and weak if <0.35.¹⁴ Discriminant validity was tested using the Mann-Whitney test. For this test, the patients were placed in 2 groups according to the 5 possible grades (group AB and group CDE) for comparison before and after the surgery.

Responsiveness. Preoperative and postoperative response distributions were calculated. We also tested the floor and ceiling effects by documenting the percentage of patients who rated the lowest and the highest degrees, respectively. If <30% of patients had scored the limits of the scale, the floor or ceiling effect was considered acceptable.² With the ordinal scales (KSS/CPA scale) converted to continuous variables (A = 100, B = 75, C = 50, D = 25, E = 0), the effect size in the study was calculated as

$$\frac{(\text{mean postoperative value} - \text{mean preoperative value})}{\text{standard deviation of the preoperative value}}$$

The standardized response mean was calculated as

$$\frac{(\text{mean postoperative value} - \text{mean preoperative value})}{\text{standard deviation of the change in value}}$$

Moderate effects were defined as >0.50, and large effects were defined as >0.80.²

Minimal Detectable Change. Minimal detectable change (MDC) was established using the distribution-based method^{13,16} with the conversion scale described above. MDC was defined as the minimum amount of change needed to identify a real health change resulting from the standard measurement error. With CIs of 90% (corresponding to a 10:1 likelihood) applied as a score of 1.64, we calculated the MDC as

TABLE 2
Preoperative and Postoperative Outcome Scores^a

	Preoperative	Postoperative
Marx activity scale	22.1 ± 28.5	48.5 ± 27.3
Tegner activity scale	1.9 ± 1.6	4.0 ± 1.8
sIKDC		
Overall	67.2 ± 13.7	87.2 ± 8.8
Symptoms	24.7 ± 5.0	31.6 ± 4.3
Function	5.3 ± 2.6	8.4 ± 5.0
Sport activities	28.3 ± 6.8	36.7 ± 3.7
Overall self-assessment	42.4 ± 26.0	75.5 ± 12.8

^aValues are expressed as mean ± SD. sIKDC, International Knee Documentation Committee Subjective Knee Form.

$$MDC = 1.64 SEM \times \sqrt{2}; SEM = SD \times \sqrt{(1 - \alpha)},$$

where α is the reliability coefficient of the scale from test-retest studies or Cronbach alpha. In the current study, the ICC was chosen for MDC calculation. All analyses were performed using SPSS 24.0 software (IBM). All reported *P* values are 2-tailed with $\alpha = .05$.

RESULTS

The pre- and postoperative scores on the Marx activity scale, Tegner activity scale, sIKDC, and overall self-assessment for the 77 study participants are shown in Table 2.

Reliability

The ICCs for the KSS/CPA scale were 0.85/0.84 after the surgery. Cronbach alpha coefficients for internal consistency of the new rating scale were 0.73 preoperatively and 0.89 postoperatively.

Validity

The preoperative Spearman correlation coefficient between the CPA section and the overall self-assessment score was 0.52 (*P* < .001), whereas the preoperative Spearman correlation for the KSS section and the Marx activity scale was 0.57 (*P* < .001). However, other coefficients showed relatively lower correlations (Table 3). The postoperative Spearman correlation coefficients for the KSS/CPA scale were moderate to strong (>0.35) compared with other clinical parameters, indicating an acceptable correlation (Table 3).

The discriminant validity was excellent. Group AB had much higher scores postoperatively than group CDE for the Marx and Tegner activity scales, sIKDC, and overall self-assessment score (*P* < .05), whereas preoperatively the difference was smaller between groups AB and CDE (Table 4). Also, the patients established a graded response of measurements pre- and postoperatively on the KSS/CPA scale (Figure 2).

TABLE 3

Pre- and Postoperative Spearman Rank Correlation Coefficients of the KSS/CPA Scale With Other Outcome Measures^a

	Marx Score	Tegner Score	sIKDC				Overall Self-Assessment
			Overall	Symptoms	Function	Sport Activities	
Preoperative							
KSS section	0.57 ^b	0.36 ^b	0.35 ^b	0.32 ^b	0.24 ^c	0.22	0.37 ^b
CPA section	0.36 ^b	0.25 ^c	0.35 ^b	0.26 ^c	0.33 ^b	0.32 ^b	0.52 ^b
Postoperative							
KSS section	0.46 ^b	0.44 ^b	0.49 ^b	0.46 ^b	0.38 ^b	0.44 ^b	0.48 ^b
CPA section	0.66 ^b	0.61 ^b	0.57 ^b	0.56 ^b	0.37 ^b	0.49 ^b	0.58 ^b

^aCPA, cutting-pivoting ability; KSS, knee stability in sports; sIKDC, International Knee Documentation Committee Subjective Knee Form.

^bCorrelation is statistically significant ($P < .01$; 2-tailed).

^cCorrelation is statistically significant ($P < .05$; 2-tailed).

TABLE 4

Comparison of the KSS/CPA Grading Groups With Other Outcome Measures Preoperatively and Postoperatively^a

	Marx Scale	Tegner Scale	sIKDC				Overall Self-Assessment
			Overall	Symptoms	Function	Sport Activities	
Preoperative							
KSS section							
Group AB	44.6 ± 33.2	2.3 ± 1.3	83.3 ± 11.2	29.6 ± 3.8	8.6 ± 1.8	34.6 ± 4.7	78.6 ± 9.4
Group CDE	19.8 ± 27.3	1.9 ± 1.6	65.6 ± 13.0	24.2 ± 4.9	4.9 ± 2.4	27.7 ± 6.7	39.4 ± 25.0
P	.016	.228	.002	.005	.001	.007	.001
CPA section							
Group AB	61.3 ± 31.1	3.4 ± 2.3	76.7 ± 18.3	28.4 ± 6.3	6.4 ± 3.2	32.4 ± 6.6	70.6 ± 18.1
Group CDE	19.4 ± 26.5	1.8 ± 1.5	66.6 ± 13.3	24.4 ± 4.9	5.2 ± 2.5	28.0 ± 6.8	40.5 ± 25.4
P	.004	.057	.168	.149	.369	.188	.012
Postoperative							
KSS section							
Group AB	55.1 ± 24.5	4.3 ± 1.7	88.7 ± 8.4	32.2 ± 4.3	8.8 ± 5.5	37.1 ± 3.5	78.3 ± 10.9
Group CDE	23.4 ± 23.1	2.6 ± 1.4	81.6 ± 8.0	29.2 ± 3.0	7.1 ± 1.5	34.8 ± 4.1	64.7 ± 14.1
P	<.001	<.001	.005	.010	.013	.015	<.001
CPA section							
Group AB	66.6 ± 17.5	5.1 ± 1.5	91.0 ± 7.7	33.3 ± 4.2	8.3 ± 1.3	37.9 ± 3.2	81.6 ± 9.8
Group CDE	30.9 ± 23.4	2.9 ± 1.3	83.6 ± 8.2	29.9 ± 3.7	8.6 ± 7.0	35.5 ± 3.8	69.5 ± 12.7
P	<.001	<.001	<.001	<.001	.027	<.001	<.001

^aValues are expressed as mean ± SD. CPA, cutting-pivoting ability; KSS, knee stability in sports; sIKDC, International Knee Documentation Committee Subjective Knee Form. Group AB, grade A plus grade B; Group CDE, grade C plus grade D plus grade E.

Responsiveness

After ACL surgery, most responses were in the normal or near-normal range. The percentage distribution of responses for each grade of the KSS/CPA scale was collected (Table 5). Floor effects were found in the KSS and CPA sections preoperatively, at 50.65% and 59.74%, respectively, and we found no evidence of unacceptable ceiling effects.

For the KSS/CPA scale, a large effect size was seen at 18 months after surgery, at 2.09/1.76. The standardized response means and MDCs were calculated for the KSS and CPA sections. The MDCs were <25 (ie, a difference of 2 adjacent degrees), indicating that our classified gradation was effective to detect change (Table 6).

DISCUSSION

This study analyzed a new rating scale (the KSS/CPA) for rapid evaluation of a patient's ability to participate in high-level sports activities after surgery for an ACL injury. The new measurement focuses on cutting and pivoting activities for patients who sustain an ACL tear or have already undergone ACL reconstruction and have returned to sports. The developed scale was found to have acceptable psychometric parameters, including test-retest reliability, internal consistency, construct and discriminant validity, responsiveness, and MDC.

The KSS/CPA scale presented satisfactory ICCs and internal consistency for reliability. In terms of construct validity, the correlation between KSS/CPA and other

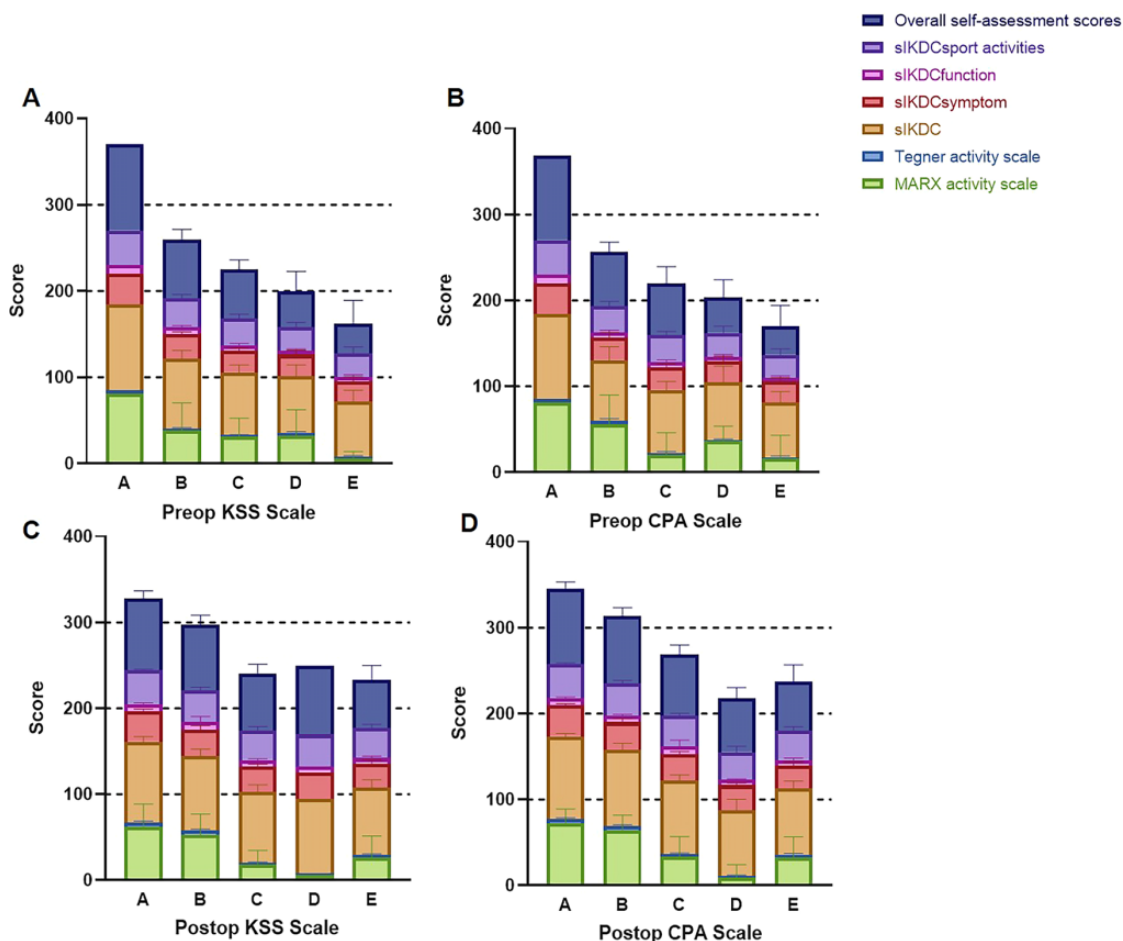


Figure 2. Distribution of (A, B) preoperative and (C, D) postoperative outcome scores within the KSS/CPA grading distribution. For each KSS/CPA grade, the outcome scores are stacked in a single column. Each score presents a decreased tendency for KSS/CPA grades A to E. Error bars indicate SD. There are no error bars in grade A on the preoperative KSS section, grade A on the preoperative CPA section, or grade D on the postoperative KSS section, because only 1 patient distributed in each case. CPA, cutting-pivoting ability; KSS, knee stability in sports; Preop, preoperative; Postop, postoperative; sIKDC, International Knee Documentation Committee Subjective Knee Form.

TABLE 5
Distribution of Responses for Each Grade of the KSS/CPA Scale (N = 77 Participants)^a

Section and Grade	Preoperative	Postoperative
KSS section		
A (normal)	1 (1.30)	15 (19.48)
B (nearly normal)	6 (7.79)	47 (61.04)
C (abnormal)	7 (9.09)	9 (11.69)
D (severely abnormal)	24 (31.17)	1 (1.30)
E (dysfunctional)	39 (50.65)	5 (6.49)
CPA section		
A (normal)	1 (1.30)	12 (15.58)
B (nearly normal)	4 (5.19)	26 (33.77)
C (abnormal)	17 (22.08)	31 (40.26)
D (severely abnormal)	9 (11.69)	4 (5.19)
E (dysfunctional)	46 (59.74)	4 (5.19)

^aData are reported as n (%) of participants. CPA, cutting-pivoting ability; KSS, knee stability in sports.

TABLE 6
Responsiveness for KSS/CPA Scale^a

	Effect Size	Standardized Response Mean	Minimal Detectable Change
KSS section	2.09	1.63	22.48
CPA section	1.76	1.29	24.50

^aCPA, cutting-pivoting ability; KSS, knee stability in sports.

outcome measurements was acceptable, especially postoperatively (>0.35). Additionally, the new rating scale demonstrated a graded response of measurements for discrimination. Although floor effects were detected in the KSS and CPA sections preoperatively, the effect size at 18 months after surgery was considered large, along with a reasonable MDC (<25).

The new scale—graded on knee instability (KSS section) and ability to participate in sports, frequency of participation, and discomfort after participating (CPA section)—distinguishes amateur players who are ready to return to high-level sports (eg, soccer, skiing⁷) from those who should not. Patients with an ACL injury or reconstruction graded A or B based on the KSS and CPA sections scored much higher than those with lower grades (C, D, and E). The good identification rate of the KSS/CPA scale showed that patients who felt less giving way sensation or performed better cutting-pivoting motion were more likely to be engaged in higher level sports (Tegner activity scale²) more frequently (Marx activity scale^{5,18}) with less discomfort (sIKDC⁹). This finding correlates with clinical experience and published data. The Saltin-Grimby Physical Activity Level Scale^{7,22} categorizes physical activities into 4 levels, with “higher-level, specific” activities implying that the patient was performing more cutting-pivoting motions more frequently.

We also found that the KSS/CPA scale presented moderate to strong correlation with these measurements, specifically during the postoperative follow-up period. Interestingly, patients with higher overall self-assessment scores were more likely to perform cutting-pivoting sports activities, which is indicative of the possible contextual factors, such as fear of reinjury and/or a lifestyle change, that affect patients after ACL treatment.¹

The new scale exhibited excellent responsiveness with a large effect size. Furthermore, the MDC of both the KSS and CPA sections was <25, implying that the gradation of the scales is reasonable. However, floor effects were detected preoperatively, mainly because the ACL plays a crucial role in controlling cutting-pivoting motions¹¹ and an ACL injury would greatly interfere with these motions. Similar floor effects are found in other widely used scales, such as the 36-Item Short Form Health Survey.¹⁷ Our unique measurement scale should take approximately 1 minute to complete. Consequently, it could supplement the use of other clinical measures for more comprehensive evaluation of cutting-pivoting ability and knee stability.

The distribution of responses for each grade showed that more than half of the patients were graded as dysfunctional after an ACL injury, whereas 80.52% of patients (graded A or B on the KSS section) were back to normal or nearly normal, and 49.35% (graded A or B on the CPA section) showed good performance in cutting-pivoting motions. That is, nearly half of the patients who had ACL reconstruction were capable of performing competitive sports, correlating with previously published data.¹ With the new KSS/CPA scale, those patients graded A or B could be classified as “safe to return” and should be encouraged to engage in higher level sports activities during rehabilitation. For those with lower grades, however, attention must be paid to augmenting the strength of muscles around the knee joint. Sports activities involving cutting-pivoting motions should be avoided unless thorough warm-up exercises are performed, including lateral slide, rush to stop within a short distance, and jogging or fast walking along a pathway, such as a Mobius ring, that goes in opposite directions with gradual acceleration and pathway narrowing.

Among community-level athletes who have undergone surgery for an ACL injury, the KSS/CPA scale is the first in the literature to allow self-assessment of the specific skills required for high-level sports activities. The Tegner activity scale is also designed to evaluate activity level, with scores of 1 to 5 representing recreational sports activity and >5 representing higher level or competitive sports activity.²³ However, the Tegner scale stratifies activities into 10 levels based on specific sports rather than skills and therefore poses difficulty for application among all populations participating in different sports.^{2,23,24} Although the Marx activity scale places a focus on specific functional activities⁵ in terms of running, decelerating, cutting, and pivoting,^{5,18} frequency of activity is considered the sole outcome measure, which could be affected not only by function but also by the amount of time a person has available for recreational sports activity. Thus, our scale takes into consideration a patient’s ability to participate in sports activity, the frequency of activity, and subjective knee feelings in order to better assess capability and readiness to return to high-level sports. Furthermore, composed of simply 2 questions for gradation, the newly proposed scale presents minimal responder burden, compared with the sIKDC, although sIKDC scores were reported to be effective for assessment of failure in the Readiness to Return to Activity Criteria test battery.¹⁵ Comparison with other reported scales indicates that for patients with ACL injury who are willing to return to high-level sports activities after surgery, our new rating scale is an effective alternative for quick assessment of high-level skill abilities.

Clinical, objective examinations of knee function have been validated as screening tools for high risk of reinjury after return to sport, whereas the duration of play and patients’ feelings might affect the risk of reinjury.²⁵ Therefore, we propose that this new scale, which considers ability, frequency, and subjective feelings, could add to the tools that a clinician uses during rehabilitation and in decision making about return to high-level sports. When results are documented as grade A or B on both parts of the KSS/CPA scale, a minor adjustment is required for rehabilitation, and focus could be turned to the quality of specific skill accomplishment; if any result is assessed as grade C, D, or E, competitive or high-level sports activities are not recommended and emphasis should be placed on enhancing knee function and muscle strength. Considering the current findings, we hope that the scale will provide guidance for rehabilitation protocols for amateur athletes to ensure a safe return to high-level sports activities.

Limitations of the study involve the test-retest reliability assessment. We performed the test only postoperatively, and preoperative validation is recommended for better application. Second, we used overall self-assessment scores, which require further validation and evaluation for its general use, to evaluate patients’ overall perceptions regarding the state of the knee for sport functioning. Third, the results of the MDC calculation require comparison with the minimal clinically important difference, because it has been reported that the anchor-based minimal clinically important difference shows more accurate estimates than the MDC throughout all cohorts.¹⁶ Thus, an anchor-based (eg,

degree of satisfaction) minimal clinically important difference is required for calculation in further study. Moreover, further investigation is required regarding correlation of the reinjury rates and the grouping of grades (AB vs CDE) based on our scale at the time of return to sport, and specific patients with underlying high risk of reinjury⁶ should be included for subgroup analysis. Further prospective clinical studies should be carried out to evaluate the use of this new scale and explore the relation between this scale and the possibility for return to sport.

CONCLUSION

The new rating technique presented, the KSS/CPA scale, could be a supplement to other clinical measures for comprehensively evaluating cutting-pivoting ability and knee stability.

ACKNOWLEDGMENT

The authors thank Nancy Schatken, BS, MT(ASCP), from Liwen Bianji, Edanz Group China (www.liwenbianji.cn/ac), for editing the English text of a draft of this manuscript.

REFERENCES

- Ardern CL, Webster KE, Taylor NF, Feller JA. Return to sport following anterior cruciate ligament reconstruction surgery: a systematic review and meta-analysis of the state of play. *Br J Sports Med.* 2011;45(7):596-606.
- Briggs KK, Lysholm J, Tegner Y, et al. The reliability, validity, and responsiveness of the Lysholm score and Tegner activity scale for anterior cruciate ligament injuries of the knee: 25 years later. *Am J Sports Med.* 2009;37(5):890-897.
- Collins NJ, Misra D, Felson DT, Crossley KM, Roos EM. Measures of knee function: International Knee Documentation Committee (IKDC) Subjective Knee Evaluation Form, Knee injury and Osteoarthritis Outcome Score (KOOS), Knee injury and Osteoarthritis Outcome Score Physical Function Short Form (KOOS-PS), Knee Outcome Survey Activities of Daily Living Scale (KOS-ADL), Lysholm Knee Scoring Scale, Oxford Knee Score (OKS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), Activity Rating Scale (ARS), and Tegner Activity Score (TAS). *Arthritis Care Res (Hoboken).* 2011;63(suppl 11):S208-S228.
- Ebert JR, Edwards P, Yi L, et al. Strength and functional symmetry is associated with post-operative rehabilitation in patients following anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc.* 2018;26(8):2353-2361.
- Flosadottir V, Roos EM, Ageberg E. Translation, cross-cultural adaptation, and validation of the activity rating scale for disorders of the knee. *Orthop J Sports Med.* 2017;5(9):2325967117729361.
- Getgood AMJ, Bryant DM, Litchfield R, et al. Lateral extra-articular tenodesis reduces failure of hamstring tendon autograft anterior cruciate ligament reconstruction: 2-year outcomes from the STABILITY Study randomized clinical trial. *Am J Sports Med.* 2020;48(2):285-297.
- Grimby G, Borjesson M, Jonsdottir IH, et al. The "Saltin-Grimby Physical Activity Level Scale" and its application to health research. *Scand J Med Sci Sports.* 2015;25(suppl 4):119-125.
- Hartigan E, Axe M, Snyder-Mackler L. Time line for noncopers to pass return-to-sports criteria after anterior cruciate ligament reconstruction. *J Orthop Sports Phys Ther.* 2010;40(3):141-154.
- Hefti F, Müller W, Jakob RP, Stäubli HU. Evaluation of knee ligament injuries with the IKDC form. *Knee Surg Sports Traumatol Arthrosc.* 1993;1(3-4):226-234.
- Johnston JT, Mandelbaum BR, Schub D, et al. Video analysis of anterior cruciate ligament tears in professional American football athletes. *Am J Sports Med.* 2018;46(4):862-868.
- Jones PA, Herrington LC, Munro AG, Graham-Smith P. Is there a relationship between landing, cutting, and pivoting tasks in terms of the characteristics of dynamic valgus? *Am J Sports Med.* 2014;42(9):2095-2102.
- Kaeding CC, Leger-St-Jean B, Magnussen RA. Epidemiology and diagnosis of anterior cruciate ligament injuries. *Clin Sports Med.* 2017;36(1):1-8.
- Kim JK, Park ES. Comparative responsiveness and minimal clinically important differences for idiopathic ulnar impaction syndrome. *Clin Orthop Relat Res.* 2013;471(5):1406-1411.
- Kim SJ, Basur MS, Park CK, et al. Crosscultural adaptation and validation of the Korean version of the new Knee Society knee scoring system. *Clin Orthop Relat Res.* 2017;475(6):1629-1639.
- Logerstedt D, Di Stasi S, Grindem H, et al. Self-reported knee function can identify athletes who fail return-to-activity criteria up to 1 year after anterior cruciate ligament reconstruction: a Delaware-Oslo ACL cohort study. *J Orthop Sports Phys Ther.* 2014;44(12):914-923.
- Lyman S, Lee YY, McLawhorn AS, Islam W, MacLean CH. What are the minimal and substantial improvements in the HOOS and KOOS and JR versions after total joint replacement? *Clin Orthop Relat Res.* 2018;476(12):2432-2441.
- Mahomed N, Gandhi R, Daltroy L, Katz JN. The self-administered patient satisfaction scale for primary hip and knee arthroplasty. *Arthritis.* 2011;2011:591253.
- Marx R, Stump T, Jones E, Wickiewicz T, Warren R. Development and evaluation of an activity rating scale for disorders of the knee. *Am J Sports Med.* 2001;29(2):213-218.
- Musahl V, Karlsson J. Anterior cruciate ligament tear. *N Engl J Med.* 2019;380(24):2341-2348.
- Nawasreh Z, Logerstedt D, Cummer K, et al. Do patients failing return-to-activity criteria at 6 months after anterior cruciate ligament reconstruction continue demonstrating deficits at 2 years? *Am J Sports Med.* 2017;45(5):1037-1048.
- Nawasreh Z, Logerstedt D, Cummer K, et al. Functional performance 6 months after ACL reconstruction can predict return to participation in the same preinjury activity level 12 and 24 months after surgery. *Br J Sports Med.* 2018;52(6):375.
- Rödger L, Jonsdottir I, Rosengren A, et al. Self-reported leisure time physical activity: a useful assessment tool in everyday health care. *BMC Public Health.* 2012;12:693.
- Smith MV, Klein SE, Clohisy JC, et al. Lower extremity-specific measures of disability and outcomes in orthopaedic surgery. *J Bone Joint Surg Am.* 2012;94(5):468-477.
- Tegner Y, Lysholm J. Rating systems in the evaluation of knee ligament injuries. *Clin Orthop Relat Res.* 1985;198:43-49.
- Webster KE, Feller JA. Clinical tests can be used to screen for second anterior cruciate ligament injury in younger patients who return to sport. *Orthop J Sports Med.* 2019;7(8):2325967119863003.
- Webster KE, Feller JA. Return to level I sports after anterior cruciate ligament reconstruction: evaluation of age, sex, and readiness to return criteria. *Orthop J Sports Med.* 2018;6(8):2325967118788045.

APPENDIX

Please indicate how you felt when you performed the activities below in the past 3 months or lately after the injury.* (Tick an option below)

Knee Stability in Sports Section

Giving-way sensation/instability from the knee:

	During Cutting and Pivoting Activities	During Linear Activities
<input type="checkbox"/>	Never	Never
<input type="checkbox"/>	Occasionally	Never
<input type="checkbox"/>	Frequently	Never
<input type="checkbox"/>	Frequently	Occasionally
<input type="checkbox"/>	Frequently	Frequently

Cutting-Pivoting Ability Section

	Ability to Complete Cutting-Pivoting Activities	Frequency of Cutting-Pivoting Activities	Discomfort From the Knee After Cutting-Pivoting Activities
<input type="checkbox"/>	Capable	Frequently	No
<input type="checkbox"/>	Capable	Frequently	Yes
<input type="checkbox"/>	Capable	Occasionally	No
<input type="checkbox"/>	Capable	Occasionally	Yes
<input type="checkbox"/>	Incapable (have tried)	NA	Yes

Figure A1. The KSS/CPA Scale.

*Cutting and pivoting activities = changing directions or turning your body while your foot planted while playing a sport. Linear activities = running in a straight direction, including accelerating or decelerating.

TABLE A1
Grading for the KSS/CPA Scale^a

Knee Stability in Sports (KSS) Section: Giving Way Sensation/Instability From the Knee			
During Cutting and Pivoting Activities	During Linear Activities		Grade ^b
Never	Never		A (normal)
Occasionally	Never		B (nearly normal)
Frequently	Never		C (abnormal)
Frequently	Occasionally		D (severely abnormal)
Frequently	Frequently		E (dysfunctional)
Cutting-Pivoting Ability (CPA) Section: Cutting-Pivoting Activities			
Ability to Complete	Frequency	Discomfort From the Knee After the Activity	Grade ^b
Capable	Frequently	No	A (normal)
Capable	Frequently	Yes	B (nearly normal)
Capable	Occasionally	No	C (abnormal)
Capable	Occasionally	Yes	D (severely abnormal)
Incapable (have tried)	NA	Yes	E (dysfunctional)

^aNA, not applicable.

^bGrading: A = 100 points; B = 75 points; C = 50 points; D = 25 points; E = 0 points.