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Sprinting and hamstring strain injury: beliefs and practices of professional physical performance coaches in Australian football.

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Sprinting and hamstring strain injury: beliefs and practices of professional physical performance coaches in Australian football.
Abstract (200 words)

Objectives: The purpose of this study was to establish beliefs and practices of physical performance coaches regarding sprinting and Hamstring Strain Injury (HSI) in Australian Rules football.

Designs: Delphi validated questionnaire

Setting: Online

Participants: Eighteen high-performance managers of the Australian Football League.

Main Outcome Measures: Descriptive statistics were collected to establish experience, whilst central themes were established for the analyses of the beliefs and practices.

Results: Nine (50%) physical performance coaches responded to an email invitation to complete the questionnaire. Participants held an undergraduate degree and had 9.2 ± 4.3 years of experience. Accelerations (n = 9), maximum speed sprints (n = 9) and running with hip flexion (n = 7) were the most common activities associated with HSI by coaches. Coaches believed sprinting, eccentric strength training and proper periodisation were effective strategies to reduce HSI risk. There is a disparity between beliefs and practices when using GPS to monitor sprinting, however, all coaches reported regular exposure to sprint training across both pre and in-season training cycles. Overstriding (n=9) and pelvic instability (n=6) were identified as key flaws in running mechanics.

Conclusions: This information can be used to improve future training strategies, whilst these findings indicate further investigations into the areas of sprint training and running mechanics for HSI risk reduction.
KEYWORDS - injury prevention, high-speed running, coaching, hamstring, Australian football
1. INTRODUCTION

Hamstring strain injury (HSI) is a frequent, costly injury in team based, field sports that have a high-speed running component\(^1\,^2\). In field sports such as Australian Rules football (ARF), HSI results in an average of 25 missed matches per club per year\(^1\), and as of 2012, each club spent approximately $245,842 on costs associated with this injury\(^3\). Considering this, many modifiable risk factors have been identified\(^4\), with the aim of developing various training strategies to mitigate their risk of occurrence such as high-speed running load management\(^5\,^6\), flexibility training\(^7\) or eccentric hamstring strengthening exercises\(^8\).

Within the sport of ARF, it is common for strength and conditioning staff to expose athletes to a combination of strategies to reduce the risk of injuries. As HSI is the most common cause of missed matches in ARF\(^1\) and therefore has a marked effect on a team’s performance\(^8\), it would be logical to assume that HSI risk mitigation is a key pillar of a successful high-performance program. Despite this, HSI rates have remained consistently higher than other injuries over the past 20 years in ARF, indicating that there is still a disconnect between research and practice in the elite setting. This may be partially explained by the paucity of research with low ecological validity.

Hamstring strain injury prevention research initially focused on flexibility\(^7\) as the primary modifiable risk factor to target for preventative interventions, however this is now accepted as a weak risk factor for HSI. Research has since focussed towards eccentric hamstring strength training\(^8\,^10\), which is currently viewed as a stronger risk factor for injury. However, recently a shift in the research has focussed on high-speed running and sprinting exposure as a HSI research area\(^5\,^6\,^11\). Early indications suggest the importance of addressing these factors, however little is known about the HSR and sprinting training practices in elite sports. Although the scientific evidence-base is used to inform training to prevent HSI has increased substantially over the past 10 years, physical performance coaches may not rely solely on research evidence to inform their practice. The gap between research and application to practice is noted across many elite sports\(^12\). Physical performance coaches instead establish their evidence-based practice from their professional experiences, formal and informal discussions with practitioners and academics and scientific literature\(^13\).
Currently, there is general, low detail, published evidence to describe the methods used by professional ARF teams to prepare players for the physical demands of competition. Although this has been explored in other sports, like baseball\(^1\), there is no information in elite ARF. Therefore, the purpose of this investigation was to understand the beliefs and practices of professional ARF physical performance staff towards the training, and assessment prescribed to mitigate the risk of HSI. A better-developed understanding about the sprinting and complementary practices currently implemented by physical performance coaches, will help align the needs of practitioners with the findings of academics. This will improve the implementation of injury prevention strategies for HSI, and serve as a reference to bridge the gap between research and practice in elite ARF.

2. METHODS

2.1 Participants and study design

To establish the beliefs and practices of professional physical performance coaches working in the Australian Football League (AFL), an online survey was distributed to current high-performance managers. These high-performance managers were targeted as they are at the forefront of their field within the highest level of ARF. Respondents were asked to describe, in detail, both their beliefs, and their practices regarding strategies to reduce the risk of HSI in ARF with a focus on sprinting.

Eighteen high performance managers in the AFL were invited to take part in a brief 20-30 minute survey during the 2019 post-season. High performance managers were chosen as the point of contact for each of the 18 AFL teams, as they are tasked with overseeing and implementing the high performance program across both strength and conditioning and medical staff. This includes the implementation of strategies targeting the reduction of HSI. This project received approval from the Human Research Ethics Committee (Approval Number – B19-024). Potential respondents were informed of the risks and benefits of this study via an online plain language information statement that accompanied the survey. Consent was implied by completing and submitting the survey. Of the 18 high performance managers invited to participate, nine successfully completed the survey (age: 38.9 ± 4.4, male: 9 female: 0). No coach or team name was associated with any responses to protect the anonymity of the respondents.
2.2 Instruments

A survey addressing the beliefs and practices of professional physical performance coaches regarding sprint training and HSI was developed by the authorship team based upon previous research into strength and conditioning coaching practice\textsuperscript{14}. Following development of the survey, two rounds of Delphi Panel consultation took place. The Delphi process has been previously used to improve survey validity, as it relies on multiple rounds of review by a panel of experts in a specific field to ensure a consensus decision is made\textsuperscript{15,16}. Six experts representing physical performance coaching, sports physiotherapy practice and sports science/sports medicine research took part in the Delphi review process. Initially, three rounds of consultation were deemed desirable; however, a group consensus was achieved following the second round of reviews. To ensure readability and understanding, the survey was piloted with three physical performance coaches working in semi-professional ARF. The survey included questions designed to collect demographic data, as well as open and closed response questions regarding the beliefs and the practices of the participants regarding HSI in Australian Rules football. An example of an open-ended question is “Do you think your athletes should be doing more or less maximum speed sprinting for hamstring strain injury prevention? Why/Why not?” A final copy of the survey questions can be seen in the supplementary materials.

Each club’s high-performance manager was contacted via email, which included a brief introduction of the topic and a link to the online survey (Qualtrics, Provo, UT). Participants were informed that the aim of this research was to determine the current beliefs and practices of professional physical performance coach’s regarding HSI. The surveys were distributed in November 2019. Each high-performance manager received a reminder email with a follow up link monthly, until the survey closed in February of 2020. Following data collection and analysis, a copy of the results was distributed to all 18 of the invited high-performance managers.

2.3 Statistical analysis

This survey contained both closed and open-ended questions. Closed questions were subject to analysis methods previously used in peer-reviewed research\textsuperscript{14,17}. Once survey responses were recorded in Qualtrics (Qualtrics, Provo, UT), responses were exported into Microsoft Excel (Version 16.0.4) for
analysis. In line with previous research, individual responses were defined as raw data. From this point, higher order themes were established by researchers through analysis of the raw data. During the analysis, two researchers (BF and ST) independently coded the responses and generated themes for each open-ended research question. Researchers had previous experience analysing and interpreting qualitative strength and conditioning data. These themes were then discussed between the researchers to establish agreed central themes that accurately represented the responses. For the majority of questions, the raw data from participant responses encompassed multiple concepts, which supported more than one theme.

3. RESULTS

3.1 Participant characteristics

Nine of the 18 respondents invited to participate completed the online survey, resulting in a response rate of 50%. The average time for the respondents to be working in their role within the AFL was 9.2 ± 4.3 years. Respondents reported a variety of formal qualifications, including undergraduate degree (n = 9), postgraduate degree (n = 6), Graduate Certificate (n = 2), and PhD (n = 2). Professional qualifications included the Australian Strength and Conditioning Association (ASCA) Level 1 Qualification (n = 8), ASCA Level 2 (n = 2), ASCA Level 3 (n = 3), Exercise and Sport Science Australia (ESSA) Exercise Scientist (n = 5), ESSA Sport Scientist (n = 2), and ESSA High Performance Manager (n = 4).

3.2 Beliefs around the mechanism of hamstring injury

Respondents reflected their beliefs about different aspects of strength and conditioning related to hamstring strain injury. When asked about the frequency of events that lead to HSI, sprinting (acceleration), sprinting (maximum speed) and running in hip flexion were adjudged very common or common activities associated with HSI in ARF (Table 1). Overstriding was identified as a key mechanical flaw that contributes to HSI. Visual observation was the most common method of analysing running mechanics (n = 9).
3.3 Activities and strategies to reduce the risk of hamstring strain injury

Table 2 describes coach’s perceptions of strategies commonly used to mitigate the risk of HSI. This is followed by Table 3 which outlines the hamstring injury screening practices implemented by respondents working in ARF, as well as the training interventions used to mitigate the risk of HSI, and the implementation of these methods by AFL teams.

Table 2. Coach’s perceptions regarding effective strategies to reduce the risk of HSI.

Table 3. Australian Rules Football (ARF) Physical Performance Coaches practices regarding hamstring strain injury (HSI) risk reduction.

3.4 High-speed running and sprinting thresholds

The respondents in this study reported that they believed 5.8 ± 0.7 m.s⁻¹ to be a mean representative of HSR in absolute terms. There were a range of definitions for relative HSR terms, however the most common answer was 70% of maximum running speed (%V_max) (n = 4), whilst 75%V_max (n = 2), 80%V_max (n = 1), 85%V_max (n = 1) and velocity at VO2max (n = 1) were all listed answers. Respondents believed 7.6 ± 0.4 m.s⁻¹ to represent sprinting in absolute terms. In relative terms, three different speeds were identified, starting at >85%V_max (n = 3), >90%V_max (n = 5) and >95%V_max (n = 1).

All respondents reported measuring high-speed running in both absolute and relative terms. Some respondents provided an absolute and relative term for HSR and sprinting, whilst some only provided one option. Figure 1 is an indication of the range of velocity thresholds used to measure HSR and sprinting in absolute and relative terms.
[Figure 1. Absolute and relative velocity bands used by respondents to quantify high-speed running and sprinting. Note - some respondents did not provide a value for all categories listed, reflecting the uneven sample distribution.]

3.5 Sprint training

Respondents were asked about their beliefs regarding sprint training and testing for hamstring injury prevention, when designing a training session for their team. Tests of maximum running speed were reported in the pre-season (n = 8), and the in-season (n = 6). The most common testing procedure was to collect maximum running speed from global positioning system (GPS) data (n = 9), whilst respondents reported moving away from testing maximum speed with timing gates (n = 3), citing “time consuming” and “the risk of injury” as barriers. Respondents reported regularly exposing (1-2 times per week, across most weeks of the year) exposing their athletes to maximum speed sprinting, however most advocated for a more individualised approach to sprint training for field sport athletes. Full results are included in Table 4.

[Table 4. Central themes regarding sprint training and the association with hamstring injury.]

Six of the nine respondents (66.7%) identified injury risk as a barrier to implementing sprint training with their team, whilst one of the respondents identified the fear is amplified by the lack of job security as a physical performance coach in the AFL. The most common barrier to speed testing their athletes was fear of injury from testing (n = 6).

3.6 Trends in physical preparation

The final question in the survey asked respondents to reflect on the changes in HSI injury prevention practices in the AFL across their career, with a clear increase in HSR the most popular response (n = 7). Respondents also identified that Pilates or core exercises were common (n =4), as well as increase in the popularity of eccentric hamstring and isometric hamstring strengthening
exercises (n = 4). Four of the nine respondents suggested that they question the functionality and application of the Nordic hamstring exercise with their athletes.

[Table 5. Trends in physical preparation of elite Australian Rules Football athletes.]

4. DISCUSSION

This is the first study to investigate the beliefs and practices of professional physical performance coaches working in the AFL regarding sprinting and complementary practices used to reduce the risk of HSI. More specifically, the link between sprinting and HSI is well established, however it is evident there is a gap between the interpretation of evidence and the prescription. It is possible that this may be due to factors outside the control of physical performance coaches, such as fixturing, time allocation between tactical, technical and physical coaching, along with prioritization of other strength and conditioning aspects. Moreover, the respondents felt that the best way to mitigate the risk of HSI occurrence was to implement a well-periodized training plan that incorporates eccentric hamstring strength training, core/lumbopelvic exercises and exposure to maximal velocity sprinting. Respondents advocated for the individualisation of sprint training; however, there was disparity between velocity thresholds that should be used to classify sprinting.

4.1 Perceived risks for hamstring strain injury

Whilst sprinting was a primary theme regarding the occurrence and prevention of HSI, sub-themes such as acceleration, maximum speed and running mechanics were characteristics of Australian football that are associated with HSI. Less prominent themes included both eccentric and isometric hamstring strength, along with proper periodisation and kicking. Both acceleration and maximum speed sprinting were reported as high-risk activities for HSI in professional ARF. This result is consistent with prior findings. Prior work suggests that the early stance or the late swing phase of sprinting is where injury occurs, however it now appears most likely that the late swing phase is when the injury occurs. Nearly half of all respondents (44.4%) indicated they felt an athlete’s running mechanics contributed to HSI. This may be characterized by running in a position of
hip flexion at high speed, such as when gathering a ball from the ground\textsuperscript{22}, however it can also refer to other nuances such as overstriding, or abnormal pelvic motion. These inefficiencies may be amplified at high-speed; in fact, in previous studies\textsuperscript{23, 24, 25}, the influence of running speed has been the main factor in the increased workload demands of the hamstrings.

Interestingly, kicking was also indicated by three respondents (33.3\%) to be associated with HSI risk in ARF athletes. This means that 66.7\% (\(n=6\)) felt that kicking was a neutral or uncommon mechanism for HSI. Previous research by Duhig et al.\textsuperscript{26} demonstrated drop punt kicking has been previously shown to decrease eccentric knee flexor strength. However, prescription and monitoring of HSR is the more commonly prescribed strategy to reduce the risk of HSI, possibly because approximately 84\% of HSI in field sports occur in the biceps femoris, frequently injured in HSR activities\textsuperscript{19}. Injuries associated with kicking are much less frequent and often affect the medial hamstrings (semitendinosus or semimembranosus)\textsuperscript{19}. This finding may indicate disconnect in the physical preparation of ARF athletes. The coach’s in this study recognised that low levels of eccentric hamstring strength are a risk factor for HSI, however the respondent’s beliefs surrounding mechanisms of injury are not always directly influenced by the research.

Another finding was that no respondents reported that a poor warm-up was a factor related to HSI occurrence. In fact, one respondent stated that, in relation to recently modified rules that restrict the time allowed for warm-ups prior to competition, “it made no difference whatsoever to injury rates”. This might be explained by elite level of competition, where adequate warm up procedures are the norm, when compared to amateur level competition. Additionally, jumping, landing and change of direction activities were not perceived as activities commonly associated with HSI. These mechanisms are more consistent with anterior cruciate ligament injury aetiology\textsuperscript{27}.

4.2 Hamstring strain injury risk mitigation strategies

4.2.1 Eccentric hamstring strength training and monitoring

Eccentric hamstring strength training was cited by seven respondents (77.8\%) as an effective strategy to mitigate the risk of HSI. A frequently cited study, specific to eccentric hamstring strength and ARF was that of Opar et al.\textsuperscript{8} which indicated that a 10N increase in eccentric hamstring strength
reduces the risk of HSI by 8.9%. Owing to the substantial evidence that supports the efficacy and
effectiveness of this method for mitigating the risk of HSI, this finding was expected\textsuperscript{8,10,28}. All
respondents in this study used weekly eccentric hamstring strength testing as a screening measure for
HSI, which is a practice supported within the scientific literature\textsuperscript{13,28}. Although testing was noted as a
common practice, it was reported that the physical performance coaches understand that the
information obtained from the screen is a singular piece of information that is a part of a larger
decision making process. For example, one participant stated, “even if they produce good scores, it
doesn’t mean they’re not vulnerable, it just decreases their vulnerability”.

Three respondents (33.3\%) also reported using muscle imaging to screen players, however all
responses suggested that this was reserved for “players who are deemed at risk”. This indicates that
screening may be used if a player is flagged as having more than one risk factor for HSI, such as
previous injury or age\textsuperscript{29}. Research suggests that monitoring a combination of eccentric hamstring
strength and biceps femoris fascicle length would provide the best chance to identify an individual at
risk of HSI, as observed by Timmins et al.\textsuperscript{30}. This may not be possible in a professional ARF team, as
eccentric hamstring strength testing is quick, and the results are instantaneous. On the contrary,
hamstring muscle imaging creates a greater logistical challenge, typically requiring external expertise,
manual analysis and is largely dependent on the operator.

Four respondents (44\%) indicated that there was some debate as to the functionality of the
Nordic hamstring exercise, due to “non-specific and isolated non-functional” nature of the movement.
This may be because the Nordic hamstring exercise is a slow velocity, eccentrically biased movement
that primarily targets the semitendinosus\textsuperscript{31}, whereas most injuries to the hamstrings occur in the biceps
femoris\textsuperscript{19}. Despite this, the Nordic hamstring exercise still activates the biceps femoris to higher levels
than other investigated resistance training exercises\textsuperscript{32}, which may further support the inclusion for HSI
prevention. A weak lumbopelvic area has been suggested to influence optimal running mechanics\textsuperscript{33},
therefore targeted prescription to improve pelvis control\textsuperscript{31} might be a possible reason for the inclusion
of the exercises.
4.2.2 Correcting running mechanics

Interventions to improve the running mechanics of athletes were reported by eight of the nine coaches as effective. For example, all responding coaches indicated a belief that overstriding contributed to HSI, potentially resulting from fatigue. Participant nine stated that “poor mechanics creep in once athletes’ fatigue, whether this be hips dropping, overstriding”, which suggests coaches are aware that other factors may be also present in the HSI prevention puzzle. Whilst eight of the nine (88.9%) coaches felt interventions were effective, all coaches reported that they assessed and prescribed training to improve running mechanics in order to reduce the risk of HSI. Specifically, overstriding was noted as a key contributor to HSI as stated by participant five who noted that it “overloads the posterior chain”. Similarly, abnormal pelvic motion, which may be partially attributed to fatigue, was an aspect of running mechanics that was reported by participants to increase the risk of HSI. It has been postulated that abnormal pelvic motion may contribute to a loss of co-contraction within the key musculature of the lower body, ultimately increasing the risk of injury. Therefore, training strategies aimed at improving fatigue tolerance, may provide an indirect injury prevention benefit, and potential performance benefits.

Few training strategies have directly addressed the modification of running mechanics. An example of this is a training study by Dallam et al. which reported that a decrease in stride length and improvement in sub maximal running economy was achieved following 8 weeks of training. This study was in a sub-elite population however, and at sub-maximal running speeds, which makes the inference of improvement in sprinting difficult. The transfer of training to improve running mechanics was questioned by three of the respondents. For example, a respondent stated, “it is hard to make a meaningful impact because when it comes to competition athletes revert back to their comfortable gait”.

As all physical performance coaches who responded to the survey appear to implement the same strategies, it becomes apparent that the nuances within the programming distinguish each program from the other. This suggests that whilst there is general agreement about the mode of intervention, no one set of specifics regarding the programming may be best or, at least this has not been identified yet. All the coaches that responded to this survey recognised proper periodisation;
strategic manipulation of stimulus and recovery, as an effective strategy to reduce the risk of HSI in field sports. Although there is limited scientific evidence to suggest that these technical components of running at high speeds may increase the risk of HSI, the previous experiences of the coaches may influence their beliefs around what contributes to this injury.

4.2.3 Exposing athletes to high speed running

Regular exposure to sprinting in order to reduce the risk of HSI was supported by all respondents. The individualisation of sprinting exposure was reported as important by six of the nine respondents, as “some players need to focus on different qualities and that takes priority” (Participant 3). Respondents indicated that 2-3 weekly exposure’s in the pre-season and 1-2 in-season was common. In-season “the game is one exposure and the second exposure is 4-days post game and 2 days before the next, depending on the week to week game structure” (Participant 4). This scheduling allows rest periods consistent with recommended guidelines for speed training, however it is unknown if this is best practice for mitigating HSI risk. Further to the point, there is speculation that sprint training has been presented as potential vaccine for hamstring injury; however, there is limited high-level evidence for this at the current time.

These findings highlight that professional ARF teams complete sprinting activities more frequently in the pre-season, and that clubs are reliant on match play for speed exposure in-season, as five of the nine coaches explicitly stated. This may lend itself to some error though, as whilst athletes may achieve high speeds regularly within games, maximum speed is not always possible in field sports. Time allocation for sprint training, particularly in-season remains as a considerable barrier for the implementation of sprint training. This is because physical performance coaches are working to manage the recovery of the athletes from competition, along with the needs of the technical and tactical coaching staff. Moving forward, further research should investigate the variability of sprint exposures on team sport athletes. Their may also be scope to address the notion of high responders and low responders, in a similar vein to strength and aerobic training for adaptations to sprint training.
4.2.4 Monitoring Exposure to High Speed Running

A key trend in the physical preparation practices for HSI in the AFL was the increase in HSR monitoring for all clubs. Within this theme it was noted that there was “a big increase in monitoring of high-speed running” across the last 15 years. Additionally, this may be reflected in research by evidence suggesting that acute spikes in HSR workload increase the risk of HSI. This theme is further supported by the quantity of training load research, including the use of technical sessions underpinned by a physiological variable.

This leads to a key point of this study; the numeric values respondents believed represented HSR and sprint thresholds were different in most instances, to the HSR and sprint thresholds they used to monitor and prescribe training. This is best highlighted in Figure 1 and Figure 2, where a clear discrepancy between absolute and relative thresholds is shown. When relative speed beliefs and practices were examined, the most common belief was >90%V_max represented sprinting, yet no coaches were reported measuring sprinting at relative speeds faster than 85%V_max. Arguably, 5% may not seem like a large discrepancy, but when the workload demands of the hamstrings increase exponentially at running speeds above 80%V_max, this may well be significant. Essentially, coaches are reporting they regularly employ sprint training, but the different definitions of sprinting may lead to a misunderstanding of what a sprint is.

This variation amongst speeds across respondents highlights the room for improvement to reduce the risk of HSI in professional ARF, preferably with relative speed zones. In contrast, 3 respondents (33.3%) noted that they no longer tested maximum running speed using timing gates and indicated that they prefer to obtain measures of maximal speed via GPS. Five respondents (55.5%) in this study suggested this was for injury prevention reasons. Eight of the nine respondents (88.9%) noted that they tested maximum running speed using GPS technology. This may be considered more practical from an implementation perspective, which in turn, is supported by research suggesting it is a reliable measure of running demands.

The findings of this study should be considered alongside the limitations associated with it. The survey had a 50% completion rate, as there were only 18 possible respondents. Participants were only asked about their experience within the AFL system, not other experiences in comparative elite
level competitions. This means that these findings are representative of professional ARF teams that participated in this study and therefore, may not be applicable to the rest of the AFL or to other elite field sport populations. Although this survey was completed anonymously, the notion of response bias may have been present. Respondents may have felt the pressure to answer questions in accordance with what they felt researchers were hoping to find, opposed to answering completely truthfully. Nevertheless, the findings from this survey provide a detailed insight into the beliefs and practices of professional physical performance coaches in professional ARF for HSI prevention.

4.3 Conclusion

This article describes both the beliefs and practices of professional physical performance coaches’ working in professional ARF regarding HSI. Both practitioners and academics now have a source of data describing the beliefs and practices regarding HSI at the highest tier of competition, the AFL. Physical performance coaches report that they are regularly exposing their athletes to sprinting for HSI prevention; however, the fear of injury is prominent, possibly as result of the consequences associated for both players and staff. There also appears to be a disparity between beliefs and practices when using GPS to monitor HSR, however use of more suitable relative speeds may close this gap. Improving both injury prevention and performance outcomes. Finally, assessing and training running mechanics is common amongst coaches in professional ARF; however, the link to HSI is not yet well established. This requires further investigation as the findings of this survey indicate all respondents indicated they believed one or more aspects contributed to HSI. Physical performance coaches can use this information to review and improve training practices, whilst academics can use these findings as a footing to improve empirical evidence in sprint training and running mechanics for HSI prevention.
References


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### Table 1. Coach’s perceptions regarding activities associated with hamstring strain injury (HSI).

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### Table 2. Coach’s perceptions regarding effective strategies to reduce the risk of HSI.

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<td>11.1%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Proper Periodisation</td>
<td>11.1%</td>
<td>88.9%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

COD – Change of Direction
Table 3. Australian Rules Football (ARF) Physical Performance Coaches practices regarding hamstring strain injury (HSI) risk reduction

### Hamstring injury screening practices of elite physical performance coaches in ARF

<table>
<thead>
<tr>
<th>Theme</th>
<th>Responses</th>
<th>Raw data representing this response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weekly Eccentric</td>
<td>9 (100%)</td>
<td>“We have used the NordBord previously, testing every week and comparing (within reason) to baseline”</td>
</tr>
<tr>
<td>Strength</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muscle Imaging</td>
<td>3 (33.3%)</td>
<td>“Have used fascicle length imaging in the pre-season for players who are deemed at risk”</td>
</tr>
</tbody>
</table>

### Training strategies used to reduce the risk of HSI in ARF

<table>
<thead>
<tr>
<th>Training Intervention</th>
<th>Teams using intervention</th>
<th>Teams not using intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eccentric Strengthening</td>
<td>9 (100%)</td>
<td>0</td>
</tr>
<tr>
<td>Isometric Strengthening</td>
<td>7 (77.8%)</td>
<td>2 (22.2%)</td>
</tr>
<tr>
<td>Traditional Resistance Training</td>
<td>9 (100%)</td>
<td>0</td>
</tr>
<tr>
<td>High-Speed Running Training</td>
<td>9 (100%)</td>
<td>0</td>
</tr>
<tr>
<td>Sprint Training</td>
<td>9 (100%)</td>
<td>0</td>
</tr>
<tr>
<td>Flexibility Training</td>
<td>5 (55.6%)</td>
<td>4 (44.4%)</td>
</tr>
<tr>
<td>Core/Lumbopelvic Training</td>
<td>9 (100%)</td>
<td>0</td>
</tr>
<tr>
<td>Training to Improve Running Mechanics</td>
<td>9 (100%)</td>
<td>0</td>
</tr>
<tr>
<td>Proper Periodization</td>
<td>8 (88.9%)</td>
<td>1 (11.1%)</td>
</tr>
</tbody>
</table>
Table 4. Central themes regarding sprint training and the association with hamstring injury.

<table>
<thead>
<tr>
<th>Theme</th>
<th>Responses</th>
<th>Raw data representing this response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individualisation</td>
<td>6 (66.7%)</td>
<td>“Sprint training is definitely beneficial, but risky in the sense that the dose must be individualised to each athlete”</td>
</tr>
<tr>
<td>Unknown Volume</td>
<td>5 (55.6%)</td>
<td>“I certainly think it is beneficial, but the volume or dose is hard to get right”</td>
</tr>
<tr>
<td>Timing/Planning</td>
<td>5 (55.6%)</td>
<td>“Can be difficult to incorporate around a floating schedule”</td>
</tr>
</tbody>
</table>

When and how are athletes exposed to maximum speed sprinting?

<table>
<thead>
<tr>
<th>Theme</th>
<th>Responses</th>
<th>Raw data representing this response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase of training</td>
<td>9 (100%)</td>
<td>“We perform twice per week every week in pre-season, with three days break between sessions. In season we use the game as one exposure, and the second exposure is at least 4 days post-game, and 2 days before the next game, depending on the week to week game structure.”</td>
</tr>
<tr>
<td>Scheduling in-season</td>
<td>8 (88.9%)</td>
<td>“In-season: Match day + 1 day during the week depending on needs and how the athlete has recovered.”</td>
</tr>
</tbody>
</table>

Are your athletes completing enough maximum speed sprinting for hamstring injury prevention?

<table>
<thead>
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<th>Raw data representing this response</th>
</tr>
</thead>
</table>
| Individualised             | 6 (66.7%) | "Ideally more, but depends on the individual needs, some players need to focus on different qualities and that takes priority."
                                          |                                                      | "More. As long as it is periodized, and has correct overload, athletes become resilient to high levels of sprint training. " |
| More sprinting             | 4 (44.4%) |                                                                                                    |
| Satisfied with the amount of sprinting | 2 (22.2%) | “Happy with current doses.”                                                                        |
Table 5. Trends in physical preparation of elite Australian Rules Football athletes.

<table>
<thead>
<tr>
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<th>Responses</th>
<th>Raw data representing this response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in prescription and monitoring of HSR</td>
<td>7 (77.8%)</td>
<td>“More coaches using higher speed/ sprint training as a measure of prevention.”</td>
</tr>
<tr>
<td>Increased use of eccentric and isometric strength exercises</td>
<td>4 (44.4%)</td>
<td>“Definitely the introduction of Nords (Nordics), I think there is more eccentric strength training in the gym.”</td>
</tr>
<tr>
<td>Continued use of pilates and core/lumbopelvic exercises</td>
<td>4 (44.4%)</td>
<td>“Still a big focus on core control.”</td>
</tr>
</tbody>
</table>


Figure 1. Absolute and relative velocity bands used by respondents to quantify high-speed running and sprinting. Note - some respondents did not provide a value for all categories listed, reflecting the uneven sample distribution.
Conflict of Interest

None declared

Ethical Approval

This project received approval from the Human Research Ethics Committee (Approval Number – B19-024). Potential respondents were informed of the risks and benefits of this study via an online plain language information statement that accompanied the survey. Consent was implied by completing and submitting the survey.

Funding

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Acknowledgements

The authors would like to thank all of the performance coaches for the cooperation with this study.
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