

A summary of the analysis of Prices hamstring injury data reveals;

(A more complete description follows)

1. The percentage overestimation of hamstring strains in the AFL Injury Survey is at least 23%- it could be to the order of 40%. “Hamstring strain” is probably overestimated in most injury surveys.

2. Why did the player think their hamstring injury occurred?

The largest category is back and hamstring tightness in the days preceding their strain. The categories where most of the restrains occurred are the most alterable.

3. NSAID's

Being on NSAID's may be associated with an increased likelihood of straining a hamstring, and may also increase the risk of a restrain?

4. Training schedule in the days prior to hamstring injury.

Training, albeit lightly, the day prior to the game appears to increase the risk of a hamstring strain.

4. Timing of Hamstring Injuries during Matches and at Training

The majority (62%) of players were injured during the middle 10 minutes of each quarter

In the central part of the quarter there is an overlap of the fastest pace of the game and where fatigue begins to occur.

5. The undisclosed hamstring strains.

11% of AFL footballers with a hamstring injury in 2002 suffered a reoccurrence in the privacy of the training facility as part of their rehab program.

6 Hamstring rehabilitation program parameters in AFL footballers

A) Players that successfully returned to play ran approximately 30% less frequently, than the group that failed in their return to play.

B) Those who successfully returned to play engaged in strengthening exercise approximately 15% less frequently than those who suffered a recurrence of return to play.

C) Core Stability Training – Transversus Abdominus emphasis specified.

The group that successfully returned to play engaged in specific core stability training approximately 25% less than those that failed in their return to play.

D) Number of sessions per day of hamstring stretching was recorded. The group that returned successfully to play engaged in hamstring stretching at the same frequency of those who failed to return to play. This frequency was 2.6 times a day, with 30% more players stretching three times a day than those stretching once a day.

E) The number of full training sessions before returning to play was approximately even between the two groups. The group that successfully returned to play trained on average 3.1 sessions prior to successfully returning to play and the group that failed on their return to play trained on average 3.4 sessions.

7. Do the hamstring symptoms change with treatment directed at proximal structures?

AFL physiotherapists are active in treating proximal structures and this has an effect in a significant number of cases.

8. An AKE deficit has a better association with severity of a hamstring strain and predicting a recurrence than a PSLR deficit in the post-acute period.

9. Time taken to jog pain-free is better than time taken to walk pain-free as a predictor of time to return to play. This mildly better predictor may be because it is slightly closer to the return to play date.

10. Region of Hamstring Injured.

Players with a distal muscle tendon injury take longer to return to play and have a greater risk of restraint.

11. Specific grading of a hamstring muscle strain corresponding to pathological severity is proposed.

Further explanation of the Hamstring analysis follows;

1. What influence did the focus on studying hamstrings in 2002 have on the number of hamstring strains in that season?

Hamstring Strains	1997	1998	1999	2000	2001	2002	2003	2004	2005
Incidence	6.8	6.4	6.7	5.6	6.1	4.5	5.8	6.3	5.2

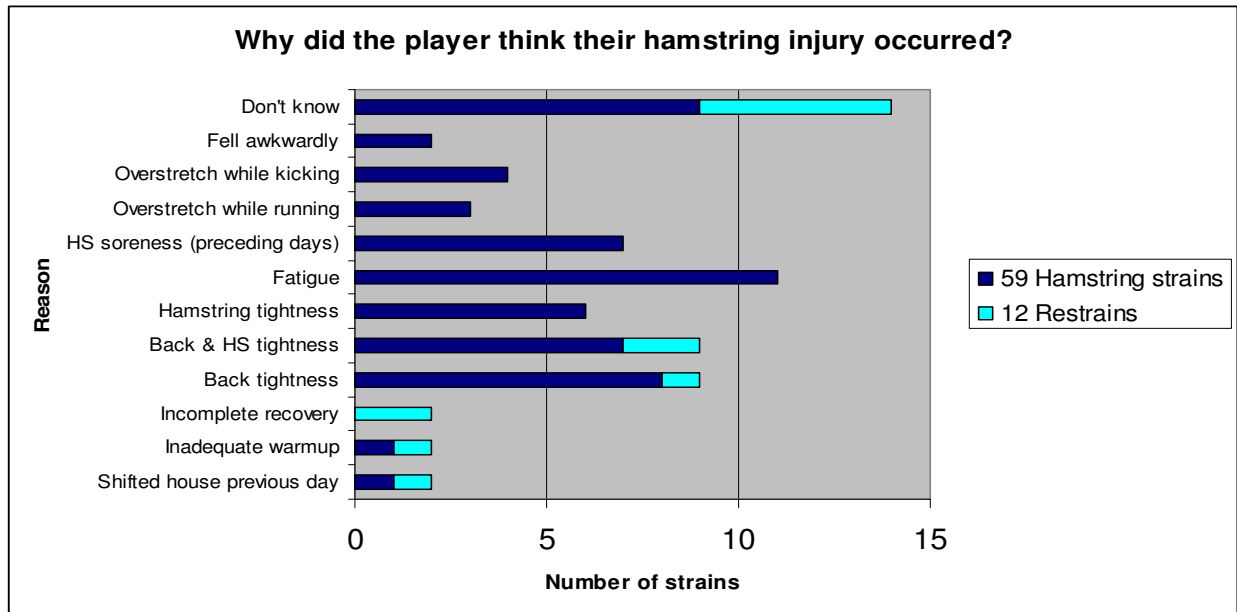
In 2002 there was an average of 4.5 hamstring injuries per club which is significantly less than the historical average of greater than 6. The rate of recurrence was similar to the long term average at 30%.

It would appear that the greater focus on hamstring strains through the entry criteria into Prices AFL hamstring study mean that fewer injuries were labeled as hamstring strains by club medical staff from the 10 Victorian based clubs. Given that the incidence of hamstring strains is taken over 16 AFL clubs and that probably 4 of the 59 players in the cohort didn't have a hamstring strain(ie negative imaging, negative physio evidence and didn't miss a week) this makes the % of overestimation of hamstring strains in the AFL Injury Survey to the order of 40%. Even if the lowest recorded incidence of 5.2 (in season 2005) is used for comparison then there is still to the order of a 23% overestimation of hamstring injuries in the AFL Injury Survey.

If AFL doctors and physiotherapists tick the box that says "Hamstring strain" at a frequency greater than what true hamstring strains occur then it is probably overestimated in most surveys of injuries, particularly those carried out by less experienced and expert practitioners.

The ramification of this may be that many Injury Surveys of hamstring strains where recording is carried out by members by club medical staff and especially those recorded by staff who are not medically trained will result in an overestimation of hamstring injury. This suggests that the results of scientific publications relying on data based on collection of injury information not ratified by an independent expert in hamstring strains may be flawed (eg The AFL Injury Report, {Woods, 2004 #134; Orchard, 1998 #171; Gabbe, 2005 #155; Gabbe, 2001 #174; Askling, 2003 #53}.

2. Why did the player think their hamstring injury occurred?



In an open ended question to the player these were the reasons given as to why the player felt their hamstring injury occurred.

The largest category is back and hamstring tightness in the days preceding (note the 3 categories of back tightness, hamstring tightness and combination back and hamstring tightness).

The most alterable categories are those at the bottom of the table which is also where most of the restrains occurred.

For example; Does the club know when a player is moving house and should they actively intervene to assist?

3. NSAID's

21 of the 59 first time hamstring injured players were on NSAID's (36%).

Eighteen footballers (31%) were taking NSAI's in the days following their hamstring strain, nine of these (50%) were taking them at the time of injury, suggesting that nine players were specifically prescribed NSAID's for the initial post injury period (ie 12 were taken off NSAID's).

We know of the NSAID status of 7 of the 9 players who restrained in the first 3 weeks after returning from injury; 5 of these 7 were on NSAID's (71%).

If there are less than an average of 36% of players on NSAID's on an AFL list this may mean that players on NSAID's are more at risk of straining a hamstring- this probably is not a statistically significant proportion.

Does being on NSAID's mean a player is more likely to strain a hamstring? They appear to be at greater risk of a restrain if taking them in the few days following injury (Warren, 2007).

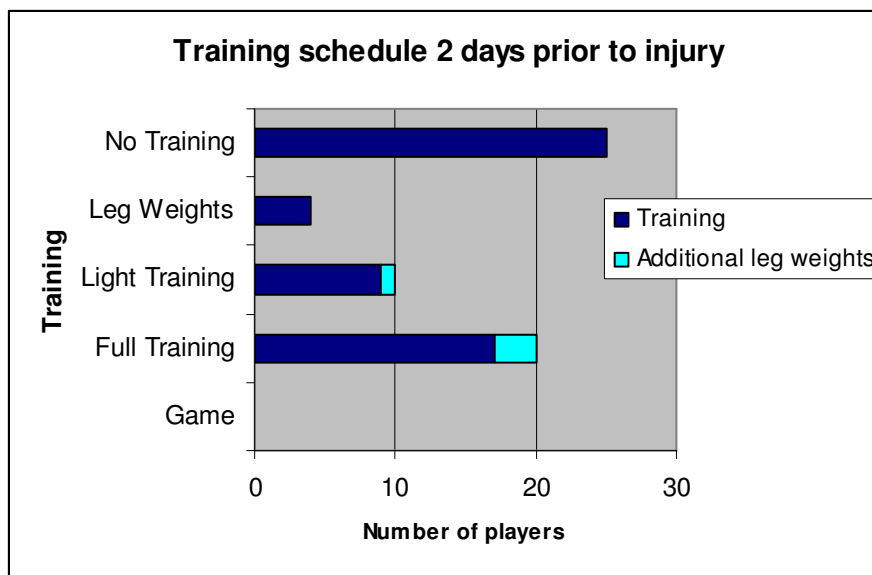
Confounding factors; Older players are more likely to be on NSAID's and may also be more likely to strain a hamstring, although the age factor was not supported by Prices study.

Taking NSAID's in the first few days following a hamstring strain has a trend towards association with an improved chance of returning to play in three weeks or less. Despite NSAID's being recommended immediately following a muscle strain (Kujala, Orava et al. 1997; Clanton and Coupe 1998) with early signs of improvement on the healing of muscle injury (Prisk and Huard 2003), their current use in AFL football appears to be a decision based on clinical experience rather than clinical science (Orchard 2005). There is theoretical merit in delaying NSAID's for a few days following hamstring injury as their earlier use may interfere with the chemotaxis of cells which is necessary for the repair and remodeling of regenerating muscle (Clanton and Coupe 1998). Alternatively, it might also be argued that by limiting pain and inflammation, other changes predisposing to injury at new sites such as inflammation-induced atrophy and/or pain inhibition are reduced, allowing rehabilitation to proceed at a faster rate. It is also possible that, in hamstring strains in Australian footballers, none of these factors has a significant influence, or even that these opposing influences cancelled each other out.

Taking NSAID's in the first few days following a hamstring strain has a trend towards being associated with suffering a recurrence of a hamstring injury in the first three weeks of returning to play. There appears to be opposing effects of early functional improvement and subsequent late impairment in functional capacity and histology observed with the use of NSAID's in muscle injuries and repair (Prisk and Huard 2003). NSAID's induce changes in the healing response that have yielded conflicting effects (Almekinders and Gilbert 1986; Obremsky 1994; Mishra, Friden et al. 1995; Reynolds 1995; Almekinders 1999; Levine, Bergfeld et al. 2000). Research has clearly shown that NSAID inhibition of prostaglandin production after muscle injury results in changes in the regenerative process and long-term deficits in muscle functional capacity. The exact mechanism by which this occurs remains unknown, but disruption of growth factor driven processes is a likely culprit. In addition, it appears as though COX-2 and the prostaglandins have an important function with regard to the formation of fibrosis within diseased tissues (Prisk and Huard 2003). While early loading helps to minimize secondary atrophy, it can itself increase the risk of re-injury while the scar is still weak (Buckwalter 1995).

This is one of the more interesting results of this study because it is one of the few alterable factors when initially assessing a footballer with a hamstring strain in the post acute period. If an Australian Football player has a medial hamstring strain then, based on this study, it is reasonable to prescribe NSAID's in the post-acute period. This may provide an earlier return to play (Kujala 1997, Clanton 1998) without increasing the risk of recurrence.

4. Training schedule in the days prior to hamstring injury.



The dominant training profile in the 59 players to have a hamstring strain for the first time in 2002 was training lightly the day prior to the game (30/59, 51%), 21 of this 30 had the day off 2 days prior and 20 of this latter group of 21 (95%) had a full training session 3 days prior.

The second dominant training profile was to have had the day off prior to the game (25 out of 59, 42%) with 18 of this group of 25 (72%) training fully 2 days prior.

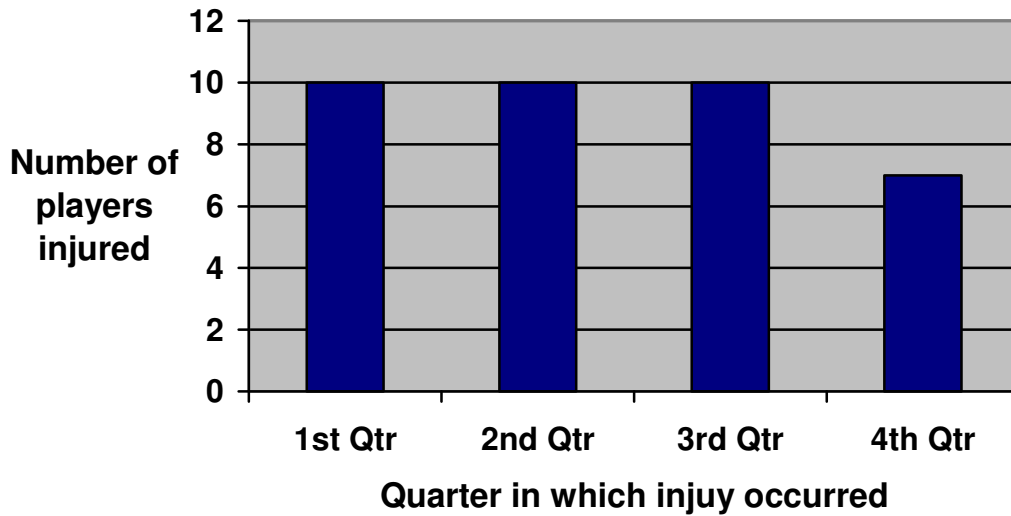
With the dominance of this latter training schedule amongst AFL clubs it is possible that training, albeit lightly, the day prior to the game is a risk factor for hamstring strains.

No study has looked at the influence of training schedules on the incidence of hamstring injury.

4. Timing of Hamstring Injuries during Matches and at Training

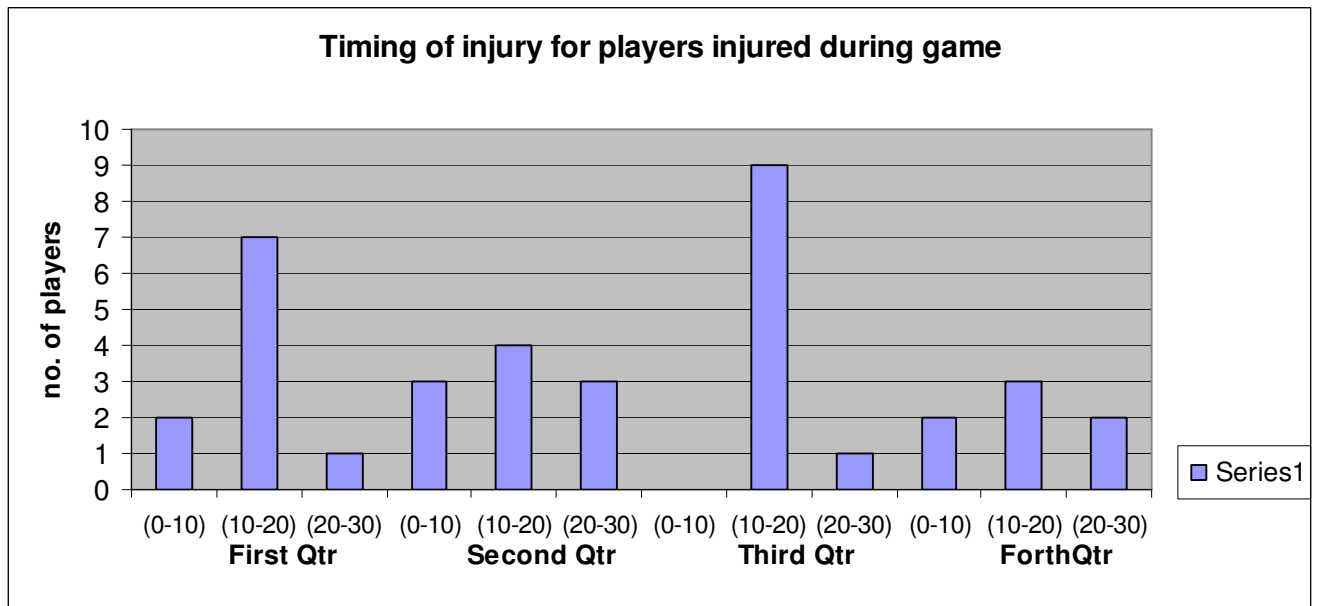
The majority of players were injured during games (n=37, 62.7 %) and the remainder during training (n=22, 37.3 %). Of those injured during match play, ten (17.0 %) were

injured during each of the first three quarters, and seven (11.9 %) were injured in the final quarter.



Graph I Timing of injury for players injured during game

Dividing each quarter into 3 ten minute segments the majority of strains occurred in the middle of each 30 minute “quarter” and not either at the end of the quarter, nor in the final quarter towards the end of the game. Twenty-three (62%) of players were injured during the middle 10 minutes of each quarter





Woods et al {Woods, 2004 #134} found that hamstring strains were mostly sustained at the end of matches and training sessions (Figure **Error! No text of specified style in document.**). He felt this supported the notion that fatigue may be a predisposing factor for such injuries as previously discussed (see **Error! Reference source not found.** in Prices Masters thesis; **Error! Reference source not found.**). This study did not support these game participation findings, with the majority of strains occurring in the middle of each 30 minute “quarter” and not either at the end of the quarter nor in the final quarter towards the end of the game.

One possible explanation for this finding is that in this central part of the quarter there is an overlap of the fastest pace of the game and where fatigue begins to occur. Injuries occurring at training tended to occur after training for longer than 30 minutes where fatigue becomes a greater factor. A muscle’s decreased ability to generate force is thought to reduce its energy absorption capacity, which in turn predisposes the muscle to injury {Mair, 1996 #73;Garrett, 1990 #32}. This highlights the importance of addressing endurance of the hamstrings in preventive and rehabilitation programs in addition to the more usual strength and power emphasis.

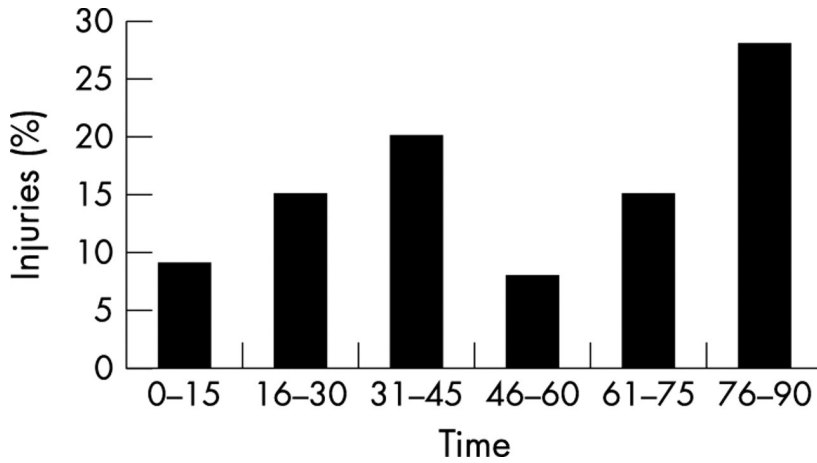
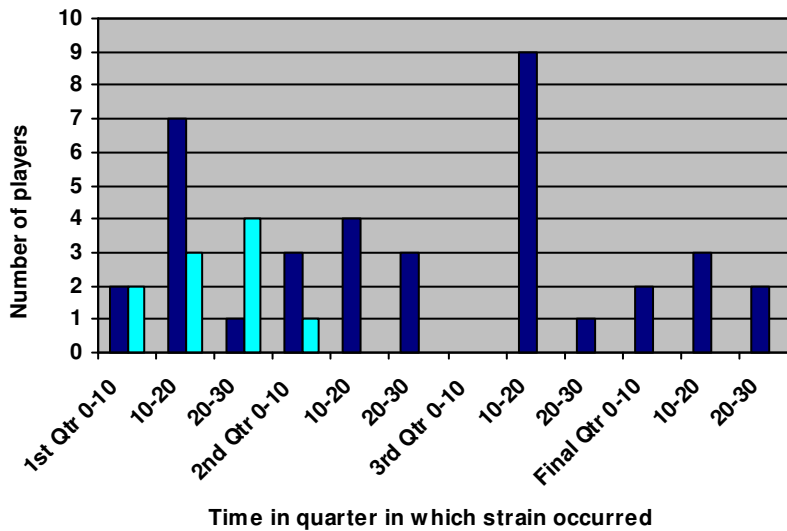


Figure Error! No text of specified style in document. Time of hamstring strains sustained during soccer match play {Woods, 2004 #134}.

Timing of injury for players re-injured during game



It would appear that these players were not fit to be selected
 It is possible that increasing fatigue as the first quarter evolved led to increasing susceptibility to re-injury.

5. The undisclosed hamstring strains.

The Physiotherapist and the player were asked if the player suffered **significant soreness during training that resulted in an inability to train in subsequent sessions.**

The number of days until the previously hamstring injured player was able to resume training was recorded;

70 players qualified for this analysis (two players were excluded because were thought not to have hamstring strains in the first place).

8 players (11%) took six days or longer to resume training after what would appear to be re-injury in training. The range was six to ten days. Six players took seven days or longer (9%, range 7-10).

Of those AFL footballers with a hamstring injury in 2002, it would appear that approximately 10% of them suffered a recurrence in the privacy of the training facility as part of their rehab. This is beyond the scope of the AFL injury surveillance analysis. The statistical average of approximately 30% of recurrence in the same season in AFL footballers may well be greater if recurrences suffered in the privacy of the training facility as part of their rehab are included.

6 Hamstring rehabilitation program parameters in AFL footballers

The Physiotherapist was asked to nominate how often the players ran, engaged in hamstring strengthening and Core Stability Training (Transversus Abdominus emphasis specified), as apart of their rehabilitation program. The options were every day, two times every three days, every second day and less than every second day. Seventy players qualified for analysis. This group was split into the successful return to play group, which comprised sixty players and compared with a group of ten who restrained on return to play. This group of ten comprised 9 players. One player re-strained on two occasions, in the same season.

A. Players that successfully returned to play ran approximately 30% less frequently, than the group that failed in their return to play.

The successful group ran, on average, once every 1.7 days; in other words, almost once every second day. The group that failed in their return to play ran on average every 1.23 days; in other words closer to everyday, as apart of their rehabilitation. Is this a trend or is it significant?

B. Those who successfully returned to play engaged in strengthening exercise (including eccentric strengthening, hamstring curls and lunges) approximately 15% less frequently than those who suffered a recurrence of return to play

The successful return to play group engaged in strengthening exercise on average slightly less than every second day (43% of players engaged in strengthening daily, 28% engaged in strengthening every second day. 23% engaged in strengthening less than every second day). 50% of players who failed in their attempt to successfully return to play engaged in strengthening every second day, 40% engaged in strengthening every day and 10% engaged in strengthening less than every second day.

C. Core Stability Training – Transversus Abdominus emphasis specified.

The group that successfully returned to play engaged in specific core stability training approximately 25% less than those that failed in their return to play.

They engaged in core stability training approximately every second day whereas those who did not successfully return to play engaged in core stability training on average two times every three days.

D. Number of sessions per day of hamstring stretching was recorded. The group that returned successfully to play engaged in hamstring stretching at the same frequency of those who failed to return to play. This frequency was, on average, 2.6 times a day. 31 AFL footballers (44%) stretched mostly twice per day. 30% more players stretched three times a day than those stretching once a day.

E. The number of full training sessions before returning to play was approximately even between the two groups. The group that successfully returned to play trained on average 3.1 sessions prior to successfully returning to play and the group that failed on their return to play trained on average 3.4 sessions.

Summary; Analysis of the hamstring rehabilitation program parameters suggests that the group that failed on their return to play trained more often than the group that was successful on return to play. In particular, they ran approximately 30% more often, and engaged in core stability training approximately 25% more often and they engaged in strengthening approximately 15% more often. Simply put; they trained more.

The number of times they stretched as part of their rehabilitation and the number of full training sessions they participated in prior to returning to play were equivalent between the groups of successful return to play and those who failed.

It is possible that one of the ingredients of failing on return to play is over-training. The recommendation from this study are to engage in training consisting of running, strengthening and core stability not more frequently than every second day, particularly in players thought to be at risk of re-injury.

Furthermore the players should engage in a stretching session two to three times per day and engage in three full training sessions before returning to play.

7. Do the hamstring symptoms change with treatment directed at proximal structures?

Physiotherapists were asked whether the treatment directed at more proximal structures altered the signs in the hamstring.

In order of frequency and effect; 37% of physios found that treatment directed at the gluteal trigger points had a positive effect in 37% of cases. For players successful in returning to play, lumbar spine treatment had a positive effect in 33% of cases and slump techniques had an effect in 23% of cases. Sacroiliac joint treatment was carried out on two players (3%), both with a positive effect.

8 hamstring injured players (13%) had alteration in the hamstring symptoms with treatment directed at the gluteal trigger points, lumbar spine and slump combination. In other words, 13% of players had treatment directed at all three areas, which brought about a positive effect in hamstring assessment signs.

Of the players that failed in their return to play 20% had benefit from treatment directed at each of gluteal trigger point, lumbar spine and slump. While this possibly doesn't tell

us anything in particular about the re-injury group, it does tell us that **AFL physiotherapists are active in treating proximal structures and this has a beneficial effect in a significant number of cases.**

8. Clinical analysis indicated that AKE has a better association with severity of a hamstring strain and predicting a recurrence than PSLR in the post-acute period.

While neither length test was significant AKE (active knee extension) had a p-value 0.265 compared with PSLR with a p-value of 0.999 in the univariate analysis of factors predicting an association with taking longer than 3 weeks to return to competition. In predicting those at greater risk of suffering a restraint AKE had a p-value of 0.050 compared to PSLR with $p=0.631$.

It is unclear exactly what is being stretched differently in the PSLR and AKE. AKE has been theorized to be a more sensitive test for hamstring length because the pelvis appears to be more stabilized (Bohannon 1983), however this has not been supported by current evidence. Stretching the neural structures, fascial planes and muscle over the ischial tuberosity in the PSLR yields a clinically different result than stretching these structures over the knee in the AKE. The sensation of stretch is different between the tests and is different whether either test is performed actively or passively. The fact that the deficit in motion in the injured limb with the AKE test has a better correlation with time to return to play and predicting a recurrence than the PSLR test may be related to the fact that the AKE was actively performed. Despite the lack of supporting evidence, it is possible that active movement, possibly through reciprocal inhibition, influences flexibility tests on injured muscle

As a broad rule of thumb (based on Price's experience), if AKE is used as a predictor of time to return to play then;

If <10 degrees deficit then 1-2 wks

If 10-20 degrees deficit then 3+/-1 wks

If 20-30 degrees deficit then 4wks+/-1 wks

If > 30 degrees deficit then 5-7 +/-1 wks

9. Time taken to jog pain-free is better than time taken to walk pain-free as a predictor of time to return to play. This mildly better predictor may be because it is slightly closer to the return to play date.

Time taken to walk pain-free was the single strongest predictor of time to return to play in Price's thesis which did not include time taken to jog pain-free because it often occurred outside the 3 day initial assessment period.

As a broad rule of thumb, if the time taken to walk pain-free is used as a predictor of time to return to play then;

If < 1 day to walk pain-free then 3 wks or less to return to play,

If 2 or more, then more than 3 wks,

If 5 or more, then more than 6 wks.

As a rule of thumb, if the time taken to jog pain-free is used as a predictor of time to return to play then;

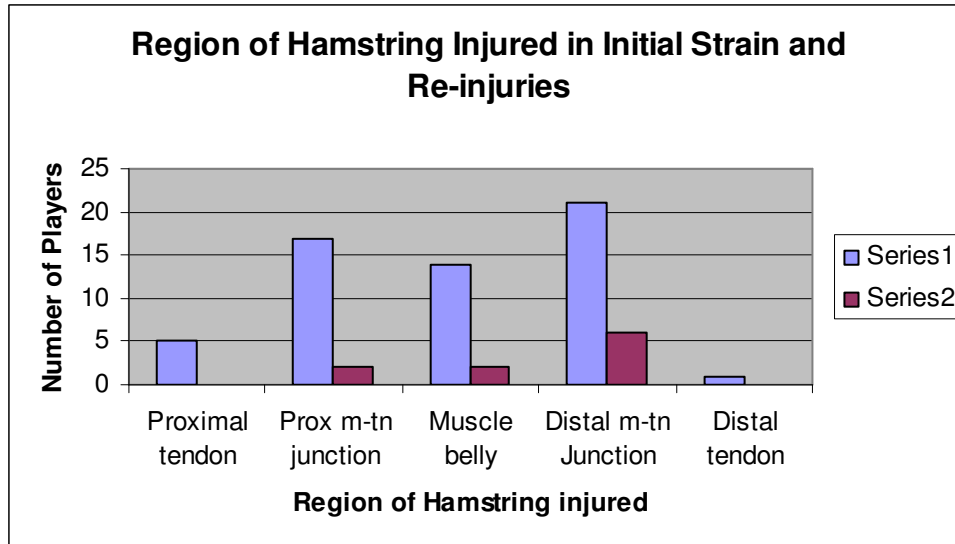
If 2 or less days to jog pain-free then less than 2 wks to return to play,

If 3 or more, then more than 2 wks,
If 5 or more, than more than 4 wks.

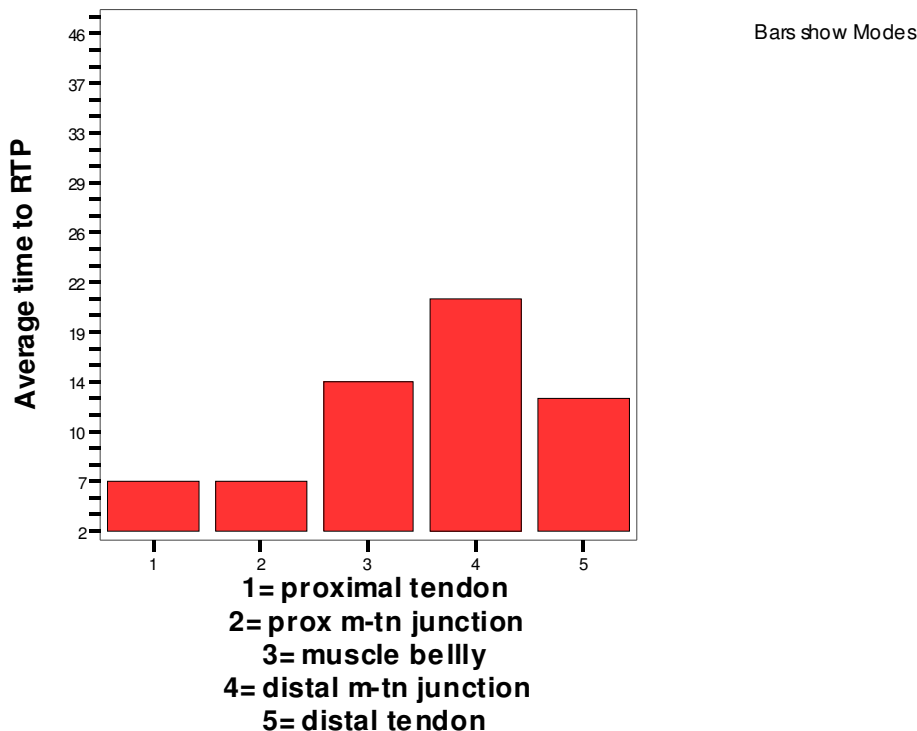
10. Region of Hamstring Injured.

The most comparably tender palpable aspect of the injured hamstring was categorized into proximal tendon, proximal muscle-tendon junction, muscle belly, distal muscle-tendon and distal tendon injury according to surface anatomy {Grant, 1978 #10}.

The re-injury group comprised 2 each of proximal muscle-tendon junction and muscle belly and 6 with a distal muscle tendon injury.



Players with a distal muscle tendon injury take longer to return to play (average 22 days) compared with players with an injury to the muscle belly (14 days) and distal tendon (13 days). Those with proximal injuries tended to take 7 days to return to play.



11. Proposal for specific grading of a hamstring muscle strain corresponding to pathological severity.

Grade 1 - the athlete may notice a mild or moderate pain in the posterior thigh, they may be able to continue to train or play, or may not be aware of the discomfort until after cooling down or the next day.

Clinical assessment within the first 3 days reveals;

Negligible or less than 10 degree AKE deficit which may or may not be painful,

Strength tests may or may not be painful (strength tests in outer range are more likely to be painful, eg HST, TOST [Hamstring Drag Test or Take of the Shoe Test] or bridging with heel on a chair)

Able to walk pain-free within 1 day,

Able to jog pain-free within 2 days

Successfully returns to play in 2 weeks or less.

Grade 2- the athlete notices moderate posterior thigh pain while sprinting, kicking jumping or stretching and usually has to stop the activity and limp away.

Clinical assessment within the first 3 days reveals;

Greater than 10 degree AKE deficit which reproduces posterior thigh pain,

Positive HDT or TOST (hamstring drag test or take of the shoe test),

Unable to walk pain-free within 1 day,

Unable to jog pain-free within 2 days,

Unable to return to competition within 3 weeks

Grade 3 - This strain represents complete rupture or avulsion. These are often associated severe pain in the hamstring compartment and result in extensive bruising (Devlin 2000),

Clinical assessment within the first 3 days reveals;

Greater than 30 degree AKE deficit which reproduces posterior thigh pain,

Positive HDT or TOST (hamstring drag test or take of the shoe test),

Unable to walk pain-free within 3 days, often requires assistance to ambulate.

Unable to jog pain-free within 7 days,

Often able to palpate a defect in the hamstring compartment.