

# How Can We Optimize a Safe Return to Sport for Youth Athletes? Emerging Concepts and Perspectives – Multidisciplinary Approach

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**Background:** Although exercises and physical activities are beneficial for overall health, it can unfortunately result in a musculoskeletal injury that requires a surgical intervention in physically active youth. One of the major injuries young athletes sustain is anterior cruciate ligament (ACL) tear, which often requires a surgical intervention. Following the ACL reconstruction (ACLR) surgery, athletes need to participate in rehabilitation and often perform return-to-sport (RTS) testing. During this process, the RTS decision requires the contributions of multidisciplinary sports medicine healthcare providers.

**Purpose:** To discuss how to optimize a safe RTS from the perspective of multidisciplinary sports medicine healthcare practitioners and synthesize them with research-based evidence using a clinical scenario involving a female athlete following ACL injury.

**Methods:** A clinical scenario of a young female basketball player with an ACL tear is presented. In this particular case, the patient had a previous ACL tear history in her contralateral limb. Thigh circumference, knee range of motion, quadriceps and hamstrings strength, hop tests, and psychological readiness measures at 9 months post-operatively is also presented.

**Results:** An orthopaedic surgeon, academic-physiotherapist, sports psychiatrist, clinical physical therapy, and performance and sport scientist provided their RTS perspectives based on the given scenario. Because of her previous history and low psychological readiness, several emerging concepts were discussed including neurocognitive-based rehabilitation, cognitive-behavioral therapy, and step-by-step RTS progression (return to participation, sport, and performance).

**Conclusion:** The current article synthesized clinical insights from various sports medicine healthcare with practitioners and research evidence based on an ACL clinical scenario. The approaches discussed in this paper may be beneficial to facilitate safe RTS.

**Keywords:** pediatrics, female athletes, rehabilitation, ACL, knee injury

## Introduction

Regular physical activity is one of the main contributors to optimize general health.<sup>1,2</sup> Although regular physical activity provides many health benefits,<sup>3</sup> such as fitness development at early ages,<sup>4</sup> negative events sometimes happen. One of the most common negative consequences is injury. Injury is prevalent among young athletes. According to the Center for Disease Control and Prevention injury surveillance study,<sup>5</sup> it was estimated 2 million injuries, 500,000 doctor visits, and 30,000 hospitalizations occur annually, which could be burdensome in both physical and psychological standpoints.<sup>6-8</sup> Additionally, injury often leads to time loss from practices and competitions for young athletes as well as time away from their teammates.<sup>9,10</sup> Furthermore, there is a financial burden associated with injury, which further impact organized team

performance.<sup>11</sup> Among these musculoskeletal injuries, some of the more serious musculoskeletal injuries require orthopaedic interventions, such as surgery.

One common sport injury requiring surgical intervention among young athletes is an anterior cruciate ligament (ACL) tear. The ACL tear is often observed in sports that involve cutting, pivoting, and jump-landing maneuvers such as basketball, handball, and soccer,<sup>12</sup> and existing evidence suggests that the incidence of ACL tears is higher among young, healthy female athletes compared with their male counterparts who participate in similar sports.<sup>13</sup> According to the National Collegiate Athletic Association (NCAA) data, female soccer and basketball players have 2.4 times and 4.1 times higher risk for an ACL injury than their male counterparts in the same sports at college level, respectively.<sup>14</sup> The majority of athletes who sustain an ACL injury and hope to return to pivoting and cutting sports, go on to have an ACL reconstruction (ACLR).<sup>15</sup> Following the ACLR surgery, post-ACLR rehabilitation is necessary to improve joint range of motion (ROM), muscular strength, and functional neuromuscular controls.<sup>16</sup> After rehabilitation, sports medicine providers may use a battery of return-to-sports (RTS) tests to assess recovery of the surgical limb.<sup>17–19</sup> These measures are often referenced to the contralateral limb and quantified by limb symmetry index (LSI).<sup>20–22</sup> Recently, the importance of measures beyond physical function, specifically psychological readiness to RTS, is often assessed using tools such as ACL-Return-to-Sport-after-Injury (ACL-RSI).<sup>23,24</sup>

Many studies have reported recommendations for RTS and ACL-RSI testing following ACLR surgery.<sup>25,26</sup> Among them, several systematic review and meta-analysis articles suggested that the outcome of the RTS tests are not associated with the future risk of ACL injury.<sup>27–29</sup> This has been controversial since a safe RTS is a priority for all medical care professions including orthopedic physicians (orthopedic medical doctors), allied healthcare providers (physical/physiotherapists, athletic trainers), and psychological/psychiatric therapists because they are a part of this recovery process as healthcare practitioners. For athletes who complete rehabilitation and RTS tests following ACLR, re-integration into fields/court activity, with their teammates is a significant step forward and needs to be performed safely. In short, some studies<sup>27–29</sup> report that there were no or inconsistent associations between current RTS test batteries and risk of secondary ACL injury (re-tear of graft and/or a new tear/injury to the healthy, contralateral knee). From the time of the ACL injury to the decision of RTS and return to competition, many healthcare professionals are involved. However, the literature that synthesized all of their clinical expertise and discuss the safe RTS is lacking. Therefore, the purpose of the current article was to discuss how to optimize a safe RTS from the perspective of multidisciplinary sports medicine healthcare practitioners and synthesize them with research-based evidence using a clinical scenario involving a female athlete following ACL injury.

## Clinical Scenario

### Who

A 19-year-old, competitive female college basketball player (position: small forward)

### What Happened

During a basketball game, the patient jumped for a rebound and hyperextended her left knee on landing. She immediately felt significant pain and could not continue playing.

### Diagnosis

ACL rupture, confirmed by MRI.

### Special Note

The patient had a previous history of an ACL tear on the contralateral (right knee) 4 years prior when she was 15 years old. At that time, the hamstring tendon was harvested from the affected limb and used as a graft for her ACLR. Despite this being her 2<sup>nd</sup> ACL tear, her goal is to return to basketball activities.

### ACLR Surgery

The patient had surgery 4 weeks following the ACL injury. At this time, ACLR with bone-patellar tendon-bone (BTB) graft procedure was performed.

## Progress Following ACLR

Post-operative rehabilitation began immediately following her ACLR. Her initial post-operative course began without complications, with adequate pain control, and no concern for infection. Once the inflammation and pain had subsided, she started active and passive ROM exercises and isometric muscle contraction under the guidance of her physical therapist. Once she made further progress, she started performing isotonic exercises with near full ROM using a tubing band and weight at the ankle. She was able to jog at 3 months without noticeable pain or compensatory mechanics. From 3 months to 6 months, her rehabilitation exercises involved (basic) agility, balance, and plyometrics in conjunction with fundamental basketball movements. After 6 months, her rehabilitation incorporated more functional training including various sport-specific (basketball-based) drills.

## RTS Test

At 9 months post-operatively, she performed a series of RTS tests with the following results:

- a) Thigh circumference – 10 cm from top of the patellar
  - i. Right limb: 43.5 cm
  - ii. Left limb: 42.0 cm
- b) Knee extension ROM
  - i. Right limb: –4 degrees
  - ii. Left limb: 0 degree
- c) Knee flexion ROM
  - i. Right limb: 145 degrees
  - ii. Left limb: 142 degrees
- d) Isokinetic test – Concentric contractions at 60 degrees/sec
  - i. Quadriceps: LSI 82%
  - ii. Hamstrings: LSI 86%
  - iii. Hamstrings/Quadriceps (H/Q) ratio: 58%
- e) Hop tests for distance and time
  - i. Single-Leg Hop: LSI 80%
  - ii. Single-Leg Triple Hop: LSI 76%
  - iii. Single-Leg Crossover Hop: LSI 72%
  - iv. Single-Leg Timed Hop: LSI 84%

In addition to the three RTS tests, ACL-RSI was collected:

- f) ACL-RSI (out of 100)
  - i. Overall scores: 51.2
  - ii. Confidence in performance subscale: 58.8
  - iii. Emotional subscale: 40.1
  - iv. Risk appraisal subscale: 55.4

## RTS Recommendations/Perspectives

### From an Orthopaedic Surgeon

This patient, unfortunately, underwent a second ACLR surgery: one for each knee, not revision ACLR. Evidence suggested that patient-reported outcome measures including Knee injury and Osteoarthritis Outcome Score (KOOS) and Lysholm scores of the revision ACL injury patients are much worse than primary ACL injury patients.<sup>30</sup> Moreover, weaker muscle strength, lower Tegner activity levels, and more severe osteoarthritis signs were found in the revision ACL injury patients compared to the primary ACL injury patients.<sup>30</sup> It was, indeed, unfortunate; however, could be considered as fortunate that the second ACL injury occurred in contralateral limb, not a revision (not a re-tear of the graft on the same, ipsilateral knee). From this reason, I am cautiously optimistic for her to gain good knee joint stability and

neuromuscular function through a post-operative rehabilitation. Yet, I have a concern. Anecdotally, young athletes who sustained ACL injury two times, regardless revisions or contralateral tear, tend to move each of the rehabilitative milestones quicker than primary ACL injury patients. This may be because they have gone through rehabilitative exercises of each phase previously. The familiarity of the rehabilitative process may facilitate the swift pace. However, instead of aiming a speedy recovery, I highly suggest to take adequate time to perform rehabilitative exercises with good quality of movement. Another concern I have is a use of the LSI measures. Since she had an ACL tear on her right knee 4 years prior, it is difficult and some ways invalid to assess the stability, strength, and function of her left knee using LSI measures.

Overall, since she has already sustained two ACL injuries, it would be beneficial to examine morphologic factors (example, posterior tibial slope), familial history, concomitant meniscus or cartilage injury, and knee and general joint laxity. Then, depending on the identified factors and in scenario of another ACLR, additional surgical procedure such as anterolateral complex augmentation during ACLR including lateral extraarticular tenodesis (LET) or anterolateral ligament reconstruction (ALLR), or slope reduction osteotomy should be considered. Orthopaedic surgeons need to be fully aware of the risk of further ACL injury and conduct pre-operative planning for high-risk patients who wish to return to sporting activities.

### From an Academic-Physiotherapist

Considering that she had also ACLR on her right knee 4 years ago (deficits in her right lower extremity may have persisted), the interlimb comparisons (left/right) should not be taken as the only performance index. Reference values for the isokinetic strength and jump test reference values are available for elite female basketball players after ACLR:<sup>31</sup> as an example, peak torque/body weight values allow for better interpretation of the strength potential (when compared to LSI). Pre-injury screening data (eg pre-season team testing), when available, are also a valuable reference source.<sup>32</sup> Following recent neuroscience research advances, it is crucial to include neurocognitive loads (and motor dual-task challenges) both in rehabilitation and testing (eg visual-cognitive hop tests), as performance deficits are not only related to the physical status of the athlete.<sup>33</sup>

As the young age and the two ACLRs put her at higher risk for further injury, her training in return to competition should/must be optimized, with the goal to possibly reach her pre-injury performance.<sup>34,35</sup> Psychological readiness is associated with RTS and return to pre-injury level of performance.<sup>35,36</sup> The ACL-RSI scores should be interpreted with caution, considering that the “optimal psychological profile” differs between individuals.<sup>36</sup> Ideally, this scale should be further implemented during the RTS process, to monitor the changes in the psychological profile over time. Her overall score at 9 months post-ACLR (51.2 points) indicates that her psychological readiness for a potential RTS is not yet sufficient, and that she needs more time and work to regain her confidence mentally and emotionally.<sup>37</sup> The strengthening and conditioning program should be intensified, as well as the basketball-specific training. Waters et al<sup>38</sup> described a set of basketball-specific movement drills (skill drills, reactive drills, contact drills, and combinations of each of these). The training progression needs to be performed at many levels: from low-intensity to high-intensity drills, from 1:1 drills with the sport PT/ATC to group practice, from no-contact to contact drills (defensive/offensive).<sup>39</sup> As the ideal test battery does not exist, the training drills are also used as test situations, where the staff (PT/ATC, coaches) evaluate the player’s ability to master technically, physically and mentally these basketball-specific and complex demands.<sup>40</sup> The ultimate goal is to re-integrate the (optimally prepared) player in full-contact, unrestricted team practice, following shared-decision making among all stakeholders (athlete, medical team, coaching staff). She should also implement neuromuscular exercises (eg core/hip stabilization, reactive stabilization drills for the lower extremity, ...) in her warm-up routine, in terms of secondary prevention.<sup>41</sup> Eventually, and if the athlete asks for, she could benefit from the professional help of a sport psychologist/mental health practitioner during the RTS/return to performance process.<sup>42</sup>

### From a Sports Psychiatrist

The total ACL-RSI and each of the subscales are scored on a scale from 0 to 100, with higher scores representing greater psychological readiness to return to sport.<sup>43</sup> Various thresholds have been implemented, but multiple studies have suggested that total scores less than 56 to 62 points are associated with increased difficulty returning to one’s previous

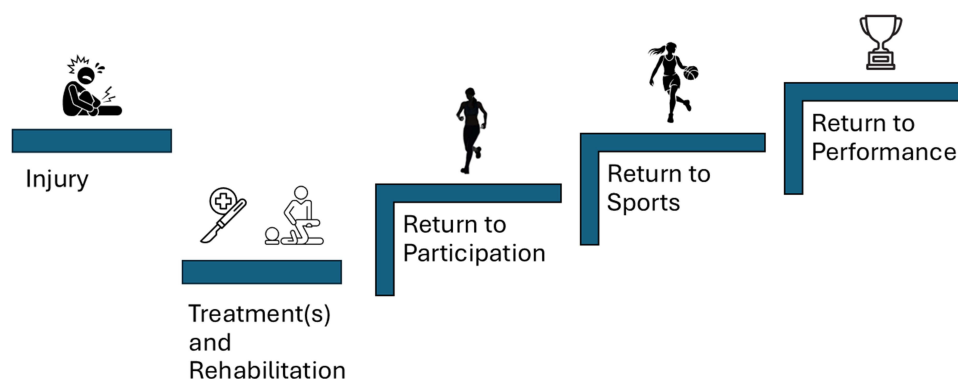
level of sport participation.<sup>37,44,45</sup> One study found that the risk appraisal subscale took the longest to improve after ACLR and had a significant impact on the ability for athletes to return to sports.<sup>46</sup> This patient scored relatively low on the overall score as well as the subscales, suggesting that early implementation of psychological interventions would likely be helpful. Cognitive-behavioral therapy (CBT) in particular could be beneficial to target maladaptive thought patterns or emotional factors, both of which could significantly impact the likelihood of successful RTS.

It is important to recognize that sport-related injuries can be traumatic for young athletes and may be associated with psychological responses similar to those seen with post-traumatic stress. Given the prolonged nature of recovery after ACLR and the rigorous rehabilitation required to return to sports, sustaining an ACL tear can be devastating for an athlete. This is particularly true for athletes sustaining a second ACL tear (whether contralateral ACL or ipsilateral/graft tear), after having already overcome the myriad physical and psychological challenges associated with this type of injury. While many athletes undergoing ACLR might benefit from formal psychological treatment such as CBT, all sports medicine and allied health providers can participate in supporting the mental health of these athletes by simply asking how they are doing emotionally throughout the entire course of recovery, validating their experiences, encouraging help-seeking behaviors, and providing support when needed.

### From a Clinical Physical Therapist

Given that this injury is this patient's second lifetime ACL injury, we must take caution in her RTS progression. As discussed previously, the familiarity this patient has with the rehabilitation process could promote a swifter progression through her rehabilitation. Therefore, it is the duty of her rehabilitation team to ensure she is reaching the milestones set at each stage and moving along with appropriate pace. In looking at the RTS process as a continuum as originally proposed by Ardern and other physical therapy experts as a consensus statement<sup>47</sup> and later discussed by Meredith et al<sup>48</sup>. The process of "return to sport" can be broken down into three parts: "return to participation", "return to sport", and "return to performance", and step-by-step return to approach is clinically feasible (Figure 1). While she currently does not achieve a 10% threshold in LSI scores of both strength and hop tests, the "return to participation" phase is ideal step for her at this time. "Return to participation" is defined as a return to training below the level at which she had been participating in sport prior to her injury. This type of training can include activities that she would not be participating in with her teammates such as non-contact cutting and pivoting drills. She could start in a highly controlled environment and gradually progress to a more challenging environment, simulating more team practice-oriented environments.

In deciding on when to progress her to the "return to sport" phase of training, she should perform the battery of hop testing and strength testing as she has been tested with these measures previously and progress can be objectively tracked with these measures. However, in agreement with other clinicians, these tests should not be the only measures to consider in her RTS testing as she has had previous ACLR surgery on her contralateral limb, affecting the comparison of each limb. Quality of her movement patterns during plyometric and cutting/pivoting drills should be considered as well. Once the patient has achieved strength and hop testing within 10% and she has demonstrated improvement in her movement



The original idea of return to participation, sports, and performance was introduced by the 2016 Consensus statement written by Ardern CL and experts \*ref #47

**Figure 1** Step-by-Step Return Approach Model.

patterns, she can progress to the “return to sport” phase in which she would gradually integrate into her team practices, but not at the desired level of performance. This phase begins progressing from non-contact drills, to contact drills, then game-like scrimmages and finally a return to competitive play. During this progression, the rehabilitation team would be checking in with the athlete to monitor for signs of diminished strength, ROM, or pain as indicators as to whether or not she can continue the progression. Finally, she would enter the “return to performance” phase. In this phase, she would continue to progress her strength, agility, and sport-specific functional skillsets, ideally with a strength and conditioning specialist/fitness coach, to progress towards pre-injury levels of play. This can be the longest phase of the RTS process as it can last one to two years past her ACLR surgical date.

A continuum-based approach to the RTS process can be highly beneficial for the athlete for a variety of reasons. It encourages the athlete and rehabilitation team to have ongoing evaluations upwards of two years past the surgical date to assess for any deficits of strength, pain, ROM and psychological readiness for sport. This athlete, in particular, does demonstrate through her psychological readiness testing that she does have apprehension for RTS; therefore, a stepwise progression of RTS approach may be feasible to improve her confidence in her sport as she advances through her phases of RTS. Further, this stepwise approach likely facilitates professional communications among the athlete/patient, rehabilitation therapists, and coaching staff members. One important aspect of this stepwise approach is to establish clear goals in each phase. Finally, in looking at the RTS as a continuum, the athlete could progress or regress depending on her responses to each goal that she achieves in her journey back to sport.

### From a Performance and Sport Scientist

This young female basketball player still demonstrated inadequate LSI values in peak muscle torque of quadriceps (82%) and hamstring (86%) as well as single leg hop tests (ranges from 72% to 84%), and it is concerning. Several articles suggested  $\geq 90\%$  of the LSI for safe RTS.<sup>26,49</sup> One of the studies reported 84% of quadriceps LSI values in no ACL re-injury group compared to 75% in re-injured group at the time of RTS following ACLR.<sup>50</sup> One good news is her H/Q ratio. Her H/Q ratio was 58%, which may be clinically sufficient. One documented evidence showed H/Q ratio of 58% in concentric muscle contraction at angular speed 60°/s did not have ACL graft rupture while those who sustained a graft rupture showed H/Q ratio of 53% after ACLR.<sup>51</sup> The hamstring muscles are considered to take a protective role as an agonist to ACL by resisting the anterior tibial displacement that results from quadriceps muscle forces at the knee.<sup>51</sup> Thus, although she showed an acceptable H/Q ratio at this point, I encourage her to keep strengthening hamstring muscles.

To facilitate a safe RTS for her, we need to understand unique features of basketball. Female basketball players typically cover a total of  $5214 \pm 315$  meters with  $576 \pm 110$  movement changes in a match.<sup>52</sup> Also, basketball players alter their movement patterns every 1–3 seconds during a match while spending approximately 34% of their time in running and jumping activities.<sup>53,54</sup> Understanding those basketball-specific movement characteristics is beneficial to develop a sport-specific rehabilitation program and likely helps facilitate a safe RTS progression. Moreover, optimizing the load progression with respect to her basketball level (eg college, recreational, or professional), specific position (eg center, forward, or guard), and ideal timing (eg during a regular season, off-season, or perhaps, pre-season) need to be considered. During the on-court phase of the RTS, it is crucial to optimize her physical load (eg base on principle of progressive overload) with aim of avoiding rapid spikes in her training.<sup>55</sup> Also, not only her physical load control, her mental fitness/health in relation to on-court phase of the RTS process need to be monitored. Recent studies showed lower psychological readiness in RTS in females compared to males.<sup>56,57</sup> In short, in the on-court phase of the RTS process, a clinical practitioner such as athletic trainer, fitness coach, and strength and conditioning specialist needs to implement a sport-specific rehabilitation, control workload, and pay attention to psychological/mental status.

One of the recent RTS frameworks respecting specific sport content is called a *control-chaos continuum (CCC)*, which was originally designed for on-pitch rehabilitation in elite soccer<sup>58</sup> and later adapted also on basketball.<sup>39</sup> Briefly, the CCC principle described importance of gym-based physical preparation and on-court rehabilitation, which are progressing from high control training stimuli, through moderate control, control to chaos, moderate chaos and finally high chaos stimuli/conditions.<sup>39</sup> During the last stage (the high chaos stimuli/conditions phase), athlete should be able to reach  $>90\%$  maximal running speed, positional specific acceleration, repeated change of directions with adequate speed

and without pain, and specific jump-landing actions (eg shooting, rebounding, and blocking). Those sport-specific drills need to be carefully performed and progressed with qualified clinical practitioners in relation to the athlete's overall physical (eg pain) and mental (eg fear) states.

## Discussion

The purpose of the current commentary was to discuss how to optimize a safe RTS following ACLR based on clinical perspectives from various sports medicine healthcare practitioners and also to synthesize their recommendations with research evidence. In this case, the young female basketball player had two ACLR surgeries, one in each limb. As the orthopaedic surgeon and academic-physiotherapist were concerned, it would not be reliable to use the LSI as a mean of the RTS because the reference knee for the LSI (her right knee) had a previous ACLR surgery 4 years prior. Even though the initial surgery was 4 years ago, it may alter the LSI values, possibly inflating the LSI values of her left knee since the right knee may not be 100%. So, what would be a good way to evaluate a safe RTS in this scenario? As suggested by the performance and sport scientist, H/Q ratio may be an option. It was evidenced that higher H/Q ratio (higher hamstring strength in relation to quadriceps strength) is protective to initial ACL tear<sup>59</sup> and graft re-tear.<sup>51</sup> This approach does not require another limb as a reference, however it may be deceiving in a case where quadriceps strength is significantly impacted resulting in a higher ratio, rather than higher hamstring strength driving the improvement in this metric. Alternatively, according to the academic-physiotherapist, peak torque/body weight values were reported in the past study<sup>31</sup> and may be an option. In this study, isokinetic strength (60 deg/sec, 180 deg/sec, and 300 deg/sec) of the quadriceps and hamstrings were presented in elite and nonelite of female basketball players.<sup>31</sup> If an isokinetic machine is available, one study reported age-, sex-, and graft used in ACLR-specific quadriceps and hamstrings strength values,<sup>60</sup> and using the reported data as a reference may be another useful approach. Additionally, the academic-physiotherapist suggested including neurocognitive load evaluation in RTS. Incorporating neurocognitive load in rehabilitation is a fairly new idea. Several recent studies suggested assessing neurocognitive and neurophysiological functions for those who have a torn ACL.<sup>61–64</sup> One of the articles discussed importance of re-acquisition of motor skills and training of neuroplastic capacities during rehabilitation, which may potentially help reducing subsequent ACL injury.<sup>61,62</sup> In short, the concept of the neurocognitive load into rehabilitation and possibly RTS tests is emerging, and more evidence is necessary; however, this may be beneficial for the current scenario, if the theory is that neurocognitive deficits in this athlete may have contributed to the increased risk of ACL injury.

Another major concern voiced by multiple experts was low ACL-RSI scores presented at 9 months following ACLR surgery. The low ACL-RSI scores may be due to this being her second time sustaining an ACL tear. A sports psychiatrist pointed out that the ACL-RSI score ranges of 56–62 are associated with difficult to reach previous level of athletic participation. One study found that the ACL-RSI score was lower at 12 months following ACLR for those who resulted in second ACL injury among 20 years or younger.<sup>65</sup> The reported mean ACL-RSI scores of those who sustained the second ACL injury at 12 months in this study was 60.8.<sup>65</sup> The sports psychiatrist suggested the use of CBT to help psychological state of this young female basketball player. CBT has been commonly prescribed to treat anxiety and depression,<sup>66–68</sup> but there has been only one study related to CBT intervention to ACL patients.<sup>69</sup> In this study, young athletes who had ACLR surgery had a telephone-based cognitive-behavioral based physical therapy intervention for 8 weeks.<sup>69</sup> At 6 months, all patients who completed this intervention demonstrated meaningful change measured by minimal clinically important difference (MCID) on International Knee Documentation Committee (IKDC), sport/recreation and quality of life subscales of Knee Injury and Osteoarthritis Outcome Score (KOOS), Pain Catastrophizing Scale (PCS), and Tampa Scale of Kinesiophobia (TSK).<sup>69</sup> Since only one study was documented, and the title of this study was a pilot study,<sup>69</sup> more evidence is necessary, especially how the CBT-based intervention affects ACL-RSI scores and subsequent ACL injury risk. Additionally, a few studies found that female athletes tend to demonstrate lower ACL-RSI scores compared to their male counterparts.<sup>56,57</sup> Therefore, psychological intervention may need to be targeted to female athletes more than male athletes.

The clinical physical therapist presented a step-by-step RTS approach, which consists of “return to participation”, “return to sport”, and “return to performance”.<sup>48</sup> In this article, the “return to participation” consisted of two specific

components: progression to unrestricted training and clearance to full participation.<sup>48</sup> In this case, the young female basketball player did not reach to previously advocated, commonly used less than 10% of deficits in many RTS tests,<sup>26</sup> she is still in this phase (progression to unrestricted training). A similar concept was presented in other articles, which broke down the safe RTS to the following 4 phases: 1) on-field rehabilitation, 2) return to training, 3) return to competitive match play, and 4) return to play.<sup>70,71</sup> One of the articles emphasized to focus on restoring movement quality, physical conditioning, and sport-specific skills during the on-field rehabilitation phase.<sup>71</sup> Furthermore, this article highlighted importance of progressive loading during this phase. Synthesizing these suggestions into progression to unrestricted training in “return to participation” phase based on this case, this young female athlete should practice various drills in a controlled environment with emphasis of movement quality, physical conditioning and sport-specific skills under appropriate, progressive loads. Sport-specific drills (in this scenario basketball) can be found in an article titled “Suggestions from the field for RTS participation following ACLR: Basketball”.<sup>39</sup> During this phase, managing pain, swelling, and any other clinical symptoms that may be a reflection of the last phase of this rehabilitation are necessary,<sup>72</sup> and clinician(s) need to have a good communication with the athlete. After this the initial stage (return to participation), “return to sport” and “return to performance” are the next two steps.<sup>48</sup> In these phases, reconditioning could be another challenging aspect. The reconditioning could be defined as “re-establishing and/or improving an athlete’s overall physical fitness after an injury or surgery”.<sup>73</sup> One study identified diminished aerobic capacity quantified by  $VO_2$ max followed by ACLR in relation to a matched healthy control.<sup>74</sup> In addition to the aerobic fitness, the final stage of the RTS needs to simulate a real game/competition-like situation. Visual-spatial, decision-making, and perturbation training are recommended.<sup>73</sup> Using perturbation training as an example, the perturbation needs to be simulated by specific position(s) of the athlete and specific movement(s) the athlete commonly performs in conjunction with how opponent(s) tends to move, and potentially with physical perturbation/pressure. Lastly, commented by the performance and sport scientist, the rehabilitation and the RTS process should be performed in relation to the context of the sport each athlete is hoping to return including level, position, and timing. Recent studies highlighted importance of controlling workload<sup>55</sup> and challenges associated with the work load (eg levels of chaos in the RTS continuum).<sup>39,58</sup> A medical team member such as athletic trainer, fitness coach, and strength and conditioning specialist, if available, should play a major role for bridging the post-RTS to the “return-to-performance”.

## Limitations

There are several limitations in this article. Firstly, this article was not written based on actual study or experiment performed. Therefore, the concepts written in this article need a validation. Secondly, this article was a synthesis of experts’ opinions and existing literature, not a systematic review; thus, evidence level is low. Lastly, experts’ input was presented in one clinical scenario. Each ACL injury and re-tear clinical case and scenario is unique; therefore, the generatability of this article is limited to young athletes who are willing to return to competitive sports.

## Conclusion

In this article, several important ideas were discussed by various sports medicine healthcare practitioners and synthesized with recent research findings to facilitate the safe RTS following ACLR using a scenario. Collectively, the professional recommended incorporating neurocognitive load into rehabilitation, psychological interventions such as CBT, and a step-by-step RTS approach as emerging concepts for young athletes. Even after the RTS test, on-site clinicians need to control the appropriate workload of each athlete in this chaotic returning continuum. More empirical research studies are necessary to substantiate the voices from the experts in this article, which may help reduce unfortunate another tear following primary ACLR surgery among young athletes.

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