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A 10-Year Prospective Trial of a Patient Management Algorithm and Screening Examination for Highly Active Individuals with ACL Injury. *Part I: Outcomes*

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Abstract

Background—A treatment algorithm and screening examination to guide patient management and prospectively determine potential for highly active individuals to succeed with non-operative care after anterior cruciate ligament (ACL) rupture.

Objectives—To prospectively characterize and classify the entire population of highly active individuals over a 10 year period and provide terminal outcomes for individuals who elected non-operative care.

Materials and Methods—Inclusion criteria included presentation within 7 months of the index injury and an IKDC level I or II activity level prior to injury. Concomitant injury, impairments, and a screening examination were used as criteria to guide management and classify individuals as non-copers (poor potential) or potential copers (good potential) for non-operative care.

Results—832 highly active patients with sub-acute ACL tear were seen over the 10 year period. 315 had concomitant injuries, 87 had unresolved impairments, and 85 did not participate in the classification algorithm. The remaining 345 patients (216 men, 129 women) participated in the screening examination an average of 6 weeks after the index injury. There were 199 subjects classified as non-copers, compared to 146 as potential copers. Sixty-three of eighty-eight potential copers successfully returned to pre-injury activities without surgery, with 25 of these individuals not undergoing ACL reconstruction at the time of follow-up.

Conclusions—The classification algorithm is an effective tool for prospectively identifying individuals early after ACL injury who want to pursue non-operative care, or must delay surgical intervention, and have good potential to do so.

Key Terms

Knee; Rehabilitation; Decision making

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INTRODUCTION

The majority of orthopaedic surgeons in the United States advocate early surgical intervention when managing individuals with anterior cruciate ligament (ACL) rupture who wish to resume high-level sports activities.³² This practice pattern is influenced by ready access to surgical facilities, widespread private health insurance coverage of ACL reconstruction procedures, high return to sport rates after surgery, and the assumption that knee instability is an inevitable consequence of resumption of jumping, cutting, and pivoting sports after ACL injury.²⁸ Studies have reported poor patient outcomes after non-operative management of ACL injury, further reinforcing a bias towards surgical management of this injury.^{5, 7, 19, 24, 29} Additionally, there are no randomized clinical trials that have utilized current surgical and rehabilitation techniques to compare operative versus non-operative patient outcomes after ACL rupture without surgery to support one treatment approach over the other.³⁰ In the face of limited evidence to support non-operative patient management, it is reasonable to question why surgical intervention *wouldn't* be recommended for the highly active individual with ACL insufficiency.

There is evidence of a differential patient response to ACL injury. Some individuals are able to regularly participate in high level activities after injury without complaints of instability.^{15, 16, 23, 33, 40} We have operationally defined those individuals who are able to resume all pre-injury activities, including sports, without experiencing further episodes of knee giving way for at least one year after ACL injury as *copers*.⁴⁰ In contrast, *non-copers* are individuals who experience knee instability upon resumption of pre-injury activities^{16, 33}, and *adapters* are individuals who avoid episodes of knee instability by mitigating their activity level.¹⁶ Though the reported percentage of copers among the entire population of patients with ACL injury is small⁴⁰, it is clear not all active individuals need undergo ACL reconstruction to resume pre-morbid function. Furthermore, there are individuals who want to resume demanding activities for a short period of time before undergoing ACL reconstruction (e.g., the athlete wishing to complete a competitive sports season and individuals outside of the United States who are placed on a waiting list before they may undergo surgery). Implementation of a clinical decision-making algorithm may be an effective means of advising patients on appropriate activity resumption after ACL rupture without increasing the risk for further injury.

A significant obstacle in the management of patients with ACL injury is development of an algorithm that effectively discriminates soon after injury between those who may and may not succeed with non-operative care. A screening examination has been developed at the University of Delaware to prospectively identify highly active individuals early after ACL injury with good potential to return to their pre-injury activities with non-operative management (*potential copers*).²⁰ Preliminary work performed by Eastlack¹⁶ indicated a combination of self-assessment questionnaires and clinical measures of physical performance were effective in discriminating between known copers and non-copers. Fitzgerald²⁰ subsequently refined the variables that best correlated with *prospective* classification of patients as either rehabilitation (potential coper) or surgical (non-coper) candidates. A patient was classified as a potential coper versus a non-coper based on the number of giving way episodes since the index injury in addition to global rating, Knee Outcome Survey-Activities of Daily Living Scale (KOS-ADLS), and single-leg timed hop scores.²⁰

Fitzgerald²⁰ tested the effectiveness of the University of Delaware screening examination over a two year period (May 1, 1996-April 30, 1998). Patients were considered eligible for study participation if they presented within six months of the index injury, had an isolated lesion, and were regular participants in IKDC level I or II activities (≥ 50 hours/year in jumping, cutting and pivoting sports) (Table 1)^{15, 25} prior to the index injury. A total of 93 individuals completed

the screening examination, including 39 who were classified as potential copers. Twenty-two of twenty-eight subjects (79%) who chose non-operative management returned to pre-injury activity levels without further episodes of instability, additional injury, or a reduction in functional status. In comparison, other studies have reported return to sport success rates ranging from 23–39% when patients self-select non-operative management.^{3, 18, 38} The results reported by Fitzgerald²⁰ suggest the University of Delaware decision making scheme and screening examination are a better mechanism for selecting patients for return to high-level activity with non-operative management than simply attempting this treatment approach on a self-selected basis. The study by Fitzgerald²⁰, however, was limited to a relatively small sample size, and may not be representative of the entire population of highly active patients with ACL injury. The terminal outcomes for potential copers in Fitzgerald's²⁰ study who elected to pursue non-operative care have not been reported.

Few reports are available about the characteristics of those with ACL injury that influence surgical decision-making. For example, only one large demographic study has systematically documented the incidence of concomitant injury.¹⁵ Other reports suggest that most individuals with ACL rupture who elect non-operative management will experience giving way, but these reports are retrospective.^{4, 8, 11, 17} A prospective study of subjects with ACL rupture sub-classified based on function is needed to determine the characteristics of those who may or may not succeed with delayed surgical reconstruction. Over a 10-year period we have used the University of Delaware treatment algorithm and screening examination to guide management of highly active patients with ACL insufficiency. In the first article of this two part series our goal was to 1) characterize and classify the entire population of patients with acute ACL injury from the practice of a single orthopaedic surgeon, and 2) describe the outcomes of potential copers who elected to pursue non-operative management. In part two of this series we will address the determinants of dynamic knee stability that contribute to successful non-operative return to activities after ACL rupture.

MATERIALS AND METHODS

Subjects

A total of 832 consecutive patients with acute ACL insufficiency seen by a single fellowship-trained orthopaedic surgeon (MJA) between May 1, 1996 and April 30, 2006 were initially eligible for study participation. Inclusion criteria were clinical evaluation within 7 months of injury and regular participation in IKDC Level I or II activities (Table 1)^{15, 25} prior to the index injury. Presence of ACL insufficiency was determined during clinical examination by the presence of a Grade III Lachman test and a side-to-side difference of at least 3 mm¹⁵ during KT-1000 testing using a manual, maximum anterior pull, and later confirmed with MR imaging.

All eligible subjects were asked to participate in the study at the time of initial visit to the orthopaedic surgeon. There were 85 individuals (10%) who did not participate in the classification algorithm because of immediate surgery, distance, missed appointments, or declining to participate in the study. The remaining 747 patients (90%) were entered into the decision-making algorithm. All subjects provided written informed consent approved by the University of Delaware Human Subjects Review Board.

Classification Algorithm

Physical Examination and Imaging Classification Criteria—Physical examination performed by the orthopaedist identified patients with concomitant ligamentous laxity (Grade II–III), bilateral knee involvement, and the presence of any severe lower extremity or low back injury (e.g., nerve injury, fracture, disk herniation, etc.), while plain radiographs were used to

identify the presence of fracture (Fig. 1). All patients underwent MRI testing to assess the presence of repairable meniscus tears or full thickness articular cartilage lesions in the ACL deficient knee. Patients with any of these findings were excluded from participating in the screening examination. Our rationale for excluding patients from further study participation in the presence of these concomitant injuries was based on evidence that in these individuals, there would be a high probability of risking further damage to the knee if non-operative care were pursued^{3, 15}, the screening examination could not be safely completed, or that a healthy contralateral knee was not available for comparison (Fig. 1).

Pre-screening Rehabilitation Criteria—Subjects without the described concomitant injuries who had full knee range of motion, no/minimal knee effusion, $\geq 70\%$ isometric quadriceps strength on bilateral comparison using the burst superimposition technique³⁹, and could hop on their injured leg without pain underwent screening immediately. Individuals participated in physical therapy (Table 2) in preparation for the screening examination until they met rehabilitation criteria. Subjects who continued to have impairments after 1 month of rehabilitation were considered to have unresolved impairments and were referred to the orthopaedist for surgery (Fig. 1).

Screening Examination—The screening examination consisted of unilateral hop testing, evaluation of self-assessed knee function, and recording the number of giving way episodes since the index injury (Table 3).²⁰ Unilateral hop testing was conducted using the protocol described by Noyes³⁴, and consisted, in order, of (a) single hop for distance, (b) cross-over hop for distance in which the subject crosses over a 15 cm wide tape with each consecutive hop, (c) straight triple hop for distance, and (d) a timed hop in which the subject hops over a 6 m distance as quickly as possible. Measurement reliability of unilateral hop test performance has been reported to be good, with intraclass correlation coefficients ranging from .92 to .96 for the unilateral^{6, 10}, cross-over^{6, 10}, and triple hop for distance^{6, 10}, and the 6-m timed hop⁶. Testing protocol included two practice trials on each limb immediately prior to the two test trials. The test trials on each limb were averaged and a hop index was calculated for each test [(injured side score/uninjured side score) $\times 100$] except for the timed hop test [uninjured side score/injured side score $\times 100$]. To maximize patient safety, all subjects wore a functional de-rotation knee brace on the injured limb during hop testing. All patients wore shoes during testing and arm positioning was not constrained.

Immediately after completing the hop testing protocol, self-assessed knee function was evaluated with the KOS-ADLS²⁷ and a global rating of knee function (Table 3). The KOS-ADLS consists of 14 items with 5 possible answers (each answer weighted from 0 to 5 points) ranging from not limited or symptomatic to unable to perform the task, and evaluates symptoms and functional abilities during a variety of daily activities. A score of 100% equates to no symptoms or limitations during activities of daily living. The KOS-ADLS has been established as a valid and reliable tool for evaluating changes in knee function over time.²⁷ The global rating of knee function is a single number between 0–100% that requires subjects to rate their current functional status, including sports activities, compared to their pre-injury status. A score of 100% represents a full return to pre-injury activity levels.

Data Management—A database was created containing demographic information, clinical test results, and screening examination results. Demographic information, time from injury to the screening examination, and results from clinical testing were also recorded.

Screening Classification Criteria and Counseling—Classification criteria as a potential copers or non-copers were developed in a previous investigation.²⁰ Based on performance criteria from two groups of patients that were preliminarily classified as either rehabilitation (potential copers) or surgical (non-copers) candidates, a multiple regression

analysis determined the timed hop, KOS-ADLS, global rating, and number of giving way episodes accounted for 72% of the classification variance.²⁰ Cutoff levels to distinguish between the two groups were the based on values two standard deviations below the group mean for those preliminarily categorized as rehabilitation candidates.²⁰ This value was selected because we believed patients scoring below this level would be at high risk of sustaining further knee damage if returned to pre-injury activities with non-operative management.

Based on the results of the screening examination patients were classified as a potential copers using the following criteria: 1) ≤ 1 episode of giving way since the index injury, 2) $\geq 80\%$ on the 6-m timed hop test, 3) $\geq 80\%$ on the KOS-ADLS, and 4) $\geq 60\%$ on the global rating scale (Table 3).²⁰ Failure to meet *any* of the criteria resulted in classification as a non-coper. Patients classified as non-copers were referred back to the orthopaedic surgeon as surgical candidates, and potential copers were counseled that, as rehabilitation candidates, they had the option to pursue non-operative versus surgical management.

Post-Screening Rehabilitation and Return to Sports

Subjects who were classified as potential copers and elected to pursue a non-operative return to pre-injury activities were encouraged to participate in a structured rehabilitation program. Fourteen of the first 28 potential copers participated in a traditional rehabilitation protocol that included muscle strengthening, cardiovascular, agility, and sport-specific exercises (agility and sport-specific exercises were performed while wearing a functional de-rotation brace). These subjects were part of a randomized clinical trial²¹ evaluating the effectiveness of two different rehabilitation programs (traditional versus perturbation-enhanced rehabilitation) on the return to sport success rate of potential copers. Subsequently, the standard rehabilitation protocol for potential copers included perturbation training, a specialized form of neuromuscular training.²² The perturbation-enhanced rehabilitation protocol outlined by Fitzgerald²² includes 10 physical therapy sessions over a 2–5 week period. After completing the rehabilitation protocol, all potential copers were required to pass the return to sport criteria of the attending orthopaedic surgeon, including scoring $\geq 90\%$ on all four unilateral hop tests, and the KOS-ADLS and global rating of knee function questionnaires. Failure of rehabilitation or return to sports activities was defined as having a giving way episode of the knee.

Data Management and Analysis

A Chi-Square Test of Independence was used to evaluate the distribution of categorical variables ($\alpha=.05$), and descriptive statistics were used to describe the study sample population and outcomes. Medical and physical therapy charts were reviewed to obtain outcome data. An attempt was made to directly contact (telephone) all individuals who did not have a documented ACL reconstruction (ACLR) after the index injury. During the follow-up patients were asked if they had attempted a return to pre-injury sports, if they were able to do so at the same level, and if they had experienced any giving way or knee injury during the trial of non-operative care. Subjects who had not undergone ACLR at follow-up were asked to complete the KOS-ADLS and global rating of knee function questionnaires during a telephone interview conducted by a single investigator (WJH).

RESULTS

Physical Examination and Imaging Tests

Among the 747 individuals who were initially eligible and agreed to participate in the study, 315 individuals (42%) were excluded from further participation secondary to the presence of concomitant injuries associated with their ACL rupture (Fig. 1). Physical examination and imaging test results identified 57 individuals with bilateral lower extremity injuries, 66 with

concomitant ligamentous laxity, 30 with full thickness articular cartilage lesions, 137 with potentially repairable meniscus tears, and 25 with other injuries that precluded participation in the screening examination (Fig. 1).

Pre-Screening Rehabilitation

Of the 432 subjects who received pre-screening treatment to address impairments, there were 87 individuals (20%) who had persistent effusion, quadriceps weakness, limited knee motion, or pain that was not resolved after one month of physical therapy (Fig. 1).

Screening Examination

The remaining 345 subjects who met all inclusion criteria completed the screening examination an average of 6 weeks (SD=5 weeks, Range=1–28 weeks) after injury. Average age for the group was 27 years (Range: 13–57). The distribution within the sample included significantly more men (N=216, 62.6%) than women (N=129, 37.4%) ($\chi^2=22.96$, Expected N=172.5, $P<.001$). There was also a significant difference in the distribution of potential copers and non-copers within the sample, with more subjects categorized as non-copers (N=199, 58%; Female N=82, Male N=117) than potential copers (N=146, 42%; Female N=47, Male N=99) ($\chi^2=8.142$, Expected N=172.5, $P=.004$).

Rehabilitation and Return to Play Outcomes

After being identified as rehabilitation candidates, 88/146 potential copers (60%) elected to pursue a return to high-level sports activities without surgical intervention. Seventy-two percent (63/88) of the potential copers who pursued non-operative care successfully returned to high-level sports activities, and none sustained additional chondral or meniscal injuries. Five individuals experienced a giving way episode during the agility portion of rehabilitation and were referred for surgery (*failed rehabilitation*). Eighty-three subjects completed rehabilitation and passed all return to sport criteria. Return to play outcomes for two potential copers were not available, and 13 subsequently experienced a single giving way episode upon return to sports activities (*failed return to sports*). Six subjects who were unsuccessful with a return to sports had not participated in perturbation enhanced rehabilitation. Five potential copers who successfully completed rehabilitation elected to not attempt a full return to pre-injury activities that included jumping, cutting, or pivoting maneuvers; these subjects were subsequently categorized as adapters.

Terminal outcomes (ACLR versus no ACLR) were obtained for 86/88 potential copers who pursued non-operative management. All subjects who failed rehabilitation and return to sports underwent ACLR, as did the 2 subjects whose return to sports outcome was unknown[†]. Four adapters had not undergone ACLR at follow-up, while one elected to undergo reconstructive surgery 3 years after completing the screening examination because he was no longer satisfied with limited participation in low-level sports activities. Of the 63 potential copers who successfully returned to sports, 25 had not undergone ACLR, 36 had their ACL surgically reconstructed, and 2 were lost to follow-up. Arthroscopy confirmed that none of the potential copers who elected non-operative management and later underwent ACLR had extended their original injury.

Of the 29 subjects classified as potential copers who had not undergone ACLR at follow-up, 23 were available for telephone interview (Adapters N=4, Full Return to Sports N=19). One subject who had successfully returned to sports had sustained a new knee injury and recently undergone meniscus debridement, and did not complete the knee function questionnaires. Adapters' average KOS-ADLS score was 98% (Range: 97–100%), and their average global rating of knee function was 81% (Range: 70–90%). The potential copers who had successfully

returned to high-level sports activities reported an average KOS-ADLS score of 97% (Range: 87–100%), and their average global rating of knee function was 92% (Range: 50–100%).

DISCUSSION

By systematically and prospectively evaluating patients from the practice of a single orthopaedic surgeon over a 10 year period, we were able to characterize an entire population of highly active patients with ACL injury. Fifty-eight percent of patients were classified as non-copers and were not candidates for non-operative management. These results confirm the belief that, on average, the active individual with ACL injury requires surgical stabilization to permit a return to high-level activities and minimize the risk of continued knee instability.

Forty-two percent of the study sample was excluded from participating in the screening examination secondary to the presence of concomitant injuries. The most common accessory injury was a repairable meniscus tear, followed by multiple ligament involvement, bilateral lower extremity involvement, and full thickness chondral defect. Presence of a repairable meniscal tear or full thickness articular cartilage lesions prohibited participation in the classification algorithm because an injury extension or irreparable damage may have resulted from further giving way episodes. The presence of concomitant ligamentous laxity has been associated with a greater risk of knee instability and probability of further knee damage compared to isolated ACL injuries.^{3, 15} Therefore, individuals with a concomitant grade II or greater injury to a knee ligament other than the ACL were not considered rehabilitation candidates. Results from the physical examination and imaging components of the treatment algorithm emphasize two points. First, ACL ruptures frequently occur in conjunction with other knee or lower extremity injuries. Second, the treatment algorithm is by nature conservative in identification of candidates for non-operative rehabilitation: any factor contributing to an increased risk for continued knee instability or extending the original injury must be considered as rationale for surgical referral over non-operative management.

Approximately 10% of subjects eligible for participating in the screening examination did not resolve their impairments in a timely manner despite participating in supervised rehabilitation designed specifically to address range of motion, effusion, muscle weakness, and pain. An extended inflammatory response and inability to regain muscle strength after ACL injury may have been a consequence of knee instability, suggesting these individuals were not good candidates for non-operative care. Conversely, one month of rehabilitation may not have been adequate time to resolve all impairments. Our rationale for a limited rehabilitation trial to meet screening criteria was that most individuals in the United States who pursue non-operative care are attempting a rapid return to activities that surgery and post-operative rehabilitation cannot provide. A more extended period of rehabilitation to resolve impairments may result in a missed opportunity to return to the desired activity. Consequently non-operative care is no longer considered advantageous. In countries where early surgical intervention is not the standard of care, a more extended period of rehabilitation to prepare for the screening examination may provide insight to the etiology of persistent impairments after ACL rupture.

There were statistically more non-copers than potential copers among the sample who completed the screening examination ($P=.004$). The percentage of subjects classified as potential copers, though, was quite large (42%), indicating a trial of non-operative management is a viable option for many highly active individuals with ACL insufficiency. Seventy-two percent of the potential copers who elected non-operative management were able to successfully return to pre-injury sports activities without further episodes of instability or a reduction in functional status. The success rate of this group of patients identified by the University of Delaware algorithm is far greater than those described in previous studies in which a non-operative return to high-level activities based on patient self-selected basis has

ranged from 23–39%.^{3, 18, 38} The disparity in outcomes suggests use of our decision-making scheme effectively discriminates between operative and non-operative candidates, improving the probability of a safe, successful return to pre-injury activity levels.

Only seven individuals who completed a structured rehabilitation program that included perturbation training were unsuccessful with their attempt to return to sports. We have previously demonstrated rehabilitation that included neuromuscular exercises described as perturbation training (a specialized form of balance training that requires patients to maintain their balance on an unstable support surface while a rehabilitation specialist manipulates the support surface) to be more effective in returning patients to high-level activities than standard rehabilitation techniques.²¹ Motion analysis studies have indicated there is no single stabilization strategy implemented by potential copers to avoid giving way after ACL injury.¹³ Rather, there are a variety of combinations of muscle activity that result in dynamic knee stability. Perturbation training gradually exposes patients to destabilizing forces, providing the opportunity to safely explore individualized stabilization strategies. Traditional rehabilitation protocols that include resistance training, cardiovascular exercise, and agility drills do not promote the development of stabilization strategies to improve dynamic knee stability. Thus, we strongly encourage all patients identified as potential copers who elect non-operative management do so only after participating in rehabilitation that includes neuromuscular training techniques that promote dynamic knee stability.

The majority of potential copers ultimately elected to undergo ACLR after successfully returning to pre-injury activities. Our intention with development of the screening examination was to identify individuals who might be successful with short-term (e.g., finish the remainder of a sports season) non-operative management. Consequently, our recommendation was that individuals return to their physician for surgical management at a more convenient time once they had been cleared for a return to activities. There were, however, a number of individuals who chose to not undergo surgery. A limited number of these individuals had a decline in function. Two individuals rated their daily and global function less than 90%, one with a history involving meniscus debridement procedures, the other with poor function attributed to the contralateral knee. Additionally, two adapters reported their global knee function to be less than 90% because they did not attempt a return to sports and therefore their knee function was lower than before injury. The remaining individuals who had not undergone ACLR at follow-up rated both their daily and global knee function greater than 90%. Though these results are for a limited number of subjects, it appears there is potential for the screening examination to identify candidates who may have long-term success with non-operative care. Larger outcome studies are necessary to confirm the consequences of long-term non-operative management in patients prospectively identified as potential copers.

Using strict criteria from clinical tests that include functional performance, we recommend short-term non-operative care to select individuals. One reason individuals who wish to resume high-level activities are counseled against non-operative care is the increased risk for sustaining a meniscus tear or articular cartilage lesion during a giving way episode, and ultimately developing premature knee OA. Yet the incidence of knee OA after ACL rupture occurs at a similar rate whether the injury is managed surgically or non-operatively.^{31, 41} Because potential copers are counseled against non-operative care if they experience even a *single* additional giving way episode, we do not believe these patients are at greater risk for experiencing premature degenerative knee damage. Follow-up radiographic studies are necessary, however, to confirm this hypothesis. The risk for developing early knee OA after ACL injury whether the lesion is managed operative or non-operatively necessitates patient counseling regarding potential risks and benefits with either treatment approach.

Biomechanical studies provide evidence for the different functional abilities of non-copers and potential copers. Non-copers exhibit profoundly altered movement patterns after ACL injury characterized by a stiffening strategy (i.e., lower sagittal plane knee motion and knee moments, and higher muscle co-contraction in comparison to their contralateral limb and uninjured subjects) to maintain knee stability in the absence of ligamentous support.^{35–37} Conversely, potential copers have movement patterns that are intermediate to uninjured subjects and non-copers.¹³ Because inclusion of both groups in the same sample may obscure genuine differences, investigators evaluating movement patterns after ACL injury have used the classification algorithm to identify a homogenous subject population.^{1, 2, 9, 12, 14, 26} The classification algorithm has not, however, had an impact on clinical practice patterns in the United States. Early surgical reconstruction continues as the standard of care for the highly active individual who exhibits an increase in anterior tibia translation after ACL injury.³² In the face of growing evidence that early onset knee OA is a risk after ACL rupture whether the injury is managed operatively or non-operatively,^{31, 41} we must ask if surgical intervention in an asymptomatic individual has become more habitual rather than evidence based.

There was selection bias in the current study. Only individuals classified as potential copers were presented with the option of pursuing either surgery or non-operative care. Readily available resources, the risk of further knee injury, and surgery over non-operative management as the standard of care in the United States³² dictated, in part, the study design. Given these inherent limitations the current study offers the best available evidence to support the treatment algorithm and screening examination as an effective tool for predicting success in highly active individuals identified as rehabilitation candidates who pursue non-operative management. The ideal study that determines the validity of the screening examination in predicting successful return to sports based on patient classification as either a potential copers or non-copers must be performed in countries where non-operative management is the standard of care early after ACL rupture.

SUMMARY

We performed a large scale systematic evaluation of active individuals with ACL injury confirms the opinion of many sports medicine professionals: surgical reconstruction is necessary to permit a return to high-level activities. Our results indicate, however, a large number of individuals identified as rehabilitation candidates using the treatment algorithm and screening examination who elect non-operative care are able to delay surgery without experiencing further knee instability or extending the original knee injury. Given the differential response to ACL injury, implementation of a clinical decision making algorithm that provides individualized care should be considered as an alternative to a patient management strategy based on anterior knee laxity, age and pre-injury activity levels.

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Figure 1. Treatment and Screening Examination Algorithm Outcomes

PC=Potential Coper; NC=Non-Coper; ACLR=ACL Reconstruction; Rehab=Rehabilitation; RTS=Return To Sports

Table 1Activity Level Classification.^{15,25}

Level	Sports Activity	Occupation Activity
I	Jumping, cutting, pivoting (Basketball, soccer, football)	Activity comparable to Level I sports
II	Lateral movements; less jumping, pivoting than Level I (Baseball, racket sports)	Heavy manual labor, working on uneven surface
III	Straight ahead activities; no jumping or pivoting (Running, weight lifting)	Light manual work
IV	Sedentary	Activities of daily living

Table 2

Impairment Treatment Protocol.

Impairment	Intervention
<i>Effusion</i>	Ice, compression, elevation, isometric muscle pumping, retrograde massage
<i>Joint mobility</i>	Supine wall slides (patient places feet on wall and slides foot down the wall to increase knee flexion), flexion and extension active range of motion, patellar mobilizations, stationary cycling (low resistance), low-load prolonged stretching, emphasis of normal knee flexion and extension excursions during gait
<i>Muscle performance</i>	Isometric quadriceps and hamstrings contractions, straight leg raising, electrical stimulation quadriceps strength training protocol (if indicated by presence of diminished quadriceps contraction, knee extensor lag on straight leg raising, or an inability to perform a straight leg raise, resisted leg extensions (90-45°) and leg curls with elastic bands
<i>Weight-bearing</i>	Partial squats (0-45°), heel raises, lateral step-ups, trampoline jogging and hopping, encourage walking program and stair climbing
<i>Pain</i>	Electrical and thermal modalities, McConnell taping for patello-femoral pain, physician referral for medication or injection assistance

Table 3Screening examination and classification algorithm.²⁰

<u>Screening Examination</u>		<u>Classification Criteria</u> ¹
<i>Unilateral Hop Tests</i>	Single hop for distance	*
	Triple cross-over hop	*
	Straight triple hop	*
	Timed 6-m hop	≥80%
<i>Self-Assessment</i>		
<i>Questionnaires</i>	KOS-ADLS ²	≥80%
	Global rating	≥60%
<i>Number of Giving Way Episodes</i>		≤1

¹ Criteria for classification as a potential copier listed. Failure to meet any of the criteria results in classification as a non-copier.

² KOS-ADLS: Knee outcome survey-activities of daily living scale.

* Results not used as component of classification algorithm.