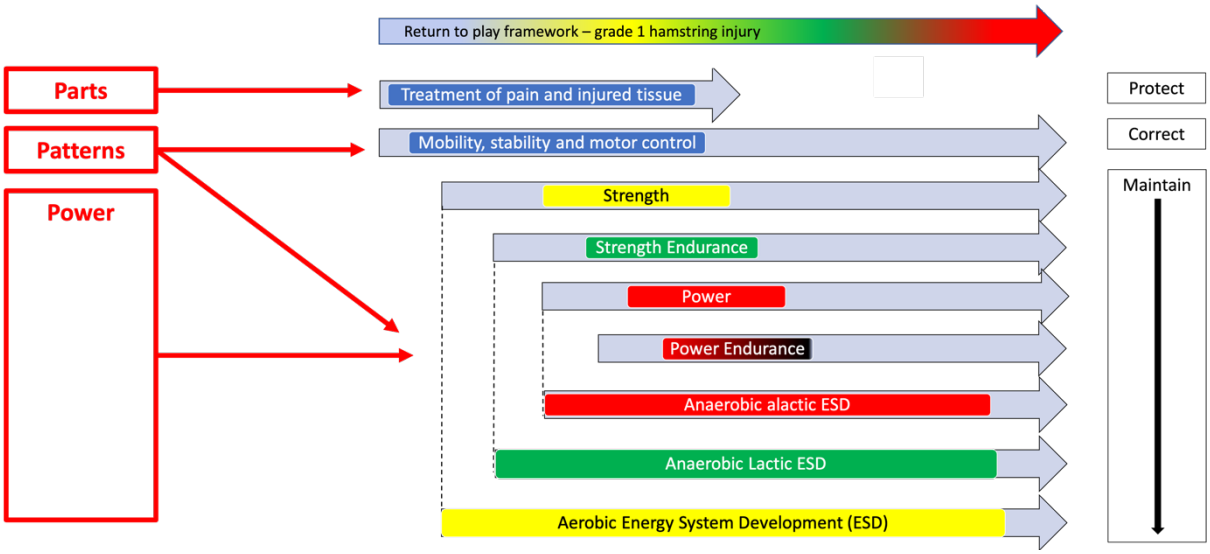
A framework for returning-to-play an NRL footballer from a grade 1 hamstring strain.

Greg Dea
Sports Physiotherapist

Taking the complex and making it simple is what a return to play framework is about, and to that end, a framework of "protect, correct and develop" is preferred – **protect** from further injury, **correct** causes, contributing factors and complicating factors, to preferred levels of competence, and **develop** capacity. It helps to get a snapshot of the protect-correct-develop process and aim it at ***parts, patterns,*** and ***power.***

The following framework provides a visual overview of how to manage multiple considerations practically.



I have previously described in detail two case studies of return to play in football athletes with muscle injuries across two timeframes (12 to 15 days post-injury and 28 days post-injury) following this framework [1, 2].

There are several considerations that, when coalesced, create a multi-dimensional protect-correct-develop framework. The considerations include the location of the injury, time-based criteria, competency- and capacity-based criteria, risk-factor-based criteria and game-based criteria.

Protect

Let's consider the importance of the location of the injury and early time-based criteria in the **protect** phase. The most vulnerable time for further muscle injury is the first 2 days, until granulation tissue and collagen type 1 are formed to provide a scaffold and anchorage

site for invading fibroblasts [3]. This first 2-day period requires protection from muscle contraction to minimise the risk of re-bleed and increase in the volume of intramuscular connective tissue. This period of protection permits clarification by ultrasound or MRI for the involvement of the biceps femoris over the semimembranosus and semitendinosis given a likelihood of delay to return to sport [4], central tendon and associated important factors that may predict a longer-than-desired recovery for a low-grade injury, such as associated fluid collection, haemorrhage or involvement of the distal myotendinous junction [5].

Regarding time-based criteria. A theoretical period of competition break has been discussed among professional European sports medicine physicians as a consideration, but it doesn't rank in many physicians' priority [6], and I would concur that being cognisant of the healing times of the injured muscle is a consideration, but not always as a limiting factor. Biological research has indicated that at "approximately 10 days after the trauma, the maturation of the scar has reached the point at which it no longer is the weakest link of the injured muscle, but, rather, if loaded to failure, the rupture usually occurs within the muscle tissue adjacent to the newly formed mini-MTJs between the regenerated myofibers and the scar tissue. However, a relatively long time is still needed until the strength of the muscle is completely restored to the preinjury level [7-9]. There is more to the context or competent and capacious return to sports function than simple muscle healing times. I've shown in a case study the possibility of a return to elite competitive football at 12 to 15 days post calf injury (15 days since injury, 12 days since the beginning return to play rehabilitation). The video presentation of this case study can be found at preparetoperform.net/btg [2]

During the protection phase, the treatment of pain through appropriate therapeutic modalities carries importance as pain with movement is a risk factor for future injury and a psychological barrier to returning [10-12]. It is well established that pain alters motor control and capacity, which in turn can increase the risk of injury [13-38].

Correct

This part of the rehab post grade 1 hamstring injury is about two considerations – support the return to capacity training and modify risk factors for future injury. There is a known link between movement outside an acceptable bandwidth tolerance and performance [23, 39-54]. Further, a large body of published research demonstrates that modifiable risk factors for future injury include mobility, motor control and capacity limitations and asymmetry [4, 55-75]. Importantly, when I say the word **correct**, I hold any treatment or rehabilitation interventions accountable for changing the behaviour of parts, patterns, or performance of the injured person according to reliable and valid evaluations that relate to the above risk factors. This requires being aware of the injured player's pre-injury movement screens, assessments, and tests. The combination of these evaluations provides for categorization of risk in athletes' [76]. Athletes categorized with pain and significant limitations and asymmetries in a battery of tests were over 17 times more likely to suffer a time-loss injury than those without. Individual components in these batteries have shown up in other research, such as pain on walking beyond day 1 hamstring strain [4], high body weight [61], mobility asymmetry in ankle dorsiflexion [77, 78] and anterior lower chain [61]. With more risk factors present, the risk of injury goes up in some populations [77, 78]. I use the Functional Movement Screen to look at movement competency and risks, Selective Functional Movement Assessment for contributing factors to pain, such as mobility and

motor control dysfunctions, and Y-Balance Tests (upper and lower quarter) to provide reliable and valid motor control screens that bias different components of the core as it relates to upper and lower quarters, then Functional Capacity Tests beyond that.

In parallel with this process of correcting risk factors for injury, I keep an eye on returning to play with many risk factors still present. While it may appear to be a deviation from a criteria-based approach, a real-world scenario of demands ensures a balanced and team-discussed risk assessment to progress rehabilitation knowing many risk factors persist. I'm aware that we need to support the return to the capacity of a player to particular accelerations, speeds of running as well as repeated sprint ability. As a guide, male under 20 rugby league athletes may be in the vicinity of 4.16 metres per second (m/s), while NRL level may be in the vicinity of 4.36m/s [79]. It is common to have male footballers returning to above 28km/h or 8m/s for repeated sprints via progressively shorter acceleration and deceleration drills by the end of my return to run program [80]. So, in addition to addressing pain, mobility and motor control dysfunctions via treatment and corrective exercise, a return-to-running program would go through several stages and phase 1 may begin at slow-walking-pace on day 2 with a combination of lateral movements. The early mobilization is important, while balanced with protection, to stimulate adhesion of regenerating myofibers to the extracellular matrix, reducing the risk of re-tear while allowing some use of the injured muscle before the healing is completed [3].

Develop and maintain

The program has simple goals in each phase (figure 1):

Figure 1 Goals of each phase of the return to run program

Progression through this program from day 2 or 3, to return to play, follows guidelines of the following:
"Do not PROGRESS the rehabilitation if the following occurs:
1. There is a reaction on the following day (i.e., soreness, tightness or guarding)
2. There is a return of pain on walking or a noticeable change of walking pattern
3. There is a need to decrease speed to maintain pain-free form and function
4. Another condition presents itself that requires an assessment before continuing."

Upon completion of phase 5, a player returns to full team training. The number of full-speed team training sessions to be completed prior to being available for match selection becomes a team discussion, with many considerations accounted for, such as the importance of the player to the impending game, the depth of the squad, the importance of the game, the age of the player, the willingness to take risks. An older player is at increased risk of suffering hamstring injury in Australian Football [61, 62], and this is likely to be a consideration in Rugby League also due to similarities in demands. It has been shown that the regenerative

capacity of skeletal muscle in response to injury is significantly reduced with age [81]. The players perceived recovery from previous injury has been identified as a risk factor for future injury if it is rated lower than 93 on a scale of 0-100 [78]. A player with a previous hamstring injury is known to be at increased of injury for many reasons, including the process of tissue remodelling after an injury may predispose the athlete to recurrent injuries and, potentially, prolonged healing time [82] and this has been seen as a direct risk factor for recurrence of hamstring injuries in Australian footballers [4].

Following this criteria has predicted return to play timelines of as early as 15 days post lower leg muscle injury [2], to 3 to 4 weeks. Within the guidelines of my return to run program, I prefer to repeat each phase twice, without reaction, return of pain, need to decrease speed or another condition presenting, to be confident of progressing. Considering time-pressures, I may skip repeating each phase twice and accelerate through the phases. This would shorten the return to play process based on criteria. The final phase of returning to team training has some evidence-guidance to it also. Taken from Hagglund et al, (2007), [83], If an athlete had missed **8-28** days of training at full speed with the rest of the team, they complete **three** full team training sessions before being available for match selection. If they missed **more than 28** days of training at full speed with the rest of the team, they must complete **four** full team training sessions before being available for match selection. These guidelines resulted in a lower reinjury rate in coach-controlled rehabilitation environments of approximately 11% compared to a control group, which was lower than the same-year recurrence rate for elite Australian footballers without the extensive sports medicine service [84]. The current rate has fallen to approximately 5% and remained stable for the past 5 years, suggesting that the addressing of concomitant risk factors may provide further lowering of the reliance on Hagglund et al's number of full team training sessions. This may bring a return to play forward.

A sample calendar of return to play post muscle injury is below.

Week	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
1	Day zero	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
	Injury occurs	Acute self-management	Clinical assessment	Clinical review.	Clinical review	Review by correspondence	Clinical review
				Begin phase 1 & medium intensity ESD	Begin phase 2 at club training & low intensity ESD	Medium intensity ESD non-running session.	Repeat phase 2 and high intensity ESD non-run session.
2	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13
	Team game day	Extended clinical review	Club training	Extra non-run day	Club training	Clinic review	Club training
	No clinic review. No training	Begin Phase 3	Stationary skills, movement preparation, medium intensity ESD non-run session	Low intensity ESD session	Begin phase 4a + skills	Medium intensity ESD non-running session.	Repeat phase 4a
3	Day 14	Day 15	Day 16	Day 17	Day 18	Day 19	Day 20
	Rest day	Begin phase 4b	Club training + clinical review by phone	Rest day	Club training	low intensity ESD non-run session	Club training
			Pool training with team.		Begin phase 5		Rejoin team training.
4	Day 21	Day 22	Day 23	Day 24	Day 25	Day 26	Day 27
	Clinical review	Club game day	Club recovery session	Rest day	Club training	Rest day	Club training - low intensity
	Rest day	Repeat phase 5			Full team training		Continue team training
5	Day 28						
	Club game day						
	Return to play						

Figure 2 Sample return to play program

This 28-day plan accounts for some phases being repeated (phases 2, 4a and 5) and is reliant on a game and club-training calendar. The individual plan may be adjusted to repeat each phase only once based on regular feedback and clinical checks and other considerations.

Combining running and supplementary ESD training

In the above sample calendar, you'll notice ESD training (Energy System Development Training). One goal of non-run-day ESD training is to keep the training load high so that the "hardware" of the body that is responsible for providing enough energy to do work can be maintained or even improved. The more efficient someone becomes with the processing of FFA, the higher the intensity is required to shift towards the use of glycogen, delaying exhaustion. So, even though the return-to-run program has a strong record of returning to the sport with very low recurrence rates, extra conditioning sessions on non-run days is often desired, by both athlete and coach who worry about the injury leading to deconditioning in energy systems.

The return-to-run program, by itself, has been successful without extra training but it was never meant to be a program delivered in isolation. When I am personally with an athlete, they often do other training. I assess, manage load, protect, treat, correct, and develop in ways other than just running. Let me be clear - I have provided this program on its own and I have provided the run program accompanied by individualised management and non-run-day energy system development (ESD) training. Either way, the desire is to provide an approach to ensure competency, capacity and addressing of risk factors for recurrence.

Athletes have the option of doing extra ESD on non-run days for two reasons – they want it, and they often need it. My Chinese athletes, for example, trained twice daily, for 6 to 7 hours each day, sometimes more. If I only prescribed a return-to-field-sports program, they would have many hours without training. The cultural change and metabolic change that such a reduced load would have on them would not be to their advantage.

In addition to keeping energy systems healthy to delay exhaustion, the second main reason I prescribe non-running ESD is to keep training loads high. If an athlete reduces their load during injury rehabilitation, there is always a risk that a return to team training and club training will be a significant increase in training load. I am to reduce the risk of injury that comes with sudden increases in training load. If the increase in training load after an injury is too rapid, the risk of injury increases, as per figure 3.

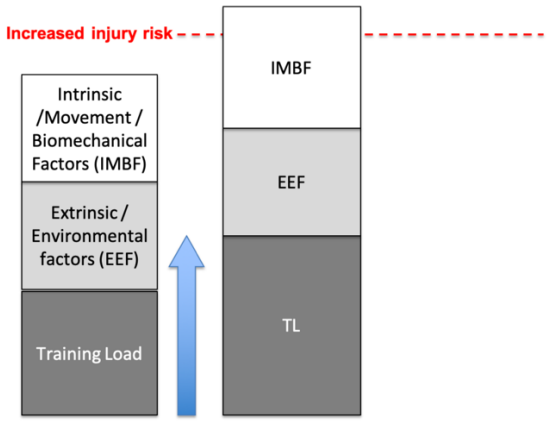


Figure 3 The effect of a sharp increase in training load is that it raises the risk of injury.

The challenge is to raise training load enough to effect fitness changes and protect against injury and illness risk [85, 86], but do it gradually enough to avoid sudden increases and raise injury risk [85, 87-89]. It is responsible to monitor for and manage against sudden increases in training loads, as per figure 3, and as recommended by researchers with deep experience in this area [85, 88, 90].

As mentioned, and referenced above, it is not just sudden increases in training load that can increase injury risk. When intrinsic movement problems exist or appear where they weren't present previously, injury risk is elevated (figure 4). Testing hamstring isometric strength in late-stage rehabilitation is a reasonable option to look for limb asymmetries and significant decreases from pre-injury if data is held.

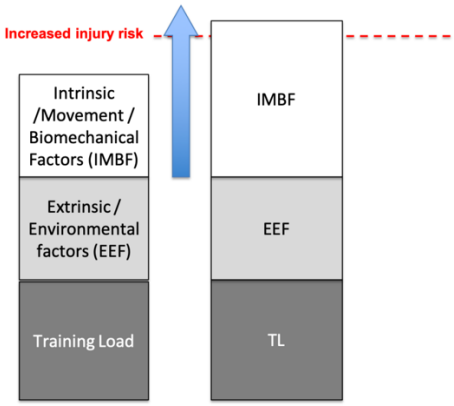


Figure 4 The effect of not addressing limited and asymmetrical movement is that it raises the risk of injury.

The following is a succinct description of the six phases of a return-to-run program (as mentioned in the calendar) with inclusive statements about correcting and maintaining energy systems.

PHASE 1

Manage the acute injury to reduce, then abolish pain, then regain movement competency.
Begin lateral movement drills. Do stationary sports skills that don't aggravate the injured body part.
Do low-intensity non-running continuous task ESD so long as the injury restrictions permit the movement tasks chosen for ESD training. Progress only if you meet the criteria for progression.

PHASE 2

Do 4 to 6 laps of 50m jogs and 30m lateral movements at approximately 50% speed. Do lateral movement drills, as per phase 1.
Reintroduce short kicking if able.
Alternate between run day and non-run day training.

Do medium to high intensity non-running continuous task ESD on non-run days, so long as the injury restrictions permit the movement tasks chosen for ESD training.

To be more confident of your ability to progress, repeat phase 2 for a 2nd session, to prove that it wasn't a fluke to get through it the 1st time.

Progress only if you meet the criteria for progression.

PHASE 3

Do 8 to 12 repetitions of 150m runs at up to 70% speed. Do these in sets of 4. After each repetition, rest for 30 seconds. After each 4th repetition, rest for 2 to 3 minutes.

2-3 x {[4 x (100m to 150m / 30s)] / 3minutes}

Reintroduce short to medium length kicking. Alternate between run day and non-run day training.

Do low intensity ESD and high intensity non-running continuous task ESD, so long as the injury restrictions permit the movement tasks chosen for ESD training.

To be more confident of your ability to progress, repeat phase 3 for a 2nd session, to prove that it wasn't a fluke to get through it the 1st time.

Progress only if you meet the criteria for progression.

PHASE 4A

Alternate between run day and non-run day training.

Do 100m runs at up to 85% speed. Accelerate from standing to get up to speed, then hold in the middle zone, then decelerate until the end, to a complete stop. Rest for 30 seconds after each rep. Rest for 3 minutes after the 6th rep. Some guidelines for running speed through the middle zones are listed below.

40m-20m-40m x 6 (30/3) → 3 to 3.5 seconds for the middle 20m zone
40m-30m-30m x 6 (30/3) → 4.5 to 5.25 seconds for the middle 30m zone
30m-40m-30m x 6 (30/3) → 6 to 7 seconds for the middle 40m zone
30m-40m-20m x 6 (30/3) → 6 to 7 seconds for the middle 40m zone

Do lateral drills as per phase 1.

Do up to 6 figure-S runs over 50m.

Do "box-runs", 2 each direction.

Do cut-and-leads, 2 each direction.

Do long distance skill executions, some while running.

Alternate between run day and non-run day training.

Do more low-intensity non-running continuous task ESD, and perhaps a small amount of medium intensity non-running continuous task ESD, so long as the injury restrictions permit the movement tasks chosen for ESD training.

To be more confident of your ability to progress, repeat phase 4a for a 2nd session, to prove that it wasn't a fluke to get through it the 1st time.

Progress only if you meet the criteria for progression.

PHASE 4B

Take 2 days of non-running training are done for each 1 day of running training

All drills that were done in phase 4a are done quicker, up to 95% speed. Some guidelines for running speed through the middle zones are listed below.

40m-20m-40m x 6 (30/3) → 2.5 to 3 seconds for the middle 20m zone
40m-30m-30m x 6 (30/3) → 4 to 4.75 seconds for the middle 30m zone
30m-40m-30m x 6 (30/3) → 5.5 to 6.5 seconds for the middle 40m zone
30m-40m-20m x 6 (30/3) → 5.5 to 6.5 seconds for the middle 40m zone

Following the above interval runs at speed, do figure-S runs (as per Phase 4a), followed by box runs, cut and leads, and then long kicking. Alternate between run day and 2 non-run days of training.

Do more low-intensity non-running continuous task ESD, and perhaps a small amount of medium intensity non-running continuous task ESD, so long as the injury restrictions permit the movement tasks chosen for ESD training.

To be more confident of your ability to progress, repeat phase 4b for a 2nd session, to prove that it wasn't a fluke to get through it the 1st time.

Progress only if you meet the criteria for progression.

PHASE 5

Approach high speed while handling the sport-specific object.
Do shorter intervals with much shorter acceleration and deceleration zones.

20m-30m-20m x 6 (30/3)
10m-30m-10m x 6 (30/3)
5m-20m-5m x 6 (30/3)
10m-40m-10m x 6 (30/3)

Then repeat the above intervals while an assistant delivers a ball to you, for 2 repetitions at each interval.
20m-30m-20m x 2 (30/3)
10m-30m-10m x 2 (30/3)
5m-20m-5m x 2 (30/3)
10m-40m-10m x 2 (30/3)

Do 4 diagonal box runs, long kicking/throwing/hitting, then join in with the rest of the team training.

To be more confident of your ability to progress, repeat phase 4b for a 2nd session, to prove that it wasn't a fluke to get through it the 1st time.

Alternate between run day and 2 non-run days of training.

Do more low intensity non-running continuous task ESD, and perhaps a small amount of medium intensity non-running continuous task ESD, so long as the injury restrictions permit the movement tasks chosen for ESD training.

Progress only if you meet the criteria for progression.

PHASE 6

If you skipped phases, complete the fitness test below. If you did all phases and passed the criteria, re-join team training in full.

Fitness test:

1. Straight-forward jog
2. Figure-eight jog
3. Zig-zag jog
4. Jog with 900 turns
5. Jog with 1800 turns
6. Jog with 3600 turns
7. Individual ball drills
8. Shooting, jumping, sprinting
9. Team training.

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