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Functional progression milestones following anterior cruciate ligament reconstruction are more appropriate than time-based criteria: a survey among the ESSKA

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Abstract

Purpose The aim of this study was to report current rehabilitation recommendations after ACL reconstruction in ESSKA community, with a particular focus on the specific criteria utilized to guide activity progression

Methods A web-based survey was developed to investigate preferences between time-based and functional ACL reconstruction rehabilitation progression milestones of ESSKA community.

Results Eight hundred and twenty completed questionnaires were received. Responders were from 86 different countries worldwide, 63% of them from European countries. Functional criteria were considered more appropriate to decide if a patient can start specific activities/exercises by 67% of the responders. Good core and lower extremity neuromuscular control were the most often used functional criteria for decision-making regarding readiness for sport-specific rehabilitation (66%), sport-specific drills without (65%) and with contact (66%). Strength assessed with an isokinetic dynamometer was considered by about half of the responders a determinant to initiate sport-specific drills without (51%—isokinetic strength, LSI > 80%) and with contact (58%—isokinetic strength, LSI > 85–90%). To determine readiness for sport-specific drills, hop tests were used by 40% of respondents for drills without contact and 48% of respondents for drills with contact.

Conclusion The results of this survey involving mainly orthopaedic surgeons indicate that functional measures are considered more appropriate than milestones based on time from surgery to guide progression through the postoperative rehabilitation process after ACLR. The main clinical relevance of this study is that updated information on collective agreement could be useful for clinicians and physiotherapists to delineate their postoperative treatments after ACLR. These results should be interpreted with caution, as this sample represents only a small portion of ESSKA community involved in knee surgery and treating patients following ACLR.

Level of evidence III.

Keywords Anterior cruciate ligament · Rehabilitation · Time-based criteria · Functional criteria · Survey

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Introduction

Postoperative rehabilitation is a critical recovery component after anterior cruciate ligament reconstruction (ACLR), facilitating successful return to preinjury levels of activity and reducing reinjury risk factors [1, 6, 12].

However, there is no consensus regarding the content of an optimal rehabilitation programme, given that there is a substantial variation with regard to the progression and return to sport within the published postoperative ACLR protocols [17]. Historically, ACLR rehabilitation protocols relied on progression milestones based on time from surgery, respecting remodelling process of the graft.[23]. Recent research has supported a blend of temporal and specific functional criteria to guide progression through the postoperative rehabilitation phases [24].

Criteria-based rehabilitation in theory may improve the final outcome as patients progress to the next phase only if specific goals of the previous phase are achieved [24].

Moreover, a criterion-based postoperative rehabilitation and a sports-specific phase that expose the athlete to the physiological, cognitive and psychological load may reduce ipsi- or contralateral second injury, as rehabilitation is tailored to obtain optimal motor control in complex condition on the sport field [7]. The decision as to when an athlete is allowed to return to sport (RTS) is multifactorial, difficult, and challenging [8], and Dingenen and Gokeler proposed that RTS should be a continuum after ACL injury and ACLR [4].

Conversely, a recent systematic review that found > 70% of published studies excluded functional measures in RTS decision-making, revealing a discrepancy between current ACLR rehabilitation practice patterns and published literature [2].

Surveys among clinicians and physiotherapists could be an interesting methodology to delineate trends in rehabilitation practices. Several surveys regarding rehabilitation tendencies have been previously performed, but functional measures were not included in the surveys [25]. Greenberg et al. analysed the use of objective tests to guide activity progression following ACLR, surveying only United States paediatric orthopaedic surgeons and physical therapists [10, 11]. To our best knowledge, a worldwide survey regarding postoperative care in ACLR including functional criteria utilized to guide activity progression has never been performed.

A web-based survey was developed to investigate the attitudes of the European Society of Sports Traumatology, Knee Surgery and Arthroscopy (ESSKA) community regarding ACLR and rehabilitation. With an easy to administer questionnaire, we wanted to get insight into preferences regarding surgical procedures, rehabilitation

recommendations and RTS criteria separately to draw conclusions for each argument. For the purpose of this study, we present the answers pertaining to the rehabilitation after ACLR. Surgical applications and RTS criteria will be reported subsequently.

Thus, the purpose of this study was to evaluate current rehabilitation recommendations after ACLR in ESSKA community, with a particular focus on the specific criteria utilized to guide activity progression.

The hypothesis of the present study was that functional measures would be more utilized than temporal criteria to guide postoperative rehabilitation progression, especially in the advanced stages of rehabilitation approaching the RTS.

Materials and methods

Questionnaire design

The project consists in the worldwide extension of a survey previously carried out in Italy among members of a national association specialized in sports traumatology and knee surgery (SIGASCOT) regarding surgical techniques and rehabilitation approaches following ACLR [25].

With the support of ESSKA/ESMA (European Sports Medicine Associates which is an ESSKA section), the new survey was implemented with the aim to determine preferences of ESSKA community between time-based and functional ACLR rehabilitation progression milestones. A task force of five orthopaedic surgeons and one physiotherapist, highly experienced in managing patients after ACL injuries, was established to develop the survey.

A questionnaire comprising 26 items about brace utilization, weight bearing status, postoperative rehabilitation programmes and starting time for specific exercises and activities was developed (“Appendix” section).

A web-based survey tool (Survey Monkey, surveymonkey.com, Portland, OR) was then configured to collect the responses.

Study sample

An international society of surgeons specialized in sports traumatology and knee surgery (ESSKA) was contacted. This society has 3440 members (members with duties paid every year) and 6334 non-members. ESSKA non-members (so-called friends of ESSKA) have access to the ESSKA academy and other ESSKA scientific facilities.

All contacts in the official mailing list of the ESSKA were considered eligible and authorization was gained to contact them without prior consent. On the basis of the mailing list, 9774 personalized invitations were sent (target population).

Permission was obtained by ESSKA board to contact the community of the society by email twice: the first time to present the research initiative and to invite each member to complete the online questionnaire; the second time to send a reminder to join the initiative only to those members who had not responded to the survey by that time. The survey was kept open from the 13th of September 2018 to the 15th of January 2019; on the 5th of December 2018 a reminder email was sent.

Statistical analysis

Data obtained from the completed questionnaires were entered into a custom database developed in Microsoft Excel Package Office 2013 (Microsoft, Redmond, USA). Response rates are summarised in terms of number and proportions of respondents. The Pearson Chi-square test and Fisher's exact test were used to study the association between number of reconstruction operations performed, geographic location by continent and selection of treatments. A p value lower than 0.05 ($p < 0.05$) was considered statistically significant. Statistical analysis was performed using PSPP software (Free Software Foundation, Inc.) for windows.

Results

At the end of the survey, 820 completed questionnaires were received (63% from ESSKA members and 37% from non-members). Responders were from 86 different countries worldwide and 63% of them were from European countries.

Surgical volume expressed as the number of ACLR procedures performed per year ranged between 25 (19%), 25–50 (29%), 51–100 (30%) and more than 100 ACLR per year (19%). A total of 17 (2%) responders were not surgeons.

The survey results are summarised in “Appendix”.

Functional criteria were considered more appropriate to decide if a patient can start specific activities/exercises by 67% of the responders. Functional criteria were more popular in America, Europe and Oceania and the data were significant (Fig. 1, $p = 0.03$). The number of reconstruction operations performed per year was not associated with functional/time choice.

A small majority of the responders indicated that they would not refer to functional criteria for brace removal (56%) and almost half of responders do not refer to functional criteria for allowing weight bearing as much as tolerated (43%), exercise bicycle (47%), and isokinetic exercises for strengthening (39%). A large proportion of the sample indicated to base on functional criteria the starting of running on treadmill (20% do not refer to functional criteria), sport-specific rehabilitation (13% do not refer to functional criteria), sport-specific drills without (20% do not refer to functional criteria) and with contact (7% do not refer to functional criteria).

Functional criteria utilized for progression through rehabilitation after ACLR are reported in Table 1.

Time from surgery progression milestones are reported in Table 2

Considering postoperative routine applications, the rate of postoperative brace utilization was 41% after isolated ACLR, and 87% in case of concomitant collateral ligaments lesions, and the rate of continuous passive motion (CPM) use was 27%. A significantly higher rate of Asian and African responders used to brace patients (Fig. 2, $p < 0.0001$). There was no significant association between the brace and CPM use and the number of reconstruction operations performed per year.

Fig. 1 Correlation between geographic location by continent and functional/time criteria choice. The data reveal a Chi-square statistic of 10.58 ($p = 0.03$). AF Africa, AM America, AS Asia, EU Europe, OC Oceania

Table 1 Study questionnaire regarding functional criteria to decide if a patient can start specific activities/exercises with summarised results (can choose more than one-tick all that apply)

<i>Brace removal (%)</i>	
Active straight leg without extension lag	28.5
100 degrees flexion achieved	21.6
Swelling ≤ 3 (scale 0–4)	13.5
Pain VAS ≤ 5	13.1
I do not refer to functional criteria	55.9
<i>Weight bearing as much as it is tolerated? (%)</i>	
Active straight leg without extension lag	27.7
Full extension possible	27.4
Normal gait pattern	21.6
Swelling ≤ 3 (scale 0–4)	14.8
100 degrees flexion achieved	9.3
I do not refer to functional criteria	42.8
<i>Single leg postural control (balance) (%)</i>	
Full weight bearing possible	67.4
Pain VAS < 5	30.3
Swelling ≤ 3 (scale 0–4)	27.8
Full ROM	26.6
ROM 0–90	21.4
I do not refer to functional criteria	21.9
<i>Exercise bicycle (%)</i>	
Swelling ≤ 3 (scale 0–4)	33.2
Full ROM	31.5
Normal gait pattern	26.3
10× active straight leg without extension lag	18.7
Symmetrical squat	11.1
I do not refer to functional criteria	36.8
<i>Running on treadmill (%)</i>	
No pain during gait	59.2
Normal gait pattern	57.8
Quadriceps strength > 4 on MRC scale	45.8
Full ROM	39.9
Good patellar mobility	36.7
I do not refer to functional criteria	19.8
<i>Strengthening open kinetic chain quadriceps between 90° and 40° (%)</i>	
Based on the patients' tolerance	54.4
Good patellar mobility	29.6
Swelling ≤ 3 (scale 0–4)	27.3
High-load eccentric resistance—80% of 1—repetition maximum	16.0
Low-load concentric resistance—50% of 1—repetition maximum	15.7
I do not refer to functional criteria	31.6
<i>Isokinetic exercises for strengthening (%)</i>	
No increase anterior knee pain post-exercise > 24 h	38.9
No increase anterior laxity over time on clinical tests (Lachman, anterior drawer, pivot shift)	30.5
Pain VAS < 3	28.4
No patello-femoral crepitus	23.9
High-load resistance at 30–60 deg/s full ROM	23.2
I do not refer to functional criteria	38.9
<i>Sport-specific rehabilitation (%)</i>	
Good neuromuscular control core and lower extremity	66.0
No ligament laxity/instability on clinical tests (Lachman, anterior drawer, pivot shift)	62.3
No giving-way episodes during the preceding phases	58.6

Table 1 (continued)

Isokinetic strength > 80%	49.7
Symmetrical running (visual and auditory) pattern for at least 10 min on treadmill > 8 km/h	48.6
Minimal effusion (grade 0–1)	47.7
Pain VAS < 3	40.9
I do not refer to functional criteria	12.9
<i>Sport-specific drills without contact (%)</i>	
Good neuromuscular control core and lower extremity	65.2
Isokinetic strength > 80%	51.5
Hop tests < 10% difference	40.5
Running with fast changes of direction	38.3
Increasing speed of straight line running with “stop and go”, progressing to change of directions	36.6
Aerobic and/or anaerobic endurance	35.0
AP laxity < 3 mm side-to-side difference	34.2
I do not refer to functional criteria	20.1
<i>Sport-specific drills with contact (%)</i>	
Good neuromuscular control core and lower extremity	66.5
Isokinetic strength > 85–90%	58.5
Running with fast changes of direction	57.2
Hop tests < 10% difference	47.9
Satisfactory clinical exam (KT-1000, absence of pivot shift)	46.3
Able to play small matches (e.g. 3 vs 3) without contact	39.1
Questionnaires (IKDC, CKRS, KOOS, KOS-SAS, ACL-RSI etc.)	24.8
I do not refer to functional criteria	17.5

Discussion

The most important finding of the present study was that functional criteria were the most important factors regarding progression phases of rehabilitation after ACLR among responding members of the ESSKA community.

These data could indicate a change of trend in ACLR rehabilitation progression decision-making, in agreement with previous surveys. A recent survey by Greenberg et al. [10] among members of the Pediatric Research in Sports Medicine (PRiSM) Society revealed that 65% and 66% utilized functional tests to initiate jogging and modified sports activity, respectively. Conversely, former national surveys among orthopaedic surgeons performed between 2010 and 2015 reported that only 30% considered functional tests to allow RTS [9].

There was a tendency between responders to correlate achieved functional conditions with time progression during the rehabilitation process, and functional criteria were more popular as the rehabilitation course progressed. While 56% of responders do not utilize functional criteria for brace removal, almost all the sample indicated to refer to functional criteria to initiate sport-specific rehabilitation (13% do not refer to functional criteria), sport-specific drills without (20% do not refer to functional criteria) and with contact (7% do not refer to functional criteria). These results reflect the multifactoriality and challenge of decision-making in

the later phases of rehabilitation, restarting sports activity, when athletes are exposed to higher physical, physiological, neurocognitive, and psychological demands [4].

Neuromuscular function and motor control have been recognized by the majority of responders as important factor for allowing sport-specific rehabilitation (66%), sport-specific drills without (65%) and with contact (66%). These data may reflect current literature recommendations that promote functional limb control and movement quality during rehabilitation of ACLR patients to improve recognition of performance deficits and prevent the risk of second ACL injury [24]. Hewett et al. [12] noted that ACLR alone does not fully abate the neuromuscular deficits and asymmetries incurred as a result of injury and assessment and treatment of bilateral limb compensations during rehabilitation appear necessary to obtain a comprehensive clinical picture of post-operative movement deficiencies.

Hop test utilization to determine whether an athlete is ready to resume sport-specific drills was recommended by only 40% of respondents for sports without contact and 48% of respondents for sports with contact. Hop tests have been purposed as an objective measure of the functional capabilities of an athlete related to the demands of high-level sport activities. These hop tests can provide a reliable performance-based outcome for ACLR patients and only require a minimal amount of equipment [20]. However, a recent review found that there is a fair to moderate

Table 2 Study questionnaire regarding time from surgery criteria to decide if a patient can start specific activities/exercises with summarised results

		≤ 2 weeks	2–4 weeks	4–6 weeks	≥ 6 weeks	I do not refer to time criteria			
Brace removal		6.5	28.4	43.2	15.4	6.5			
Weight bearing as much as it is tolerated		52.6	22.9	11.9	2.6	10.1			
Full flexion of the knee		24.1	17.8	21.6	20.0	16.5			
single leg postural control		4.8	11.8	29.9	36.3	17.2			
Exercise bicycle		8.3	22.8	36.2	25.7	7.1			
		≤ 4 weeks (%)	4–6 weeks (%)	6–8 weeks (%)	8–10 weeks (%)	10–12 weeks (%)	≥ 6 weeks (%)	I do not refer to time criteria (%)	
Running on tread- mill	1.2	4.1	10.8	16.5	21.6	37.2	8.3		
		≤ 2 months (%)	2–3 months (%)	3–4 months (%)	4–6 months (%)	≥ 6 months (%)	I do not refer to time criteria (%)		
Strengthening open kinetic chain quadriceps between 90 and 40°	13.1	25.0	29.4	13.9	7.6	11.0			
		≤ 2 months (%)	2–4 months (%)	≥ 4 months (%)	Never (%)	I do not refer to time criteria (%)			
Isokinetic exercises for strengthening	24.8	35.7	22.2	4.2	13.1				
		≤ 2 months (%)	2–4 months (%)	4–6 months (%)	6–8 months (%)	8–10 months (%)	10–12 months (%)	> 12 months (%)	I do not refer to time criteria (%)
Sport-specific rehabilitation		2.0	7.1	38.2	31.4	9.82	2.6	2.1	6.8
Sport-specific drills without contact		1.2	4.7	30.6	40.6	10.5	2.7	1.4	8.2
Sport-specific drills with contact		0.9	0.8	7.0	34.0	28.9	11.0	8.1	9.2

Fig. 2 Correlation between geographic location by continent and brace utilization. The data reveal a Chi-square statistic of 49.58 ($p < 0.00001$). AF Africa, AM America, AS Asia, EU Europe, OC Oceania

association between hop tests performed at 6 months after ACLR and RTS at 12 months after ACLR [16]. Moreover, no significant association was found between passing hop tests (with > 90% LSI as the passing criterion) and second ACL reinjury [16].

The use of hop tests batteries including hop tests whereby an athlete is forced to move as quickly as possible in multiple directions (figure-of-eight hop, side hop, or square hop tests) has been advocated for by many experts [4]. It is of great concern that based on a survey on Australian therapists, only a third of patients practiced on any hopping and landing or agility-type activities as part of their rehabilitation [5]. The above findings may suggest that one of the possible explanations why patients do not meet the RTS criteria is simply due to the lack of implementation of evidence-based rehabilitation in terms of specificity and training load. It is important to point out that a single leg hop test cannot be used as a surrogate measure for knee extensor strength, as no association has been established between hop tests and knee extensor strength [3]. This was recently confirmed as patients after ACLR performing hop tests commonly demonstrate higher LSI values compared to isokinetic testing [18].

A slight majority of respondents reported using knee strength isokinetic testing as a determinant to progress to sport-specific drills. Several studies reported isokinetic muscle strength evaluation of the hamstrings and quadriceps after ACLR to evaluate readiness to later phases of rehabilitation progression and RTS, although these measures have not been sufficiently validated as useful predictors of successful RTS [22]. Moreover, debate exists on the most optimal outcome measures and the functional relevance of testing strength in an open-chain situation [22]. Knee strength was reported as key to determine readiness for activity progression throughout all phases of rehabilitation by more than 80% of respondents of a survey among 1074 American Physical Therapy Association physiotherapists [11]; of note, more than half of those physical therapists who assessed strength indicated that they used manual muscle testing as the only strength measure. This is an area of concern as manual muscle tests using the Medical Research Council scale have several limitations, including poorly defined limits between grades ‘4’ and ‘5’ [19]. For research purposes, isokinetic dynamometry is often used for strength assessment [14]. However, isokinetic devices lack practicality in clinical settings due to cost, lack of portability and space requirements. A more clinically viable alternative is hand-held dynamometry [13] or the use of a leg press machine [Nagai 2019]. Commonly a limb symmetry index (LSI) is used, defined as the ratio of the involved limb score and the uninvolved limb score expressed in percentage ($\text{involved/uninvolved} \times 100 = \text{LSI}$). A LSI of $> 90\%$ is usually used as an acceptable cutoff score. For recreational and non-pivoting sports, an LSI of $> 90\%$ may be acceptable, whereas a $> 100\%$ LSI for knee extensor and knee flexor muscle strength for the pivoting/contact/competitive athlete has been recommended [21].

The main limitation of this study regards the very low response rate with respect to the target population of ESSKA community, with subsequent risk of a heavy non-response bias. Non-response bias weakens the reliability of the findings of most web-based surveys as well as the soundness of subsequent inference analysis. We acknowledge that a lack of response is equivalent to remaining within the consensus opinion, thus the results of our study cannot be considered as the state of the art of ESSKA community.

Another important limitation is that only 2% of responders were not surgeons. This data may limit the generalizability of these results to the population of physical therapist members. Non-surgeon members who did not fill in the questionnaire could have rehabilitation recommendations after ACLR that are systematically different from the opinions of those who completed the survey.

To limit annoyance and to facilitate the completion of questionnaire forms, several functional criteria choices were not defined in details, such as definition of “normal gait

pattern”, “aerobic and/or anaerobic endurance”, and “good neuromuscular control”. To improve further research following this survey, the functional criteria could be presented in more detail, including measurement methods, the measurement properties and the respective cutoff values.

Conclusion

The results of this survey involving mainly orthopaedic surgeons indicate that functional measures are considered more appropriate than milestones based on time from surgery to guide progression through the postoperative rehabilitation process after ACLR. These results should be interpreted with caution, as this sample represents only a small portion of ESSKA community involved in knee surgery and treating patients following ACLR.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

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