Knee Surgery, Sports Traumatology, Arthroscopy (2020) 28:2403–2414
https://doi.org/10.1007/s00167-020-06009-1

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Return to sport after anterior cruciate ligament injury: Panther Symposium ACL Injury Return to Sport Consensus Group

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Received: 8 February 2020 / Accepted: 16 April 2020 / Published online: 28 April 2020

Abstract

Purpose A precise and consistent definition of return to sport (RTS) after anterior cruciate ligament (ACL) injury is lacking, and there is controversy surrounding the process of returning patients to sports and their previous activity level. The aim of the Panther Symposium ACL Injury RTS Consensus Group was to provide a clear definition of RTS and description of the RTS continuum, as well as to provide clinical guidance on RTS testing and decision-making.

Methods An international, multidisciplinary group of ACL experts convened as part of a consensus meeting. Consensus statements were developed using a modified Delphi method. Literature review was performed to report the supporting evidence.

Results Key points include that RTS is characterized by achievement of the pre-injury level of sport and involves a criteria-based progression from return to participation to return to sport, and ultimately return to performance. Purely time-based RTS decision-making should be abandoned. Progression occurs along a RTS continuum with decision-making by a multidisciplinary group that incorporates objective physical examination data and validated and peer-reviewed RTS tests, which should involve functional assessment as well as psychological readiness. Consideration should be given to biological healing, contextual factors and concomitant injuries.

Conclusion The resultant consensus statements and scientific rationale aim to inform the reader of the complex process of RTS after ACL injury that occurs along a dynamic continuum. Research is needed to determine the ideal RTS test battery, the best implementation of psychological readiness testing and methods for the biologic assessment of healing and recovery.

Level of evidence IV.

Keywords Return to sport · Anterior cruciate ligament · Consensus statement · Rehabilitation

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Introduction

Anterior cruciate ligament (ACL) injury and subsequent treatment have been the subject of thousands of scientific investigations over the last 50 years. Amongst the controversies that persist in ACL treatment is the process of return to sport (RTS) [24, 45, 57, 60]. The rehabilitation, as well as the RTS process, begins immediately after ACL injury, and high-quality rehabilitation is an important element in both operative and nonoperative ACL injury treatment [4, 24, 74]. There is, however, a lack of standardization in ACL rehabilitation programs [19, 43]. There is also a lack of consensus on the preparation of patients for a successful RTS [5, 29, 41]. Moreover, there has been wide variability in the criteria used in RTS decision-making [10]. Although time-based decision-making is frequently used, appropriate RTS timing is uncertain, especially given the variability in the individual patient's recovery and biologic healing of the graft. Objective, criteria-based RTS programs are increasingly used, but a lack of consistency in these testing protocols still remains [9].

Controversy also remains in terms of the definition of RTS after ACL injury treatment and a successful outcome. In 2016, a consensus group from the First World Congress in Sports Physical Therapy defined a RTS continuum in general for all sports, but this has not been applied to ACL injury [5]. The RTS continuum emphasized a criteria-based progression from "return to participation" to "return to sport" to "return to performance." "Return to participation" was defined as return to training or participation in sport at a lower level, but not yet ready to return to full sporting activity at the previous level. "Return to sport" was defined as return to the previous level of sport, but not performance at the desired or pre-injury level. "Return to performance" was defined as patients' return to performance at the pre-injury level of sport. These terms are used as the patient progresses back from injury and can describe the successful RTS process. This model of a continuum is appropriate for the complex process of RTS after ACL injury because of the multiple decisions made as the patient progresses through the rehabilitation process, resumes activities and ultimately returns to the pre-injury level of performance.

An international, multidisciplinary group of ACL clinical and research experts was convened with the task of development of evidenced-based and expert opinion consensus statements on RTS after ACL injury. This applies to both operative and non-operative treatment of ACL injury as the RTS principles remain the same. The aim of the group was to provide a clear definition of RTS after ACL injury and a description of the RTS continuum, as well as to provide guidance on RTS for patients undergoing ACL treatment. The purpose of this manuscript is to report the consensus statements on RTS after ACL injury and the evidence to support the statements.

Materials and methods

An international, multidisciplinary group of ACL clinical and research experts collaborated in a consensus building effort that culminated in the ACL Consensus Meeting Panther Symposium 2019 on June 5–7, 2019 at the University of Pittsburgh Medical Center in Pittsburgh, PA, USA (Fig. 1). This global symposium included experts from 18 countries joining together to form consensus groups on current areas of ACL injury controversy, including treatment, clinical outcomes and RTS. Twenty-six international ACL experts including orthopaedic surgeons, sports medicine physicians, physical therapists and scientists were convened to form the Panther Symposium ACL Injury Return to Sport Consensus Group. A modified Delphi method was used to develop the consensus statements on RTS after ACL injury [26, 34]. This consisted of three rounds: internet survey with consensus group member feedback, in-person discussion facilitated by the three RTS session chairs (TLC, CF and BPL) and final vote.

An initial list of 11 statements was drafted by the scientific organizing committee and session chairs to address areas of current controversy and provide guidance for clinicians to address the challenges of RTS. The initial list was created as a starting point, and then the modified Delphi process commenced. For the first round, consensus group members completed an internet-based survey to indicate level of agreement or disagreement and to provide feedback on the statements. After 2 days of evidenced-based presentations by symposium delegates at the ACL Consensus Meeting, the second round of the modified Delphi was held with a structured session where each statement generated from the results of the internet-based survey was discussed and revised. The discussion was moderated by the RTS session chairs (TLC, CF and BPL). After the discussion, a vote was taken, and 80% agreement was determined a priori to represent consensus. Statements that did not reach 80% agreement were reported as such. Two assigned liaisons (SJM, TR) documented the discussion, revised each statement at the requests of the consensus group and completed literature review of MEDLINE to be included in support of the finalized statements. MEDLINE was searched in June 2019 using the terms "anterior cruciate ligament," "return to sport," and "return to play" with a focus on publications in the previous 5–10 years. To reduce potential bias, the liaisons did not submit answers to the pre-meeting survey, nor did they vote in the consensus process.

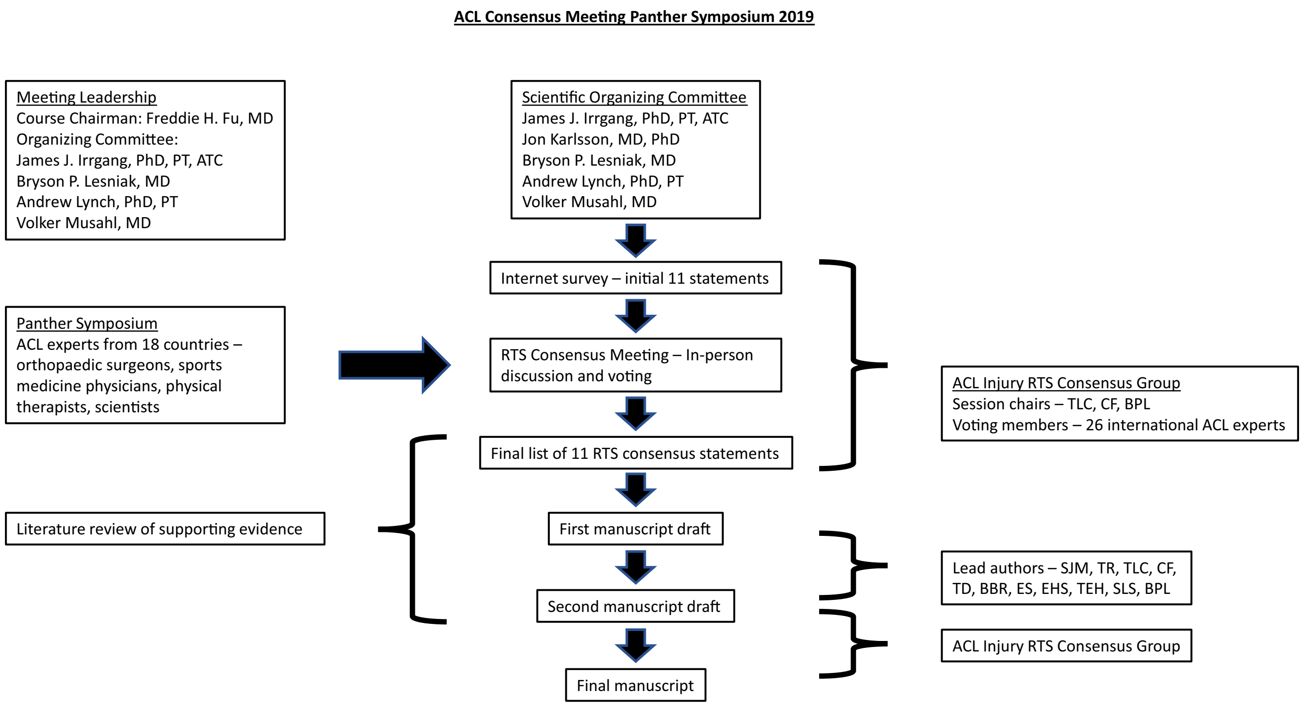

Fig. 1 International ACL experts convened as part of a consensus building effort in June 2019. Through a stepwise process, the ACL Injury Return to Sport Consensus Group developed the final consensus statements and manuscript

Consensus statements and discussion

Following discussion by the consensus group, 11 statements achieved consensus and are presented below (Table 1). These are accompanied by a summary of the pertinent evidence and rationale that support each statement. The previously published RTS terminology [5] was used to maintain consistency in the literature and expanded upon to provide further detail (Fig. 2).

Table 1 ACL injury RTS consensus statements

Consensus statement	Votes (*n*), % agreement
1. RTS is characterized by achieving the pre-injury level of sports participation as defined by the same type, frequency, intensity, and quality of performance as before injury	24/26, 92% agreement
2. Sports medical clearance should be made prior to progressing the patient to unrestricted training and competition	25/26, 96% agreement
3. Clearance to full participation (practice followed by competition) should be a multidisciplinary decision involving the patient, parent if the patient is under 18 years of age, surgeon, team physician, and physical therapist/athletic trainer	26/26, 100% agreement
4. Clearance to return to sports participation should be followed by a carefully structured plan to return to practice before progressive return to competition	26/26, 100% agreement
5. Purely time-based RTS decision-making should be abandoned in clinical practice	26/26, 100% agreement
6. RTS decision-making must include objective physical examination data (e.g. clinical tests and measures)	26/26, 100% agreement
7. Patients should pass a standardized, validated, and peer-reviewed RTS test, with respect to the healing tissues, prior to returning to full activities after ACL injury with or without ACL reconstruction	23/26, 88% agreement
8. Return to sport testing should involve assessment of specific functional skills that demonstrate appropriate quality of movement, strength, range of motion, balance, and neuromuscular control of the lower extremity and body	26/26, 100% agreement
9. RTS decision-making includes psychological readiness as measured by a validated scale	22/26, 85% agreement
10. The decision to release an athlete to return to sport should consider contextual factors (type of sport, time of season, position, level of competition, etc.)	26/26, 100% agreement
11. Consideration should be given to the nature and severity of concomitant injuries of the knee (e.g. cartilage and menisci) when making RTS decisions	25/26, 96% agreement

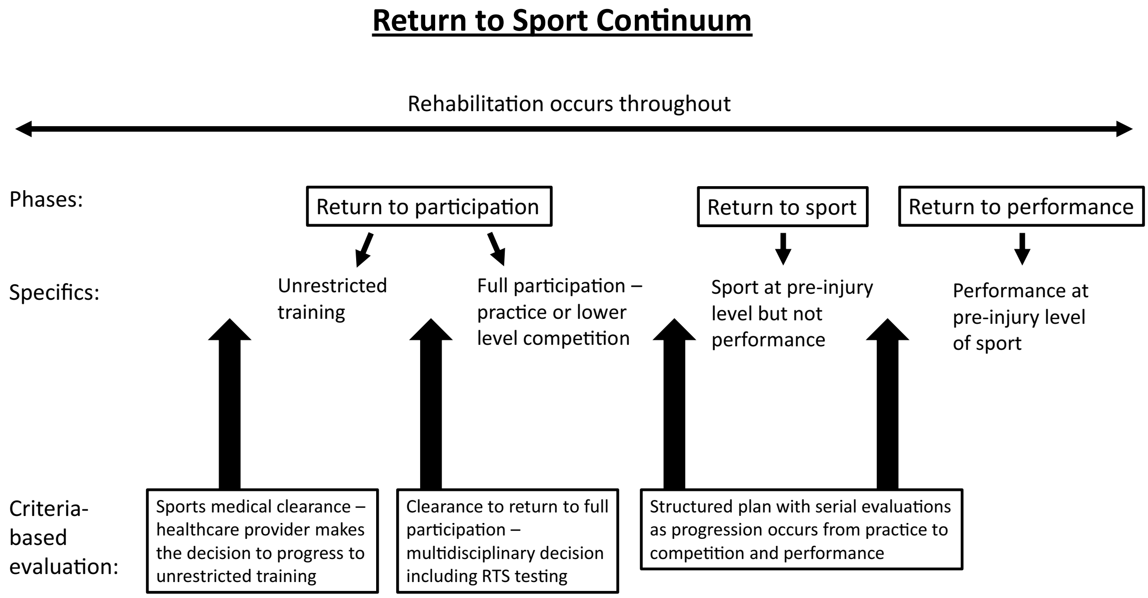

Fig. 2 The return to sport continuum is a criteria-based progression through the phases of return to participation, return to sport, and return to performance, with structured, serial evaluations throughout the process

> Return to sport (RTS) is characterized by achieving the pre-injury level of sports participation as defined by the same type, frequency, intensity and quality of performance as before injury. (24/26, 92% agreement)

RTS is one of the main goals of non-operative or operative treatment for ACL injury. Anatomic ACL reconstruction is the gold standard treatment for ACL injury in patients who wish to return to cutting or pivoting sports, have physically demanding occupations, or have persistent instability [9, 24, 46]. Some patients are able to obtain a functionally stable knee with non-operative management and return to sports [31, 70]. Previous research indicates that there is discrepancy between the reality of RTS rates following ACL injury and patients' expectations [6, 24, 62]. While approximately 90% of the patients report normal or near normal knee function on IKDC-SKF, a large systematic review reported pooled rates of 74–87% returning to some sports activity, 59–72% returning to their pre-injury sport and 46–63% returning to competitive sports [7]. The difference between the varied reports of RTS rates and patients' subjective evaluation may be due to the fact that a precise and consistent definition of RTS is lacking [9, 24, 29, 62]. Terms like "return to play", "return to sport", "return to participation" and "return to unrestricted physical activity" are used interchangeably and cause confusion in the literature [5, 6, 24, 29].

Moreover, the definition of a successful RTS remains unclear [66]. Multiple factors must be taken into consideration for determination of a successful RTS because of the differences in competition and reinjury risk. For some patients, their level of sport requires greater frequency and intensity, as well as greater training to reach the desired level of performance. For other patients, the goal is not to return to the same level of sport, and may actually be to return at a lower level. Successful RTS, therefore, represents different things to different patients. In addition, the aspects of the sport that include pivoting or non-pivoting and contact or non-contact can have dramatic differences on the risk of reinjury. Therefore, the consensus group determined that RTS must take into account the type of sport (pivoting or non-pivoting, contact or non-contact, and same as pre-injury or a different sport), frequency (daily, weekly, monthly, etc.), intensity (competitive, recreational and professional) and the performance level [39, 50, 66]. It is important to recognize that RTS is an outcome measure that must include these specific components, but RTS is also a continuous process to reach the end goal.

Conclusion: To be precise and consistent, the RTS definition must include achieving the factors of pre-injury sports type, frequency, intensity and quality of performance.

> Sports medical clearance should be made prior to progressing the patient to unrestricted training and competition (25/26, 96% agreement).

The decision of clearance to unrestricted training is multifactorial and should consider the time since injury, treatment, clinical examination, RTS testing, psychological readiness and sport-specific conditions [4, 5, 44]. Competing interests and expectations of those involved in the RTS process, e.g. patient, family, coach, surgeon, team physician, physical therapist/athletic trainer, should be recognized [5, 16, 20]. Ultimately, the decision to provide clearance to begin progressing the patient's training is to be made by the healthcare provider, including physician or physical therapist/athletic trainer. This is an important distinction determining that the healthcare provider alone should make this initial decision to progress to unrestricted training. With any conflict of interest, the healthcare provider's ethical obligation is to the patient's health [21]. Although the team physicians may experience conflicting pressures, they must be transparent and inform the patient about any concerns so that the patient is adequately informed [16]. These contextual factors make the clearance decision demanding and emphasize the importance of understanding the RTS process as a continuum with a criteria-based stepwise approach [74].

Conclusion: It is vital that the healthcare provider makes the sports medical clearance decision prior to progressing the patient to unrestricted training.

> Clearance to return to full participation should be followed by a carefully structured plan to return to practice before progressive return to competition (26/26, 100% agreement).

The RTS process should be considered as a progressive course throughout the patient's rehabilitation, taking into account the restoration of biological knee health according to the chosen treatment option, the targeted sport, and the desired level of performance, as well as concomitant knee injuries and psychological readiness [4, 5, 10, 17, 19, 20, 24, 46, 55, 76, 78]. The process should be divided into phases, including specific clinical and functional milestones that are required to be met before progression to the next phase [4, 5, 69]. As such, RTS should not be understood as an isolated decision at the end of the rehabilitation process [5]. The RTS continuum as defined by Ardern et al. emphasizes the stepwise progression through the three elements of the RTS process [5]. According to the progression of activity, the three required elements are return to participation, return to sport and return to performance. During the phase of return to participation, the athlete is physically active, may train, but is medically, physically and/or psychologically not yet ready to return to sport. During the return to sport phase, the athlete has returned to the defined sport, but the desired performance level is not yet reached. During the return to performance phase, the athlete returned to the defined sport and performs at of the pre-injury level. This model of a RTS continuum focuses on the athlete advancing through a progression of activity.

Consistent with the previous RTS continuum terminology, this consensus group used the terminology of return to participation, return to sport and return to performance, but expanded this further (Fig. 2). Return to participation was divided into unrestricted training followed by full participation to emphasize the progression of activity from training to sporting practice. Return to sport and then return to performance follow in stepwise progression. An athlete should be cleared to start with the next activity phase only if specific goals of the previous phase are achieved, and confirmed by sport-specific clinical and functional tests [69]. Serial evaluations should occur as the athlete progresses through the structured plan.

Others have similarly reported on RTS as a stepwise progression. One such group subdivided the RTS process, using the terms of graded progression from physiotherapy (rehabilitation) to sport-specific training, followed by training for competition and then actual competition [11]. Another report defined the key steps of the RTS progression as on-field rehabilitation, return to training, return to competitive match play and return to performance [13]. For consistency, this consensus group limited the terminology as seen in Fig. 2 to capture the RTS continuum with clear and precise terminology.

A three step decision-based RTS model was reported in 2010 to synthesize and categorize different aspects of the RTS process, and may also be a useful framework for providers to consider [16]. Step 1 deals with medical factors to evaluate the patient's health status, such as demographics, medical history and physical and psychological examination. Step 2 involves the sport-specific risk modifiers to evaluate participation risk, such as type of sport, competition level, limb dominance and protective capabilities. Step 3 deals with decision modifiers, such as timing of season, conflict of interest and internal and external pressure. In 2019, the strategic assessment of risk and risk tolerance (StARRT) framework modified this three-step model to group risk assessment by casual biological constructs and compare the risk assessment to the assessment of risk tolerance [63]. This framework can be useful to the healthcare provider because if the risk assessment is greater than the risk tolerance, then there is reason to not allow RTS.

Conclusion: The RTS continuum emphasizes a carefully structured stepwise progression of return to practice first, and then return to competition as summarized in Fig. 2.

> Clearance to full participation (practice followed by competition) should be a multidisciplinary decision involving the patient, parent if the patient is under 18 years of age, surgeon, team physician and physical therapist/athletic trainer (26/26, 100% agreement).

RTS occurs along a continuum, and there is a shared decision-making process that occurs over time and with multiple contributors. There are different medical and technical competencies between the different contributors (surgeon, team physician and physical therapist/athletic trainer) in this process. The principles of shared decision-making apply, and the patient is actively involved [25, 64]. A multidisciplinary decision must be made with reasonable compromise from all groups if dissent exists. This multidisciplinary approach requires well-defined roles, communication among all parties, and a system to protect the athlete from disparate risk tolerances [3, 5, 64, 69].

Inclusion of the coach as a decision-maker in this consensus statement did not reach consensus (7/26, 27% agreement). There was concern that inclusion of the coach in the medical decision would create a conflict of interest given the coach's obligation or commitment to the team. The primary obligation of the healthcare provider is the patient's health, whereas the coach remains focused on the success of the team [27]. Nevertheless, the coach, as a key person in the sports development of the athlete, needs to be informed and involved in information sharing as the athlete progresses toward sport participation. The coach has the ability to evaluate the performance of the patient as he or she returns to practice, and can provide an assessment of the patient's progress to the healthcare providers.

Conclusion: Given that the clearance to return to full participation occurs along the RTS continuum, the decision must be multidisciplinary including the patient, physicians and physical therapist/athletic trainer, but the coach is not included in the decision-making.

> Purely time-based RTS decision-making should be abandoned in clinical practice (26/26, 100% agreement).

Based on the individual differences in biological healing, impairment resolution, neuromuscular control, functional skills and psychological readiness, the period of time before RTS is variable [5, 69]. Achievement of normalized joint homeostasis (e.g., absence of effusion and resolution of pain), neuromuscular control and sufficient proprioception and strength after ACL injury may require up to 2 years and varies based on individual progress through the RTS process [41, 51]. Purely time-based is thus insufficient as individual patients can vary significantly. There is, however, an important role for time-based consideration respecting the healing process of the graft. Recent data showed that for every month, unrestricted return to competition was delayed up to 9 months postoperatively, the re-injury incidence was reduced by 51% [30].

The biology of graft healing and maturation is important and without current biological means of graft healing assessment, time is one factor to consider. There is likely a minimum time necessary to allow graft maturation, and RTS prior to 6 months likely represents unacceptably high risk. Ultimately, RTS decision-making should ensure that objective criteria are met before progressing to the next stage of rehabilitation. This structure of objective measures rather that purely time-based decision-making is mirrored in the recent literature, which has shown a transition from mainly time-based rehabilitation recommendations [9, 19, 68] to multi-tiered, criteria-based, sport-specific and patient-tailored rehabilitation and RTS programs [4, 20, 24, 29, 49, 66, 69, 77].

Conclusion: As graft maturation and achievement of joint homeostasis are multifactorial and individual healing conditions are variable, purely time-based RTS decision-making is not sufficient.

> RTS decision-making must include objective physical examination data (e.g. clinical tests and measures) (26/26, 100% agreement).

The factors to consider in decision-making during the RTS continuum must be clearly defined. One major factor that must be included is objective physical examination data [9]. Although there is limited data to guide the decision of which measures should be included, it is important to have a consistent set of objective measurements [10, 42]. Therefore, the consensus group concluded that the physical examination must include range of motion, presence of effusion, laxity testing including Lachman and pivot shift tests and quadriceps and hamstring muscle strength. These objective measures document that necessary knee recovery from major knee injury has occurred and, therefore, are key to the RTS decision-making.

A systematic review reported that greater quadriceps strength and less effusion were the physical examination findings associated with successful RTS [17]. It has also been reported that hamstring to quadriceps strength ratio deficits and failing to pass a clinical test, involving quadriceps strength and single-leg jump testing, was associated with higher ACL graft rupture rates [37]. Additionally, for every 1% increase in quadriceps limb symmetry index, there was a 3% reduction in subsequent knee injury risk [30]. The objective physical examination should be conducted with the understanding of the patient's individual sport, where some measures may be more relevant. Although the physical examination may be considered the baseline assessment for monitoring knee injury recovery, multiple other criteria, such as RTS functional testing and psychological assessment, should also be met prior to RTS.

Conclusion: Objective physical examination data are minimum to establish necessary knee recovery following ACL injury or reconstruction and is widely accepted in RTS decision-making.

> Patients should pass a standardized, validated and peer-reviewed RTS test, with respect to the healing tissues, prior to returning to full participation after ACL injury with or without ACL reconstruction (23/26, 88% agreement).

RTS testing is an area of interest for enhancement of successful RTS. Although a systematic review in 2011 reported only 13% of RTS studies over the previous 10 years utilized objective criteria, more recent studies have increased the focus on objective and criteria-based progression of RTS [2, 24, 40]. Resolution of knee impairments, including range of motion and effusion and strength and hop testing are supported by the literature, and newer studies of movement symmetry are actively being studied. A positive correlation has been reported between isokinetic knee extension peak torque and subjective knee scores and three hop tests [75]. Also, a good positive correlation was reported between knee extension acceleration rate and deceleration range for a timed hop test and triple cross-over hop. Quadriceps strength deficits may be associated with increased risk of reinjury. One study reported that 33% of patients with quadriceps strength < 90% of the contralateral extremity suffered reinjury as compared to 13% of those with > 90% quadriceps strength symmetry [30]. Furthermore, quadriceps strength testing has been used in assessment of ACL-deficient knees [23]. In this regard, isokinetic quadriceps strength testing throughout the range of motion showed most notable deficits at less than 40 degrees of knee flexion, and potential copers had a different strength testing profile than non-copers.

One consensus group suggested a RTS test battery should include strength testing, jump tests and a measurement of the quality of movement [69]. The Delaware-Oslo ACL cohort has utilized a RTS test battery including isometric quadriceps strength, four single-leg jump tests and two patient-reported outcome measures with a 90% threshold on all criteria set as a passing score [53]. Patients passing this criteria-based RTS test were more likely to report normal knee function and have more symmetric limb movement at 1 and 2 years postoperatively, and were more than six times less likely to have a subsequent knee injury after RTS as compared to those who failed the RTS test. Passing the RTS test was also associated with higher rates of return to previous level of play. In another report from the same Delaware-Oslo cohort, passing the same RTS criteria accurately predicted return to previous level of play at 1 and 2 years postoperatively with good sensitivity and specificity [30, 52]. Of those patients passing the RTS test at 6 months, 81% and 84% returned to the previous level of play at 1 and 2 years postoperatively, respectively, while 44% and 46% of patients who failed at 6 months returned to the previous level at 1 and 2 years postoperatively after passing subsequent return to sport testing, respectively. Although the evidence is mounting for objective RTS testing, further research is needed to validate these results, and clearly define the best methods of testing. There also remains the future possibility for a biological measure of the healing tissues. Advanced imaging or a biological assessment of tissue healing would be a potential useful addition to the RTS testing.

Conclusion: A standardized RTS testing battery may decrease the risk of re-injury, but further research is needed to define the exact components of the ideal test battery, and which tests should take priority or be weighed more heavily.

> RTS testing should involve assessment of specific functional skills that demonstrate appropriate quality of movement, strength, range of motion, balance and neuromuscular control of the lower extremity and body (26/26, 100% agreement).

As part of the RTS testing, specific functional skills play an important role in safe RTS. Studies have shown that quadriceps strength deficits and neuromuscular control deficits are risk factors for reinjury [30, 58]. Therefore, of the many groups that have proposed RTS testing protocols, most routinely involve functional assessments [1, 2, 28, 33]. The most commonly reported functional tests are jump tests, including single-leg jump, crossover jump, triple jump and timed jump tests typically comparing to the contralateral limb [1]. Quadriceps and hamstring strength testings have also been extensively reported, and agility testing and motion analysis are reported commonly as well. Star excursion balance testing has been shown to be a non-contact lower extremity injury predictor and ACLR patients have been reported to have residual deficits on these tests when returning to play [14, 15]. In addition, drop vertical jump (DVJ) testing and postural stability tests were reported to predict higher reinjury risk after ACL reconstruction in young athletes [58]. There remains much variability in the functional tests included, and the time points at which these occur. Regardless, functional testing remains an important consideration and multiple measures should be included. The functional assessment should include both quantitative and qualitative measures of a range of specific skills. Further research is needed to correlate the functional tests with RTS rates and reinjury.

Conclusion: Functional testing with both quantitative and qualitative assessments is increasingly accepted as standard component of RTS testing, but research is necessary to determine which assessments should be included and how they correlate with RTS and reinjury.

> RTS decision-making includes psychological readiness as measured by a validated scale (22/26, 85% agreement).

Mental health among athletes is an important consideration that has recently gained more attention. The 2019 International Olympic Committee (IOC) consensus statement on mental health in athletes reported on the high prevalence rate of mental health symptoms in athletes, and the relationship of mental health with physical injury and subsequent recovery [59]. The IOC urged that mental health is a vital component of athlete well-being and cannot be separated from physical health. Assessment of mental health and subsequent management should be a routine part of the medical care of athletes. The IOC also concluded that cognitive, emotional and behavioral responses are important factors in injury outcomes, and mental health disorders can complicate recovery. A systematic review of 28 studies reported 65% of those patients not returning to play cited a psychological reason for not returning [54]. Fear of reinjury, lack of confidence in the knee and depression were the most commonly cited psychological reason.

The ACL-Return to Sport after Injury (ACL-RSI) scale has been proposed to measure the psychological impact of returning to sport after ACL reconstruction with the hope of being able to identify readiness to return [72]. A prospective cohort study reported that patients returning to their pre-injury level of sport scored significantly higher on the ACL-RSI scale preoperatively and at 4 months postoperatively, as compared to those not returning to sport, indicating psychological readiness to return to sport [8]. This scale was validated by a large cohort study of 681 patients, which reported that an ACL-RSI threshold score at 6 months postoperatively was independently associated with return to pre-injury sport at 2-year follow-up [61]. In 2019, a cohort study of 329 patients, who returned to sports, reported that patients 20 years of age or younger with a second ACL injury had lower psychological readiness scores on the ACL-RSI scale than those without second injury [47]. Early confidence may, however, be deleterious as higher knee confidence at a younger age has has been associated with a higher re-injury rate [56]. Thus, it should be emphasized that the interaction of confidence, age and time to return to play is complex and needs to be further studied. Sound research will be necessary to understand these interactions and how the testing can be implemented to improve outcomes. Given the early promising literature, ACL-RSI scale may be a good option for assessing patients' psychological readiness during the RTS continuum.

Further validation studies are necessary to confirm that this scale is applicable to all patient groups, to assess the risks of early low and high scores on outcomes, and to determine the effect returning to sport has on patients' reporting on the ACL-RSI. Advanced rehabilitation has been used to improve functional readiness, but more recently a 5-week group training program was shown to additionally improve psychological readiness as measured with the ACL-RSI scale [48]. Greater patient-reported subjective knee scores and male gender have been associated with psychological readiness for sport, and, therefore, targeting specific groups may be the most beneficial for RTS [73].

Conclusion: Psychological factors clearly play a role in RTS, and psychological readiness should be assessed, but currently it remains unclear how psychological scales can be used to improve the RTS process.

> The decision to release an athlete to return to sport should consider contextual factors (type of sport, time of season, position, level of competition, etc.) (26/26, 100% agreement).

The first priority in the RTS decision should be the patient's health and safety, but contextual factors may also influence the timing of RTS. Multiple studies have reported that the level of competition affects the RTS rate with professional athletes returning at greater rates [7, 38]. Collegiate American football and soccer athletes on scholarship also return at higher rates than non-scholarship athletes [18, 35]. Professional athletes and scholarship collegiate athletes have a financial interest in their RTS that may provide unique motivation. These patients may be willing to accept increased risk of returning to competition prior to meeting RTS criteria, and thus the risk–benefit analysis must be considered. Furthermore, the type of sport and position played can affect RTS rates. In professional American football, quarterbacks return at higher rates than running backs and wide receivers, possibly pointing to different physical demands by position [22]. Earlier NFL draft selection, which typically represents greater potential or performance level, is also associated with greater RTS rates. These contextual factors should be considered in the decision to release an athlete to RTS, and modifications to optimize successful return should be employed.

Conclusion: RTS decision-making occurs in a dynamic continuum, and contextual factors play a role and should be considered to optimize outcomes.

> Consideration should be given to the nature and severity of concomitant injuries of the knee (e.g. cartilage and menisci) when making RTS decisions (25/26, 96% agreement).

Concomitant injuries are common with ACL injury, with meniscal injuries reported in 23–42% and cartilage lesions in 19–27% [12, 36, 65]. These injuries may have additional healing considerations that could delay the RTS. There is a lack of literature to guide this decision as evidenced by a recent systematic review that failed to find a consensus on postoperative rehabilitation and RTS for concomitant ACL reconstruction and articular cartilage lesions [67]. However, meniscus and cartilage injuries were reported to be associated with lower rates of RTS [32]. In addition, after revision ACL reconstruction, significant chondral damage was associated with lower RTS rates [71]. It is clearly important that the biological healing of the tissues is respected, but literature on RTS decision-making is lacking. Future research is needed to assess how concomitant injuries affect the RTS decision-making and how the RTS process can be optimized.

Conclusion: Concomitant injuries are common and can affect the RTS, but there is a lack of literature to guide modifications to the RTS process and decision-making.

Conclusion

RTS after ACL injury is ultimately characterized by achievement of the pre-injury level of sport. The RTS process occurs along a continuum from return to participation, which includes unrestricted training followed by full participation, to return to sport and ultimately return to performance. This consensus paper helps define the stages of the RTS continuum after ACL injury as summarized in Fig. 2. Additionally, purely time-based RTS decision-making should be abandoned, and a criteria-based progression involving a multidisciplinary team that includes the surgeon, sports medicine physician, physical therapist and athletic trainer should be utilized. The patient should progress through a structured plan as specific clinical and functional milestones are met. RTS decision-making should include objective physical examination data, validated and peer-reviewed RTS testing that involves functional assessment and psychological readiness, and consideration for biological healing, contextual factors and concomitant injuries. Further research is needed in determining the ideal RTS testing battery, the best implementation and use of psychological readiness testing, and the biologic assessment of healing and recovery.

Acknowledgements Panther Symposium ACL Injury Return to Sport Consensus Group: Mario Bizzini PhD, MSc, PT; Shiyi Chen MD, PhD; Moises Cohen MD PhD; Stefano Della Villa MD; Lars Engebretsen MD, PhD; Hua Feng MD; Mario Ferretti MD, PhD; Freddie H. Fu MD; Andreas B. Imhoff MD; Christopher C. Kaeding MD; Jon Karlsson MD, PhD; Ryosuke Kuroda MD, PhD; Andrew D. Lynch, PT, PhD; Jacques Menetrey MD, PhD; Volker Musahl MD; Ronald A. Navarro MD; Stephen J. Rabuck MD; Rainer Siebold MD, PhD; Lynn Snyder-Mackler PT, ATC, ScD, SCS, FAPTA; Tim Spalding FRCS Orth; Carola van Eck, MD, PhD; Dharmesh Vyas MD, PhD; Kate Webster PhD; Kevin Wilk PT, DPT, FAPTA

Author contributions Each named author has substantially contributed to conducting the underlying research and drafting this manuscript. Each of the authors in the Panther Symposium ACL Injury Return to Sport Consensus Group has contributed according to the Group Authorship guidelines. All authors have approved the final manuscript.

Funding There was no funding for this study.

Compliance with ethical standards

Conflict of interest CF—Karl Storz: IP royalties, paid consultant; Medacta: IP royalties, paid consultant, paid presenter or speaker; Zimmer: research support; SLS—Arthrex, Inc: paid consultant; Smith & Nephew: paid consultant; CONMED: knee design team, paid consultant; Flexion Therapeutics: paid consultant; JRF Ortho: paid consultant; Olympus: paid consultant; Vericel: paid consultant; Zimmer: Research support; BPL—Wolters Kluwer Health—Lippincott Williams & Wilkins: publishing royalties, financial or material support; SJM, TR, TLC, TD, BBR, ES, EHS, TEH—none declared.

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

Informed consent Informed consent were not applicable.

Panther group authorship disclosures Bizzini—none, Chen—none, Cohen—none, Della Villa—none, Engebretsen—Smith & Nephew grants, editor of JBJS and BJSM, Feng—none, Ferretti—none, Fu—none, Imhoff—none, Kaeding—none, Karlsson—Editor-in-Chief KSSTA, Kuroda—grants and personal fees from Smith & Nephew, grants and personal fees from Zimmer Biomet, grants from Stryker Japan KK, grants and personal fees from Johnson & Johnson KK, personal fees from Medacta International, personal fees from Arthrex, Inc, personal fees from Japan Tissue Engineering Co., Ltd,, personal fees from Hirosaki Life Science Innovation, Inc, personal fees from Arthrex Japan G.K, Lynch—none, Menetrey—none, Musahl—educational grants from Smith & Nephew and educational grants from Arthrex, Navarro—none, Rabuck—none, Siebold—Medacta International personal fees, Snyder-Mackler—none, Spalding—none, van Eck—none, Vyas—none, Webster—none, Wilk—none.

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