HAMSTRING INJURY

A CLINICIAN'S GUIDE

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On average, humans have slightly less than two legs. This information, while technically true, doesn't help if you need buy your kids some shoes. Similarly, the aggregated (group level) research work we've done on reasonably large groups of athletes recovering from hamstring injury, or teams we're trying to help reduce hamstring injury incidence doesn't necessarily tell us what we should do for the individual player. In this paper, we'll try to address this shortcoming by laying out the framework that we're currently using with hamstring injury. In this forum we're presenting what we do clinically. In that setting we're evidence-informed, not evidence-based. The difference is subtle but important in an area like this where we really don't have a lot of definitive research which unequivocally tells us things to do, or not to do. We therefore weigh up what the research tells us, draw upon our clinical experience, and develop a tailored approach for the individual athlete.

INITIAL ASSESSMENT – PITCH VERSUS CLINIC.

On-field

If you've just ran onto the field to care for a player grabbing at the back of their leg during a game, your assessment aims are to initially figure out if this is, in fact a hamstring injury, and if so, should this player continue playing, or be replaced and so begin their rehabilitation. It's obviously impossible to order an MRI during an on-field assessment of a player who tells you they just felt something in their hamstring while running. In some sports you may have the possibility of removing the player for a more comprehensive assessment off-field, but ultimately the decision will need to be made with a degree of uncertainty. Occasionally things will be clear; the decision is easy when a player tells you they felt a characteristic sharp pain in their posterior thigh (perhaps while running or stretching for a ball) and immediately had to stop because now it hurts even to walk. Much more difficult is the player who tells you they felt a "tightening" earlier in the game, and has been playing on since then, perhaps by avoiding top speed running, or playing a little more cautiously than usual. "Pawing" the ground might help your decision to remove the player if this is associated with a sharp local pain in the posterior thigh, but since they've already demonstrated they can run and participate, this will become a negotiation between you, the player, and the team's management. The shared decision will come down to how much risk of injury exacerbation should be taken for this player, on this day.

In-clinic

As always, the key here is to let the patient tell you what's wrong with minimal interruption from you. Only seek clarification, if required, to fill any gaps. You may need to ask about the exact mechanism of the injury as this may influence some treatment choices you'll have to make later (e.g. running straight versus stretch-type versus curved/accelerating run). Ask the patient about previous hamstring injuries, and the recovery from these – "when you got back playing, did you still have any problems? Were you able to run at full speed and do everything in training and games as per normal? Did you have any other problems because of this hamstring injury?". Ask what the rehab process involved in any previous injuries. This information will help frame what has and hasn't been helpful for this athlete previously and therefore further refine some treatment choices. Find out what the season's preparation was like – how much of a break did they have from training, and then what happened when training resumed. It's fashionable to dump on the notion of acute and chronic workloads, but we remain convinced that abrupt changes in exposure to hamstring loading are potentially modifiable injury risk factors (however these are quantified) so ignore this at your peril. Look out for off-season breaks punctuated by a new coaching team stamping their authority with heavier than usual pre-season conditioning. Similarly, a player whose off-season was altered perhaps by a minor surgery,

their wedding, or some other reason that they weren't able to perform usual training, and then had to jump back into full training, or worse, straight into a competitive season, will be at elevated risk of not being prepared for the physical loads they are about to undertake. Find out about any other injuries that could be interfering with preparation – the time off because of this hamstring injury might be an opportunity to increase some loading for a grumbling Achilles problem or increase the strength of the adductors in a player who's had a few groin injuries over the last few years.

Don't miss

The player who presents with a history of abrupt onset, proximal hamstring pain, likely associated with a stretching mechanism (e.g. doing the splits or being pulled forward in a water skiing fall) and perhaps lots of bruising in the posterior thigh or down their leg is assumed to have a complete proximal tear until proven otherwise. It's less likely that one of these will get missed in a professional sport setting, but in the recreational athlete setting these injuries probably present more often than they are recognised. Imaging will be required, and likely a surgical consult. A complete rupture proximally, however, doesn't necessarily mean that the patient requires surgery. The decision for surgery is neither simple nor is it one that we have a clear algorithm for, but this is beyond the scope of this paper.

Gradual onset posterior thigh pain that isn't reproduced through hamstring loading or palpation is unlikely to be a "simple" hamstring strain, and your differential diagnoses will include bone stress injury, neurological conditions, and the more sinister pathologies you always need to exclude but which also won't be further discussed here.

Rehabilitation – Early

Perhaps the biggest change we've seen in the management of acute muscle (and other tissue) injury over the last 50 years is the shift to early, appropriate therapeutic loading and away from extended periods of "protection" or complete unloading. Landmark basic science evidence shows that experimentally induced eccentric overload muscle strain injury results in individual muscle fibrils "popping" while adjacent ones remain intact. These damaged muscle fibrils shed their basement membrane and appear to reattach to adjacent healthy fibrils while at the same time there's a marked increase in the presence of satellite cells in the area. These satellite cells (which probably have migrated from adjacent healthy areas of the muscle) are mechanosensitive so need to be loaded to optimize their fusion to myotubes. Note that this is an area of emerging research, and the exact cues which initiate myonuclear addition still need to be clarified. We do, however, have indirect, but perhaps more relevant research on humans suggesting that delaying the onset of (active) rehabilitation is associated with longer rehabilitation. Two separate studies, one which randomized injured athletes to have their rehabilitation delayed, and one which was observational in this regard, showed that for every day rehabilitation was delayed, roughly 3 more days of rehabilitation were required until the athlete was discharged from care. Delay your loading by a week, pay for it with 3 weeks longer rehabilitation. Unfortunately, we don't know what the optimal exercise loading parameters should be much beyond that some is better than none, and there is an upper limit where you can damage healing and/or healthy areas of muscle.

Image: Illustration.

We can make some suggestions though for what to do in this early phase based on our clinical experience.

An aspect which may have been underappreciated in hamstring rehabilitation is the possibility that the damaged muscle suffers from local inhibition which is masked by compensation from the uninjured synergists. If you have imaging evidence of the muscle that's involved, it's of course simple to ensure that you provide exercise targeting the damaged area. Without imaging, we rely on our palpatory skills. A distal long head of biceps injury can be readily identified with palpation, however for the proximal, say, two thirds of the hamstring muscles our confidence in identifying through palpation alone the exact muscle (medial or lateral) should be tempered given the proximity and overlap of these muscles. Unfortunately, only perhaps 1 in 5 of the hamstring injuries we encounter in clinical practice are in the distal third. The actual site of the injury is most likely to be at the myotendinous junction, however even here we have some challenges as the proximal and distal myotendinous junctions span more than half of the length of the muscle, so pain in the mid belly of biceps femoris (for example) could involve an injury located at the distal aspect of the proximal myotendinous junction or vice-versa. If you are completely confident in the site of the injury, you may direct this early careful loading to just that portion of the muscle group, however there's no penalty, except for perhaps time taken, to try to target the medial and lateral hamstrings, proximal and distal selectively at this stage. At the most protective (cautious) end, you can isometrically apply gentle manual resistance to knee flexion combined with tibial rotation. Adding an element of hip extension may further load the more proximal portions.

It's easy to focus solely on the injured area and forget that the athlete is more than a hamstring strain. From the first day of rehab, consider at least maintaining the loading through other key body areas that are required for this athlete lest you run the risk of deconditioning, for example the adductors of a kicking sport athlete, or the calves of a runner. Given the athlete isn't able to do heavy "on legs" training, it may be an opportune time to programme in some overload training that's otherwise impossible during the season. Documenting areas of previous injury, and input from the strength staff will be helpful here, as of course are the player's desires and long-term goals.

Image: Illustration.

Re-assessment and prognosis

Everyone wants to know when the injured player will be back, safe on the field, taking part in full training. Here average return to play times aren't that much help when you're trying to give a prognosis for an individual. Will this player be faster or slower than usual? The difference for the same grade of injury is often weeks. In an ideal world we'd have some sort of way of objectively measuring the athlete's muscle health and relative progression back to 100%, but sadly this remains the realm of video games for the moment. A few clinical measures seem to track reasonably closely with overall rehab progress and can be helpful in both updating staff and fine-tuning your loading. An objective measurement of hamstring strength is helpful – your hands aren't good enough to quantify the highest force where any discomfort begins though. Handheld dynamometers or pressure cuffs can give you a number to compare against previous days. Improving strength measures will reassure all that the loading is appropriate and can likely be increased, whereas a reduction is an indication you've pushed things too hard.

Clinical research completed at Aspetar has revealed that careful palpation of the length of the painful area tracks quite closely with progress through rehab. The length of pain on palpation is expressed as a percentage of the initial (first) assessment length and when the length of pain is about half the initial length, the patient is typically about one third the way through rehab, and once it's down to about one-third of the original length, the patient is about halfway through rehab. But you need to be careful and systematic in how you palpate, and your instructions can make a big difference. Remember that the patient is likely worried about you hurting them, so start by palpating an area that's not injured, and explain: "This is the normal feeling when I push firmly on your muscle. When I'm checking


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the injured area, I'm going to push on both legs at the same time, and if they both feel like this, that's completely normal. If you think this leg is painful though, let me know and I'll stop straight away." Start in an area (like the proximal gastrocs) where you both know there's no injury to get some trust, and then carefully, systematically make your way through all of the hamstrings, medial and lateral, proximal and distal, palpating both legs at the same time so your patient is not reporting when something hurts, but rather when the injured leg feels different to the uninjured one. With practice, this takes about a minute on the first day, and much less subsequently when you know where you're fishing. We find it's no effort to measure the length of tenderness, and it's helpful to report this to patients who otherwise feel "it still hurts when you touch the injury, maybe I'm not getting any better". Knowing that "last week this was 12cm long, and now you're down to 6" can help athletes better conceptualise their recovery.

The amount of hamstring flexibility didn't seem to be as helpful in tracking progress, irrespective of the method used, as the daily variability was pretty large, but once the patient reported that the flexibility test (be that max hip flexion with active knee extension - "MHFAKE", straight leg raise, or simply bending over to touch their toes) was no longer painful, it was a reasonably good sign that you were close to the end of rehab.

Who's going to be a "problem child"?

It's pretty rare that a medial hamstring injury (especially in a younger player) goes on to be a repeat injury after a protracted rehabilitation. This doesn't mean that we're glib when treating these, but repeat injuries seem to be the realm of long head of biceps femoris. That said, it's probably not wise to ramp up your attention and concern when a player presents with a biceps femoris injury otherwise you run the risk of inadvertently raising their anxiety levels. Simpler is to always aim to have a careful, systematic process in place which also prevents you from having the "what if?" conversations later in an athlete who has a bad outcome.

Rehabilitation – intermediate

Most of the athletes you'll be rehabilitating from a hamstring injury are involved in a sport that needs fast running and sprinting, and for most of these, this will be the toughest thing they need to clear before returning to their sport. Accordingly, starting on some running as quickly as possible in rehabilitation is high on the list of priorities for most. It's rare in the extreme that we don't start some form of running within a few days of injury, although it should be noted that with more severe hamstring injuries this running may initially be very slow (less than 5km/hr) and is probably more accurately termed a slow shuffle. The (negative, eccentric) work done by the hamstrings increases with the speed of running, but in a non-linear manner. In a practical sense this means that increases in running speed at very slow speeds are associated with only small increases in work done by the hamstrings, but late in rehab as athletes are getting close to their top speed, very small speed increments are associated with large increases in work done by the hamstrings. Push things too quickly and you risk a recurrence, so how do you know how hard you can/should push the athlete? Frankly, you'll only ever know for sure when you've pushed too hard and an athlete has a setback. This is where it's crucial to have had a discussion early on with the player and any other stakeholders about how aggressive this particular rehab should be. The potential reward of getting the player back earlier than expected needs to be weighed against the possibility of reinjury, and a shared decision agreed to by all. A marquee player coming back from a preseason injury is likely to be afforded more time than the same player pushing hard to make an important match for which they could be the deciding factor. Regular communication during rehabilitation will foster this process and having the player and coach aware of the progressions involved during rehab makes it an easier process. Coaches might not get as much information out of you telling them the athlete has progressed from manual isometric to active concentric exercises, but they will likely understand percent running effort and/or objective measures of running speeds and distance. In these early phases where running speeds haven't got to, say, 60-70% of the player's maximum, you may include running in every session if you feel it's indicated. Once the running intensities get higher however, you will almost certainly need a day of recovery from this loading and can likely only get the player close to their top speed twice, or at most 3 times a week.

During the intermediate phase your hamstring loading will shift from "activation" type exercises where the aim is more about overcoming injury-induced muscle inhibition, and the loads are low, up to "genuine" resistance training by the end. In the earlier stages, since the loads are low, exercises can be done daily if indicated. True overload resistance training however can't be performed daily, so by the end of this stage you'll need to plan your week's loading. As the athlete prepares for a return to normal training duties, the "other body areas" training you started in the early phase of rehab will likely need to be tapered back now because they won't be as tolerant of this additional heavy loading anymore.

Rehabilitation – Late

In the final phase of rehabilitation, you need to ensure the athlete can safely replicate the loading which occurred during their particular injury, as well as the other high hamstring load activities specific to their sport and role. Sprints, repeated sprints, accelerations, direction change, running

Table 1

Typical timeframe	*0-7 days*		*2-14 days*		*7-28 days*	
Hamstring loading type	*Early*	*Criteria to progress*	*Intermediate*	*Criteria to progress*	*Late*[*]	*Criteria to return to training*[**]
"Activation"	*Manual isometric, inner range, rotation bias*	*Painless single leg squat*		*Running > 70% of perceived maximum*		*Painless maximum effort running, good recovery following day*
	Through range unresisted	*Low resistance high cadence bike painless*				*Painless maximum effort direction change, good recovery following day*
	Bike					*Painless maximum effort acceleration, good recovery following day*
	Walking gait		*Slow running (volume "on legs" work)*		*Slow running (volume on legs work)*	*Demonstrated volumes and intensities of fast running required for the individual*
"Loading"	*Double progressing to Single leg squat*		*Running and running drills up to ~70% max effort*		*Running and running drills up to ~70% max effort*	*Painless palpation*
	"Diver"		*Nordic hamstring*		*Nordic hamstring*	*Restoration of hamstring strength (uninjured leg, previous data, normative data for the position/player weight)*
	"Glider"		*Straight leg bridge*		*Straight leg bridge*	*Pain-free full range of motion*
	"Extender"		*Romanian dead lift*		*Romanian dead lift*	
			45° Hip extension		*45° Hip extension*	
"Resistance/ overload"					*Fast running*	
					Fast running with direction change	
					Acceleration to fast running	
					Sprinting longer distances	
					Sport-specific running and loading	
"Other areas[***]"	*Calves*		*Calves*			
	Adductors		*Adductors*			
	Rectus femoris		*Rectus femoris*			
	Abdominals		*Abdominals*			
	Hip extensors (sparing the hamstrings)		*Hip extensors (sparing the hamstrings)*			
	Hip Abductors		*Hip Abductors*			
	Upper body		*Upper body*			

[*] *Incorporate plyometric progressions of the resistance exercises if deemed relevant.*

[**] *Return to competition criteria includes additional criteria such as safe completion of a sufficient amount of unrestricted training, but performance/ contextual factors are also highly influential, and are beyond the scope of this paper.*

[***] *Heavy loading, if indicated.*

Table 1: Suggestions for staged hamstring loading and progression criteria.

and reaching, and chaotic environments with unplanned reactions all present options for tailoring these final phases, but the planning for this should have started at the early phase to ensure that you're steadily progressing into these activities safely. Monitoring and progressing the intensity and volume is key here. In the early phases we'd carefully suggest only allowing the athlete to progress to harder loading when they tell you "that's just too easy for me" but more care is required if an athlete tells you "hmmm... maybe I can go a bit harder... I'm not sure ..." or "I feel nervous doing that". If your sport has metrics for the player (typical distances and speeds ran) these should form the first aim for your running loads. Remember that achieving the player's average high-speed running distance means that they have not yet shown they are ready for about half of the games they play – how much longer you want to spend in rehab to reach these goals will be an important aspect of the shared decision-making process that you went through at the start of rehab.

Return to sport

It would be a mistake to start thinking about your return to sport testing and criteria during the later phases of rehabilitation. Rather, all this should have been planned at the initial assessment. Set up your minimum physical performance criteria, plus your stretch goals as well as your tolerance for risk in this case. Fast running intensities and distances, direction change, sport-specific tasks (e.g. picking up a ball while running in AFL, running and making a clearing kick in football) will likely be a large part of these. Absence of clinical signs and symptoms is also expected, but remember that we don't have any firm criteria that can absolutely guarantee a safe return to sport. However, taken together, we feel these are necessary, but not sufficient to guarantee safe return to sport.

PREVENTION

Team/organisation level

Since hamstring injury most likely accounts for the largest single category of time-loss for many sports, a focus on reducing burden should be part of every organisation's plan. In this regard, it seems that different approaches might be warranted for those with and without a past history of hamstring injury. For the majority of the squad who haven't got a history of repeated hamstring injury, we feel that systematic exposure to bouts of high speed running as a part of routine preparation will be the core of reducing hamstring injury burden. An approach is simply paying attention to the total high speed running distance performed for any individual relative to both previous weeks and typical game demands, and then "topping up" or backing off as required during the week's preparation. This is easier said than done. The entire preparation staff must be aware of this approach and it will require buy-in before the season begins. The complete injury reduction package will include not only good sprint exposure in addition to aerobic "on legs" conditioning, but warm-up running drills which can target tissue loading, as well as specific gym-based strength training for the hamstrings. Hamstring strength training will include eccentric overload with hip and knee dominant exercises, uni- and bilateral loading, at low then high speed. Clearly this presents a range of options for session programming and it's neither sensible or possible to complete this Bingo card in a week, or perhaps even a month, but throughout the course of the season all permutations should be covered as part of an overall injury reduction plan.

Implementing subjective player wellness ratings is part of most modern organisational frameworks, but truly getting to know the individual player is key to interpreting and therefore acting on these data. Younger players without a long training history may have some difficulty interpreting the difference between unaccustomed training-related muscle soreness and low-grade injury, especially when asked to score this from 0-10. Similarly a senior player with a long history of high loading who unexpectedly reports 1/10 soreness in their hamstrings for the first time in their 10-year club history will be cause for further investigation and likely action.

Individual with an extensive past history

For those with a history of repeated injury, the first step would be to ensure you're doing everything possible to allow compliance with the organisational approach outlined above. Beyond this, there should be some tailoring to find out what's worked best previously for the particular player – what exercises, how heavy, how often, as well as the 'extras' that might be required. If it's not the practice of the organisation to implement hamstring strength testing routinely to inform training, this additional monitoring is likely indicated for high risk players. Following match play, a >14% reduction in isometric hamstring strength (which is re-tested and confirmed later the same day) has been recommended as a criteria to modify training loads, and this process was prospectively associated with a marked reduction in hamstring injury occurrence.

Despite all the research attention over the last 50 years, there are still alarming gaps in our knowledge including differences between the genders for the factors we've discussed, and a distinct lack of research on adolescents, especially females. Currently our best guesses are to implement similar approaches to those recommended for adult males, but to realise that there are almost certainly important differences which are being missed in this strategy which hopefully will be revealed in future research.

References
Available at www.aspetar.com/journal

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