MONITORING THE RECONDITIONING OF THE INJURED FOOTBALL PLAYER WITH FIELD-BASED MEASURES

A CASE STUDY FOLLOWING ACL RECONSTRUCTION

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INTRODUCTION

Current research suggests that ACL reconstructions should follow a criterion-based process over successive rehabilitation phases[1,2]. Today there is increasing information on the progression criteria and methods to rehabilitate the neuromuscular system (i.e., range of motion (ROM), strength, balance, and control) and restore generic and football-specific functional capacities (e.g., jumping, landing, cutting, accelerating, and decelerating)[1,2,3,4] across each of these phases. There is, however, less information and research on the metabolic conditioning aspect of the post-ACL rehabilitation process[5,6,7,8].

Mitigating cardiorespiratory fitness deconditioning or even developing an athlete's physical fitness to a higher level than before injury during the on-field rehabilitation phase may be an overlooked factor of a successful return-to-sport process[6,7,8]. In fact, higher fitness levels translate into a lower relative internal load for a given workout, which puts players under optimal conditions when returning to train with the team (return to train phase that follows the on-field rehabilitation phase). This may support better decision-making and decrease cognitive load, which may, in turn, facilitate players' reintroduction to the intense stimuli of football practice. Importantly in this context, this also likely contributes in reducing the risk of re-injury[1].

Lastly, while there is a growing use of technology to monitor function and muscle strength in the gym (e.g., force plates, dynamometers), methods and tools that can be used in the field during the on-field rehabilitation are still limited.

In the present manuscript, we use the case of a recent ACL injury that happened to a Lille OSC player to introduce our post-ACL reconditioning approach during the first rehabilitation and on-field rehabilitation phases. We provide examples of metabolic work programming through various generic and football-specific drills. We also touch on field-based tools and strategies for monitoring fitness and running mechanics that were used to further guide the programming throughout the process.

THE CASE AND THE INJURY

Informed consent was given by the 23-year-old Portuguese international central defender with several years of experience across top European leagues and at the senior international level since 2022. While playing in French Ligue 1, he ruptured his right ACL during a tackle (Figure 1).

The knee injury during a valgus flexion external torsion traumatism was suggestive of ACL tear with associated lesions. Immobilization by rigid splint and crutch discharge was immediate. Due to a positive Lachman test, an MRI was performed 2 days later.. In addition to the ACL, there was a lesion of the proximal attachment of the anterolateral ligament and a low-grade tear of the medial collateral ligament. The lateral meniscus had a radial tear associated with damage to its posterior root and its popliteomeniscal attachment. The bruise of the posteromedial tibial plateau coupled with the hypersignal of the internal meniscocapsular space suggested a ramp lesion. The practice of a contact pivot sport at the elite level made the surgical indication necessary to restore rotational dynamic knee stability. Considering these findings, and after discussion with the patient, 10 days after the injury, reconstruction was performed by 4 strand hamstring autograft with a reconstruction of the anterolateral ligament (Figure 2)[9].

Arthroscopy also confirmed the meniscal lesions described in the MRI. The lateral meniscus was repaired with a suture anchor, and the ramp lesion was sutured by two absorbable threads. The surgery was performed without issues and the rehabilitation protocol with a non-weight-bearing protocol started immediately.

Figure 1: Snapshots showing the mechanism of the right ACL and associated meniscus tear.


Figure 2: Surgical reconstruction of the anterolateral ligament.

TIME FRAME OF THE RETURN TO SPORT PROCESS

At the time of the writing, the player had finished the on-field rehabilitation phase and was about to start the return to train phase (Figure 3). Following the day of injury, it therefore would have taken about 7.5 months for the player to return to full training with the team without restrictions. In a 15-year prospective study on 157 ACL cases in male professional football players, the median layoff after ACL reconstruction was 6.6 months to training and 7.4 months to match play[10]. The longer layoff period for the current player is related to the associated meniscus tear that worsened the severity of the injury and delayed the return to running by about a month.

In the present manuscript, we focus on the second part of the rehabilitation stages of the overall process; i.e., the first off-leg phases and the on-field rehabilitation (Figure 3), with a special emphasis on metabolic conditioning programming and monitoring.

METABOLIC CONDITIONING PROGRAMMING

Different submaximal and close-to-maximal intensity metabolic conditioning sessions were delivered throughout the return to sport process, with the format and physiological objectives being adapted to the context[11]. Context refers to the player's ability or not to perform on-leg activities

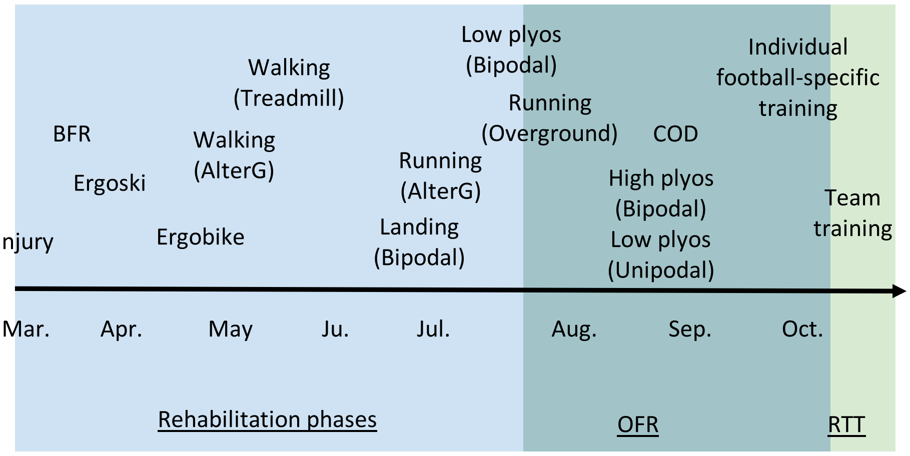

Figure 3: Progression and timing of the different phases adapted from Buckthorpe et al1. The return to sport process involves a gradual transition from rehabilitation to performance training along a continuum of on-field rehabilitation, return to train, return to competition, and return to performance. OFR, on-field rehabilitation; RTT, return to training; BFR: blood flow restriction (3-4 sessions/week throughout the first 3 months). Note that RTC and RTPer are not shown here.

TABLE 1

HIIT Types	*Aerobic contribution**	*Anaerobic (lactic) contribution*	*Neuromuscular demands***
Type 1	×		
Type 2	×		×
Type 3	×	×	
Type 4	×	×	×
Type 5		×	×

Table 1: HIITScience framework when it comes to selecting the metabolic and neuromuscular demands of HIIT sequences; Adapted from Buchheit & Laursen 2013. *: refers to exercising at an intensity close to VO2max. **: refers to high-speed running (>20 km/h) and intense accelerations, decelerations, and changes of directions.

such as running (first rehabilitation phase, Figure 3), but may also include the overall weekly puzzle and parallel gym, pitch, and technical contents that need to be aligned and integrated with the metabolic conditioning objectives. For example, while reaching high levels of cardiovascular demands (i.e., >90% of HRmax and VO2max levels) is expected during any efficient form of high-intensity interval training (HIIT) sessions, the associated neuromuscular load can be varied to fit the context[11].

For instance, a HIIT session with a low neuromuscular load (so-called Type 1 or 3 following the HIITScience terminology[11], Table 1) may be preferred at the start of the first rehabilitation phases to allow progressive overall, better "control"[12], proper muscle and tendon recovery, and importantly also, dissociated physiological stimuli to avoid interference of concurrent adaptations[11]. During the first rehabilitation phase (Figure 3), all the conditioning is performed off-leg anyway. The objective of this phase is fitness preservation/ limiting deconditioning while allowing proper post-surgery recovery and treatment[8]. This implies the use of non-weight-bearing conditioning activities exclusively, mainly involving upper body exercises (e.g., ErgoSki, Table 2 & 3) - the reality however is that football players are generally not too inclined to perform this type of work, and finding alternatives and variations that stimulate the cardiorespiratory system enough is often a challenge.

In contrast, using HIIT with large neuromuscular demands is at some point also required to elicit specific adaptations and challenge the player at a greater level toward the end of the return to sport process (end of on-field rehabilitation, return to train, return to play, and return to performance), using the so-called Types 2, 4 or 5[11] (Table 1). It is very important to progress safely with running speeds and intensity of changes of direction[13], especially in the case of a hamstring graft as in the present case. Hamstring strength is believed to be an important (but not unique) criterion for speed progression[14]; we used isometric and eccentric benchmarks to guide the run-based metabolic conditioning programming (e.g., >70% isometric strength to run >15 km/h - Type 1 & 3 run-based HIIT with work/rest ratio >1, >90% to run >20 km/h and -Type 2 run-based HIIT with work/rest ratio <1, and >90% eccentric strength to reach speeds close to max and maximal change of direction intensities, - Type 2 & 4)[15].

During the last return to train/return to competition phases, it's essentially about load management and offering complementary and tailored (HIIT) sessions to the player. This includes progressively introducing the player into team sessions while still managing his own load - this often refers to "partial training sessions" (e.g., the player takes only part in some but not all drills of the session, plays small-sided games but as a floater), that are either complemented by a tailored gym, HIIT, pitch work, or recovery and treatment[16]. HIIT session contents and physiological objectives need to be perfectly adjusted to the team training content (complementary metabolic and neuromuscular demands), so that the player gets what he needs to complete his rehabilitation process. For example, while the player may be subtracted from a small-sided game that may be too "chaotic" for him (not enough control for him at the stage of the process he is at[12]), a similar metabolic and neuromuscular load can be

Table 2

HIIT Format and modality	Total number (and frequency) of metabolic conditioning sessions (HIIT) — Recovery and Rehab (Off-leg)	On-field rehabilitation
Ergoski HIIT (sitting first and then standing when permitted)	*6 (2-4/week) Type 1**	*6 (0-1/week) On off-picth recovery days only - mixed with upper body work (e.g., power sets)*
Ergobike (submaximal)	*10 (1-2/week)*	*4 (0-1/week)*
Egobike HIIT	*>20 (2-5/week) Type 1 & 3*	*5 (0-1/week) Type 1 & 3*
Ergobike (Heat)	*>20 (1-3/week) Type 1*	*>10 (1-3/week) (Active Recovery, not HIIT)*
Run (submaximal)	*8 (4/week 2 weeks) Alter G only*	*4 (0-1/week) (4-min monitoring runs)*
Run-based HIIT (generic)	*0*	*>15 (2-3/week) Type 1, 2, 3 and 4*
Run-based HIIT (specific)	*0*	*>5 (0-1/week) Type 2 & 4*

Table 2: Number, frequency, and physiological orientation (i.e., HIIT Types) of the metabolic conditioning sessions programmed during the two first phases of the return to sport process. *: when considering lower limb neuromuscular load. HIIT: high-intensity interval training.

offered via a more "controlled" individual HIIT workout over the similar duration (Type 4, e.g., in the form of short intervals with sharp changes of directions and inclusion of the ball[13], Table 1 & 3).

This latter phase with load and contents management is often crucial when it comes to ensuring the player doesn't get re-injured, not only with regard to his rehabilitated knee but to overall muscle injuries. When elite practitioners were recently surveyed on this particular return to train period, they reported the duration of this phase to be inversely correlated with the duration of absence with the team, with player training in an adapted manner (in comparison to the team) for several weeks at minimum for injuries as long as that of an ACL[16].

HIIT SESSIONS

Overall, we are aiming for sets that last at least 4-6 min (long enough to overcome oxygen kinetics and reach the expected energy turnover) and up to 8-10 minutes per series, for a total volume per session of 10 to 18 minutes of total work[11]. In fact, since HIIT is a highly time-efficient training method, and given the myriad of other training contents that need to be fit into the daily program of the injured athlete, we aim to microdose this content (almost daily). The distribution and programming of the different formats and associated HIIT types per rehabilitation phase are described in Table 2. We also provide below some detailed examples of typical HIIT sessions used through the return to sport process (Table 3).

LOCOMOTOR LOAD PROGRESSION

The progression in terms of GPS-derived (STATSports, Apex, Sonra 5.11, Newry, Northern Ireland) typical locomotor load metrics is shown in Figure 4. Overall, total distance (TD, m), high-speed running (HSR, m), mechanical work[17] (MW, kJ, a compound measure of accelerations, decelerations, changes of direction, and high-speed actions), and Force Load[17] (Fload, scaled step impulse measured from thoracic-mounted GPS-embedded Inertial Measurement Unit, IMU, kg.ms^{-1}, ADI software, Athletic Data Innovations, New Zealand) volumes were equivalent during on-field rehabilitation to the training period before injury - except the large volume of TD of competitive matches that could not be compensated.

Interestingly, however, when looking at peak intensity periods (Figure 5), while typical team training and match m/min could be equated or even overloaded during the on-field rehabilitation (Upper panel), this was not the case for mechanical work/min (lower panel). This finding is consistent with the fact that run-based HIIT, which was frequently programmed during on-field rehabilitation (Table 2 & 3), allows players to cover a lot of ground over prolonged periods (>150 m/min >5 min)[18]. It is however often difficult to overload mechanical work/min at the session level (even with healthy players during team training) in comparison with match demands, and only some specific drills such as small-sided games with few players (i.e., 3v3 or 4v4) are effective for that[18]. This highlights the specificity of match demands and confirms that nothing replaces competition when it comes to performing some specific movements at a high pace (e.g., cutting, decelerating, ball interactions).

MONITORING FITNESS

Only maximal tests performed to exhaustion (i.e., measures of maximal aerobic speed, MAS, or the speed reached at the end of the 30-15 Intermittent Fitness Tests associated, V_{IFT} - together with respiratory gas exchanges or not), or measures of

Table 3

Metabolic work modality and format	*Example 1*	*Example 2*
Ergoski HIIT	*Objective: Type 1 (when considering lower limb neuromuscular load)* *Work / Rest: 45s/15s* *Work intensity: 200 W (self-selected to reach an RPE of >6-7)* *Work modality: seated (weight-bearing not permitted yet)* *Recovery intensity: Passive* *Repetitions: 8-6 efforts* *Series: 2 (8 min / 6 min)* *Between-series recovery: 2 min passive* *Total duration: 16 min*	*Objective: Type 3 (when considering lower limb neuromuscular load)* *Work / Rest: (40s+20s)s/60s* *Work intensity: >220W (40s) / >250 W (20s) (self-selected to reach an RPE of >7-8)* *Work modality: standing (weight-bearing permitted)* *Recovery intensity: Passive* *Repetitions: 6 efforts* *Series: 1 (12 min)* *Between-series recovery: x* *Total duration: 12 min*
Ergobike HIIT	*Objective: Type 1* *Work / Rest: 60s/60s/60s* *Work intensity: >220W* (>80% MAP), >250W* (90% MAP), 50W* (active recovery), RPE target of >7-8* *Work modality: >90 rpm* *Recovery intensity: Passive* *Repetitions: 5 x 3 efforts* *Series: 1 (15 min)* *Between-series recovery: x* *Total duration: 15 min*	*Objective: Type 3* *Work / Rest: 30s/30s* *Work intensity: >280 W* (>100% MAP), RPE target of >7-8* *Work modality: >95 rpm* *Recovery intensity: Passive* *Repetitions: 4-6 efforts* *Series: 3 (6 min / 4 min / 4 min)* *Between-series recovery: 2 min* *Total duration: 18 min*
*Ergobike HIIT (Heat, 45°C)***	*Objective: Type 1* *Work / Rest: 2min/1min* *Work intensity: 180-200 W* (Target RPE 6-7 : check response when it's a new practice)* *Work modality: >80 rpm* *Recovery intensity: 80-100 W* *Repetitions: 6 efforts* *Series: 1 (18 min)* *Between-series recovery duration: x* *Total duration: 18 min*	*Objective: Type 1* *Work / Rest: 4 min (3min+1min)/1 min* *Work intensity: 160-180 W* + 220 W* (Target RPE 6-7 : check response when it's a new practice)* *Work modality: >90 rpm* *Recovery intensity: 50 W* *Repetitions: 4 efforts* *Series: 1 (20 min)* *Between-series recovery duration: x* *Total duration: 20 min*
Run-based HIIT (Generic)	*Objective: Type 1* *Work / Rest: 15s/15s* *Work intensity: 70-75 m (90% VIFT)* *Work modality: parabolic and 45° curves* *Recovery intensity: Passive* *Repetitions: 8-10 efforts* *Series: 3 (5 min / 4.5 min / 4 min)* *Between-series recovery duration: 2 min* *Total duration: 17.5 min*	*Objective: Type 2* *Work / Rest: 10s/20s* *Work intensity: 75-80 m (100% VIFT)* *Work modality: 40-m shuttle* *Recovery intensity: Passive* *Repetitions: 8-10 efforts* *Series: 2 (5 min / 4 min)* *Between-series recovery: 2 min passive* *Total duration: 11 min*
Run-based HIIT (Specific)	*Objective: Type 2* *Work / Rest: 10s/20s* *Work intensity: difficult to control since there is often variability in the locomotor patterns and the investment of the players plays an important role. Target RPE of >7-8.* *Work modality: Accelerate maximally and run over 15 m, then receive a ball, stop to pass to a rebound wall, run in slalom between cones over 15 m, get a second ball, and shoot into a mini goal (Buchheit & Mayer 2018).* *Recovery intensity: Passive* *Repetitions: 8-10 efforts* *Series: 2 (5 min / 4 min)* *Between-series recovery: 3 min passive* *Total duration: 12 min*	*Objective: Type 4* *Work / Rest: 5s/15s* *Work intensity: As the previous drill. RPE of >7-8.* *Work modality: Accelerate maximally, brake, and perform two consecutive direction changes at maximal intensity and then get a ball to shoot into a mini goal (Buchheit & Mayer 2018).* *Recovery intensity: Passive* *Repetitions: 6-9 efforts* *Series: 2 (3 min / 2 min / 2 min)* *Between-series recovery: 3 min passive* *Total duration: 13 min*

Table 3: Example of typical HIIT sessions programmed during the different phases as per Table 2. *When no reference such as maximal aerobic power (MAP) is available, using body mass is the starting point to estimate MPA using 5 W/kg - this intensity can also be further adjusted based on player profile (lower limb muscles power and whether the player is used to cycling or not). **In addition to targeted physiological adaptations that include increases in plasma volume, improved sweat rate, and improved cardiovascular function, we use heat training to decrease the internal-to-external load ratio - it is the best example of Type 1 HIIT. Note that a short (5-10 min) adaptation period is required before starting the HIIT session in the heat.

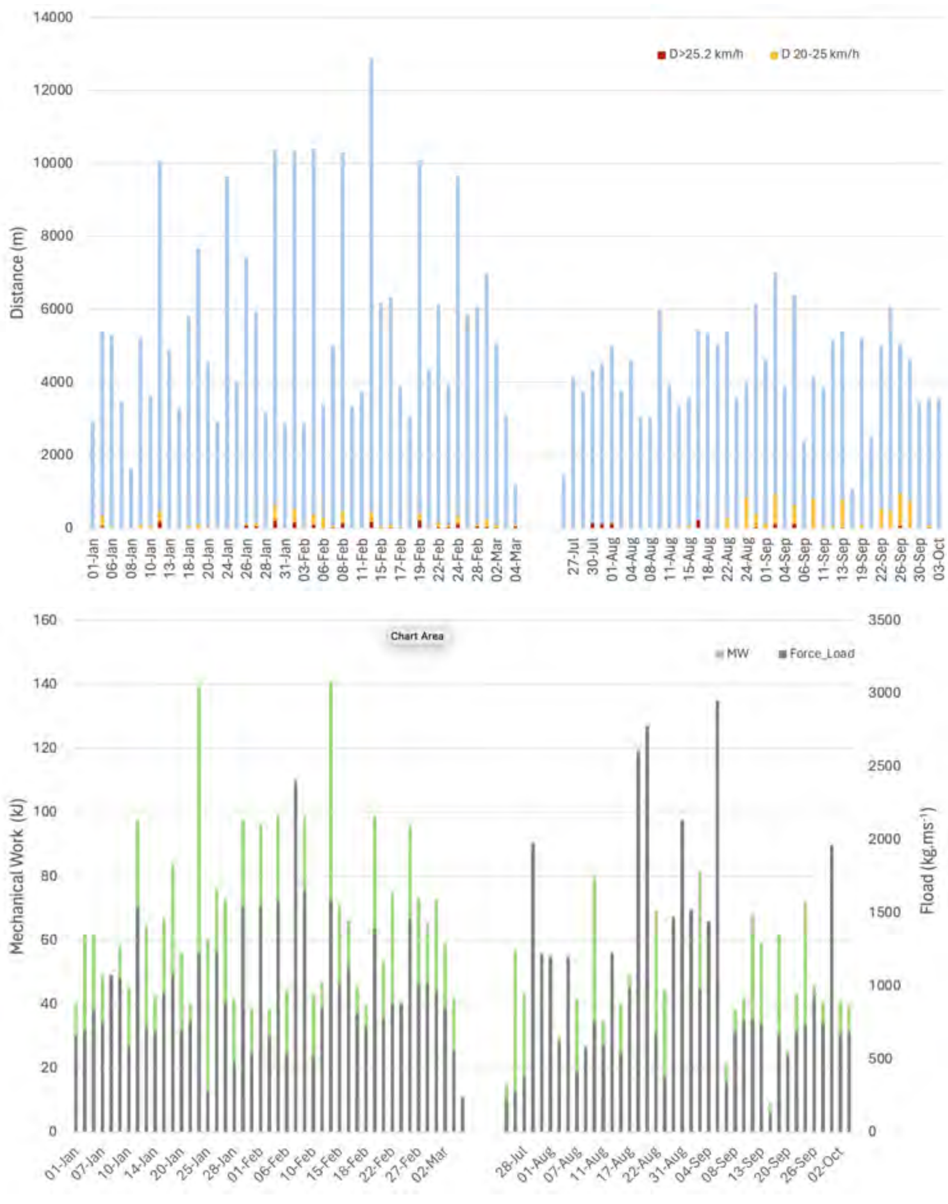

Figure 4: Locomotor load metrics 3 months before injury and during the on-field rehabilitation phase. Distances into zones (upper panel), mechanical work, and force loads (Fload) (lower panel).

blood lactate accumulation (e.g., individual lactate threshold or the speed at 4 mmol/L) can provide an absolute assessment of fitness[11]. Implementing those tests is often challenging in the tight schedule of top football players in between domestic league and international fixtures. For that reason, a short submaximal running test is often used as a proxy for changes in cardiorespiratory fitness[19]. At LOSC and as in many similar clubs, players run at 12 km/h on a 200-m course set out on the pitch (Figure 6). The heart rate sustained during the last minute of effort (HRex, expressed as a % of maximal heart rate) provides a very simple and practical and indirect marker of relative (generic) conditioning/fitness level[20].

If we consider that changes in HRex of about 4% may be representative of a change in MAS of about 0.5 km/h[20], in comparison to his pre-injury values (72% and 76% in January 2023), the player had only lost about 0.5-1 km/h of MAS when he repeated the test for the first time (5 months post-surgery, 79% on August 17th, 2023, Figure 7). This magnitude of cardiorespiratory deconditioning is very low and lower than what was reported by Almeida et al. (2018) when comparing injured and control players (difference of 8 to 11 mL/kg/min of maximal oxygen update, VO_2max, which translates into 2 to 3 km/h of MAS, considering the energetic equivalent of oxygen when running). Whether the player had lost more fitness at some point during the first rehabilitation phases (first 4 months) is unknown, since the submaximal running test could not be performed earlier. We believe nevertheless that the important and almost daily micro-dosed off-leg metabolic work done (Table 2, for a total of >60 Ergoski and Ergobike sessions) definitely helped limit the detraining effect of reduced activity; this likely explains the difference versus the data reported by Almeida et al[5]. Overall, at the time of writing, the player had regained fitness levels close to his best to date, as measured at the end of the 2022 pre-season period (Figure 7). This rate of improvement (1 km/h gained within 3 months) tended however to be smaller than the 2-km/h increase in lactate threshold speed reported by Della Villa[21] during the on-field rehabilitation phase (3 months) of a group of 50 players (mainly amateurs). The exact dose-response of HIIT and MAS/V_{IFT} improvement is likely individual and context-dependent; 6 to 8 HIIT sessions over 4 to 6 weeks are generally enough to regain/improve MAS/V_{IFT} by 1.5 km/h[22]. In the present case, transient episodes of knee pain (as a consequence of the meniscus surgery) delayed the return to running, and the specific contractual situation of the player through the transfer period was another limitation to the psychological and motivational aspects of his rehabilitation.

MONITORING RUNNING MECHANICS

Running mechanics were assessed using GPS-embed accelerometers and the Athlete Data Innovations software[17]. More specifically, the session-average difference (%) between left & right step impulses[17] (force x contact time, measured from thoracic-mounted IMU, ADI software, Athletic Data Innovations, New Zealand) was computed during each training and match, and analyzed specifically during acceleration, deceleration, straight-line running (>7.2 km/h), and while changing direction.

Figure 8 shows that in comparison to pre-injury baseline step impulse symmetry during straight-line running, there was a clear period when returning to running when the left side was unloaded (or the right side, overloaded) - which magnitude (and consistency) was greater than the usual day-to-day variability seen before the injury. This asymmetry was associated with reported right knee pain and required the player to stop running for a few days. Upon return

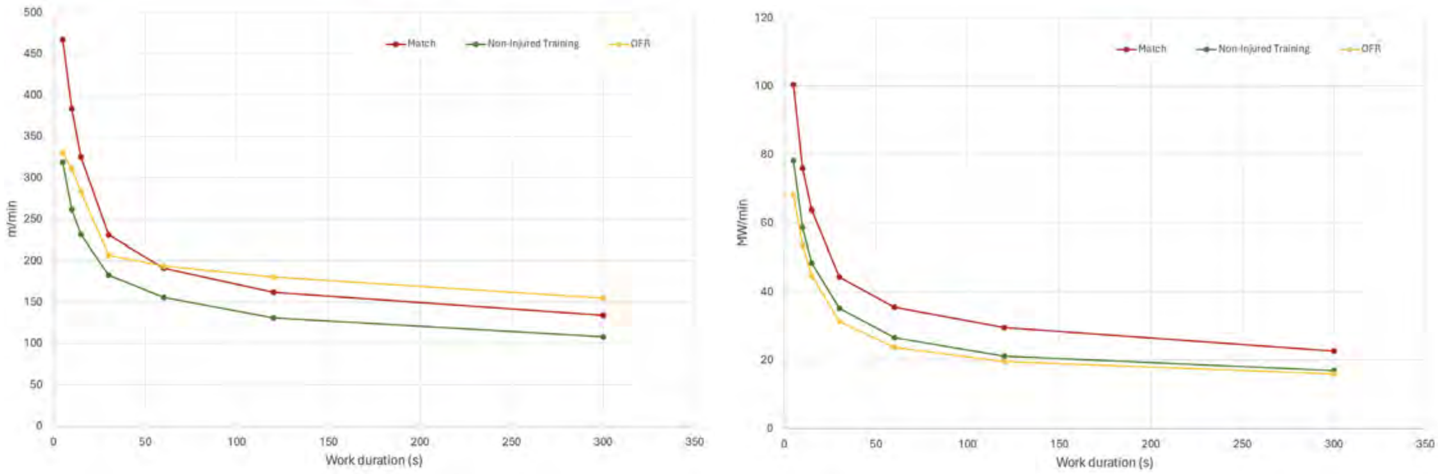

Figure 5: Peak intensity periods in terms of m/min (upper panel) and mechanical work/min (MW, lower panel) for the player when training collectively with the team before injury (n=33 sessions), during matches (n=8 matches), and during the on-field rehabilitation phase (n=31 sessions). Each line represents the average intensity profile of each context.

and while running on a softer pitch, both the pain and the asymmetry disappeared. While the reason and direction of asymmetries are always difficult to understand[23], in the present case it can be hypothesized that the greater impulse seen on the right side was caused by a longer contact time, itself related to a stiffer leg complex, which was likely caused by lower absorption capacities of the passive structures of the leg (tendons and joints). We also noted that the left stride length tended to be consistently shorter by about 2 cm (data not shown here), showing again that the right step was less effective overall. Interestingly, this lower right leg effectiveness was also confirmed by typical metrics collected during jumps (CMJ) on a force plate[24]; during this period of acute pain (early August 2023), concentric and landing impulses were recorded to be 6 and 20% lower on the right than the left side, respectively.

CONCLUSION

The analysis of the present case study has allowed us to present a snapshot of our conditioning and monitoring process at Lille OSC when it comes to rehabilitating players post-ACL surgery. Cardiovascular fitness loss after ACL rehabilitation can result in lower baseline fitness levels during mid- and late-stage rehab, which may delay their return to performance in the long run. We believe that professional players can benefit from appropriate fitness preservation/re-conditioning in the early stages of their rehabilitation, which may help them perform better once they return to training with the team.

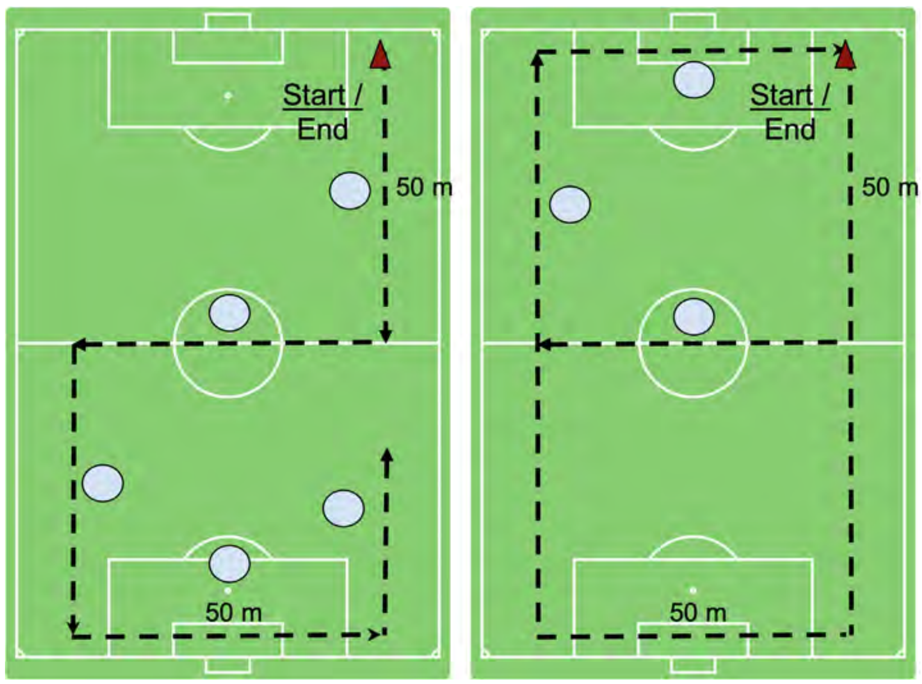

Figure 6: Set up of the 4-min submaximal run on a FIFA standard football pitch. Running at 12 km/h requires players to run each 50-m segment in 15 s (which is pretty easy to control with any stopwatch). Players run for 4 min in an 8-shape to balance the laterality of the changes of direction for 2 full laps. When running the test with the entire squat, groups of 6-8 players can start at different cones and follow each other on the course, so that all players can perform the run all together.

Key points:

- It is important to regularly monitor various indices of cardiovascular fitness, ROM, strength, and running mechanics during the season so that when an injury occurs, practitioners can have reference points toward which they can direct the rehabilitation process.
- Submaximal runs can be implemented into (team) warm-ups, and re-introduced quickly into the rehabilitation process, as soon as the player can run at 12 km/h for at least 4 min.
- In the present case, the analysis of changes in exercise heart rate revealed that, at the time of starting the on-field rehabilitation phase, the player had only lost 1 km/h of maximum aerobic speed (about 3-7 mL/kg/min of VO2max)
- The important off-leg metabolic conditioning work done during the first rehabilitation phase (Table 2 & 3, Ergoski

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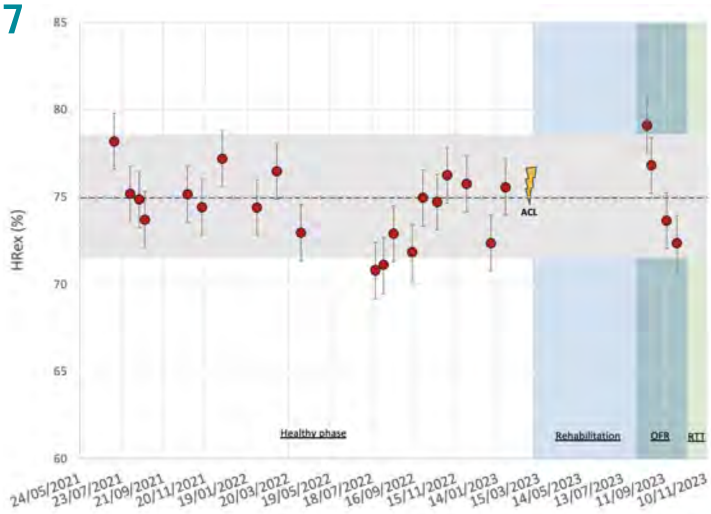

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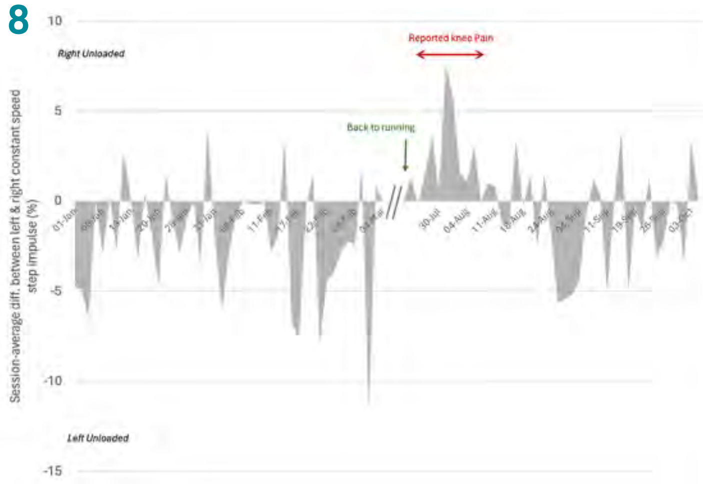

Figure 7: Changes in the heart rate (HR) sustained during the last minute of the 4-min submaximal run (12 km/h) performed over a period of >2.5 years. Note that since the test was performed throughout various environmental conditions, HR was adjusted for ambient temperature[20]. The horizontal area represents the smallest worthwhile change in HR (+/- 4%), which is equivalent to a change of +/- 0.5 km/h in MAS. Errors bars represent the Typical error of the measure (1.6%)[19]. The colored vertical area shows the different phases of the rehabilitation process.

Figure 8: Session-average difference between left & right constant speed (>7.2 km/h) step impulse (%) from 3 months before the injury to the return to run until the end of the on-field rehabilitation phase.

& Ergobike sessions) have likely helped to mitigate the deconditioning effect of inactivity.

- The metabolic conditioning work done during the 3-month on-field rehabilitation phase (Table 2 & 3, Run-based and Ergobike HIIT) allowed the player to regain his fitness up to pre-injury levels.
- The analysis of peak intensity periods revealed that reaching high mechanical work intensities are challenging during the individual on-field rehabilitation phases - this is mainly related to the specificity of some football movements that happen only when interacting with teammates and opponents, especially during competition (e.g., cutting, decelerating, ball interactions).
- In addition to usual assessments of lower limb strengths and mechanics (e.g., force trace during jumps on force plates), GPS-embed inertial measurement unit and associated analytics (e.g., ADI software) add invaluable sport-specific information to monitor stride mechanics and step impulse asymmetries throughout the rehabilitation process, that can be used to guide phase progression and day-to-day programming (load management and gym/treatment orientation).
- Finally, while these last conditioning phases of the return to sport process may be first seen as heavy performance staff-led (i.e., strength and conditioning, fitness coaches), we need to emphasize the continuous and parallel collaboration that is always required within the multidisciplinary team. Collaboration and hand-in-hand daily work from all practitioners (i.e., physios, doctors, performance staff) are indeed compulsory for a successful return to sports program[16].

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References
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