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Hamstring Strain Injury Prevention: Current Beliefs and Practices of Practitioners Working in Major League Baseball

Stephanie L. Lazarczuk, MSc, GSR*†; Jonathon Headrick, PhD*; Jack T. Hickey, PhD, AEP‡§; Ryan G. Timmins, PhD‡§; Furey A. Leva, CSCS, RSCC, USAW||; Matthew N. Bourne, PhD*†

*School of Health Sciences and Social Work, Griffith University, Southport, Australia; †Griffith Centre of Biomedical and Rehabilitation Engineering (GCORE), Griffith University, Gold Coast, Australia; ‡School of Behavioural and Health Sciences, Australian Catholic University, Melbourne, Australia; §Sports Performance, Recovery, Injury and New Technologies (SPRINT) Research Centre, Australian Catholic University, Melbourne, Australia; ||Philadelphia Phillies, PA

Context: Hamstring strain injury (HSI) is the most frequently sustained injury in Major League Baseball (MLB). However, the beliefs and practices of practitioners working in MLB regarding HSI risk factors and prevention strategies in baseball athletes have not been documented.

Objective: To document the current beliefs and practices of practitioners working in MLB regarding HSI prevention.

Design: Cross-sectional study.

Setting: Major League Baseball via an online survey.

Patients or Other Participants: Athletic trainers, physical therapists, and strength and conditioning coaches working in MLB during the 2021 season.

Data Collection and Analysis: An online survey was conducted, with participants completing the survey once. Questions pertained to risk factor identification, the use and perceived effectiveness of prevention strategies, and barriers to implementation. Descriptive statistics were calculated for each question.

Results: A total of 91 responses were received featuring respondents from 28 of 30 MLB organizations. The perceived most important intrinsic risk factors were tolerance to high-speed running for first-time HSI and previous HSI for recurrent injury. The perceived most important extrinsic risk factor for both first-time and recurrent HSI was internal communication between staff. The perceived most effective prevention strategies were managing overall workload, regular exposure to high-speed running, and periodization. The most used prevention strategies were core or lumbopelvic strengthening, traditional resistance-training exercises, and managing overall workload. Approximately half (53%) of respondents reported barriers to effective implementation of HSI prevention strategies, including player and coach buy-in, compliance, workload management, and scheduling.

Conclusions: This was the first survey to investigate MLB practitioner beliefs and practices regarding HSI prevention. Responses from practitioners regarding their beliefs about risk factors and appropriate prevention strategies varied, and discrepancies existed between the perceived most effective strategies and those most frequently used.

Key Words: muscle injuries, risk factors, sport

Key Points

- The perceived most important intrinsic and extrinsic risk factors were tolerance to high-speed running or sprinting, previous hamstring injury (recurrent injury only), internal communication between staff, and training load.
- A clear discrepancy existed between the prevention strategies perceived to be most effective and those being actively used.
- Such discrepancies are likely explained by several barriers, including the competitive season schedule, the compliance and buy-in required from both players and coaching staff, and training design (eg, time available, content).

Hamstring strain injury (HSI) is the most common injury in Major League Baseball (MLB).[1] Typically occurring during base running, HSIs account for approximately 15 days and approximately 16 days of absence for first-time and recurrent injuries, respectively.[1] Considering the substantial financial burden and associated poor performance that a larger number of injuries places on an organization, ensuring player availability is imperative to team success.[2,3] Therefore, understanding current efforts to mitigate HSI risk in professional baseball underpins the development and application of evidence-based injury prevention strategies in the future.

The epidemiology and injury events of baseball-related HSI have been described, but no researchers have examined the intrinsic or extrinsic factors that increase HSI risk in baseball.[1,4] In a recent systematic review on HSI risk factors

in other sports, Green et al demonstrated the importance of previous lower limb injury (eg, HSI, calf strains, and anterior cruciate ligament injury), age, and performance metrics (eg, hamstrings isometric and eccentric strength, strength-endurance, and high-speed running exposure) in understanding injury risk.[5] However, it remains unclear whether these factors translate to baseball populations, given the lack of available research.

The effectiveness of HSI prevention strategies in baseball has been investigated in only 1 study.[6] Seagrave et al demonstrated that an eccentric hamstring training intervention consisting of the Nordic hamstring exercise, delivered to 243 players from a single MLB organization, lowered the risk of subsequent HSI and halved the total number of days missed due to injury compared with that in the previous season.[6] This strategy is similarly effective in other sports, but the implementation rates in professional baseball are unknown.[7] An improved understanding of HSI prevention strategies currently used in MLB, including their perceived effectiveness (as ranked by baseball practitioners) and barriers to implementation, is needed to inform the design of evidence-based risk-reduction interventions.

Surveys of muscle injury prevention strategies and perceived barriers to implementation have been conducted in other team sports.[8–10] Collectively, these data show that practitioners invest substantial time in high-speed running exposure and monitoring, and in eccentric strength training, and they indicate several other strategies as being supplementary (eg, lumbopelvic control, balance and proprioception). Although HSI epidemiological data have been reported for MLB, no researchers have investigated the beliefs and practices of practitioners working in the league related to HSI.[1] Given the busy in-season schedule and long-duration game format of baseball, extrapolating responses from previous HSI-related surveys in other field-based team sports may not be appropriate.

The purpose of this study was to explore the current beliefs and practices of practitioners in MLB relating to HSI risk and prevention strategies. Specifically, we aimed to describe their beliefs of intrinsic and extrinsic risk factor importance, the use and perceived effectiveness of prevention strategies, and the perceived barriers to implementing effective strategies.

METHODS

A cross-sectional online survey was developed using a Delphi-style process, in line with similar survey studies in professional sports.[8–11] The finalized survey was distributed to all MLB athletic trainers (ATs), physical therapists (PTs), and strength and conditioning (S&C) coaches.

Survey Development

A pilot survey was developed using questions from previously published team sport injury prevention surveys.[8–11] This included extraction and modification of question wording and possible answer options (eg, risk factors or prevention strategies for respondents to rank). We worked in conjunction with an S&C coach (F.A.L.) familiar with professional baseball to ensure appropriate terminology and phrasing was included in preliminary questions. Ten participants from the following categories completed the piloting of this survey: (1) practitioners from a target profession (ie, PT, AT, or S&C coach) currently working in baseball but not assigned to MLB (n = 3), (2) researchers familiar with the HSI risk factor and prevention literature (n = 4), and (3) applied practitioners with experience managing HSI risk in team sports and from 1 of the target professions but not currently working in baseball (n = 3).

In the first round, participants were provided with the initial draft of the survey and asked whether the proposed questions should be included and whether they believed the phrasing of both the question and response format were appropriate. If the answer to either question was *no*, participants provided feedback on amendments. Participants were also able to suggest additional topics or questions that they believed were important. We reviewed all comments and modified the survey based on this feedback. In the second round, participants were asked to comment on the modifications only. Full consensus ($\geq$70% of participant agreement) on the inclusion of proposed questions and phrasing was achieved after 2 rounds.[8]

All participants provided informed consent, and the Institutional Ethics Committee at Griffith University granted ethical approval (GU reference number 2021/402). The MLB Medical Research Committee also provided permission for the survey.

Data Collection

The survey was constructed and hosted on LimeSurvey 5.1.11 (LimeSurvey GmbH). The survey link was distributed to all MLB practitioners by the leadership teams of the Professional Baseball Athletic Trainers Society, Professional Baseball Physical Therapy Society, and Professional Baseball Strength & Conditioning Coaches Society. The survey was conducted between September 20 and October 22, 2021. Respondents were permitted to complete the survey once. Although responses were submitted anonymously, respondents were asked to provide potentially identifiable information of organizations and professions. However, such information was processed and analyzed separately from all other data to maintain anonymity. Respondents submitted demographic details, perceived importance of intrinsic and extrinsic risk factors for first-time and recurrent HSI, perceived effectiveness of HSI prevention strategies, use of HSI prevention strategies, and perceived barriers to implementation. Participants were asked to rank their perceived importance of risk factors and prevention strategy effectiveness on 5-point Likert scales. Respondents identified the HSI prevention strategies used in their programs via free-text boxes and the most frequently used exercises or targeted areas within each strategy. The survey content is provided in the Supplemental Material (Supplemental Figure 1, available online at https://dx.doi.org/10.4085/1062-6050-0640.22.S1).

Data Processing and Analysis

Results were exported to Excel (version 365; Microsoft Corp) for data processing and analysis. Descriptive statistics are reported for numerical data. Percentages were calculated based on the number of responses for each question, as not all respondents completed all sections.

Responses to the following questions were matched by team (ie, responses from colleagues were grouped together) and presented as a percentage of the teams with responding

practitioners: whether and when teams tested for HSI risk factors; whether team or individualized exercise programs, or both, were implemented; and whether and when teams tested maximum sprint speed. If only 1 respondent provided information, this response was reported. If 2 respondents provided conflicting responses, the answer with more time points (from spring training, in-season, and off-season) was used. For example, if 1 respondent stated testing was conducted "during spring training and in-season," this response was favored over "during spring training" only. In the event of $\geq$3 responses from colleagues, the most common answer was used.

Likert-scale questions were scored for perceived importance of risk factors (1 = *not sure*, 2 = *not important*, 3 = *somewhat important*, 4 = *important*, and 5 = *very important*) and prevention strategy effectiveness (1 = *very ineffective*, 2 = *ineffective*, 3 = *neither effective nor ineffective*, 4 = *effective*, 5 = *very effective*).[9,11] The total score (ie, the sum of all responses) was calculated and used to determine overall perceived importance of risk factors or the overall effectiveness of strategies.

Exercises listed by respondents as being used in current injury prevention strategies were grouped under the generic or most frequently used term by respondents. For flexibility exercises, the soft tissues targeted were specified, and for mobility, the joint or region was specified. Frequency counts were produced due to the variance in the number of respondents providing information. Not all respondents provided the same number of exercises, so reporting percentages based on the number of responding practitioners was not possible.

Barriers to implementation were condensed into key themes and then into subthemes by the lead author (S.L.L.). To confirm the interpretation of responses relating to barriers and the emergent themes, a second author (J.H.) acted as a "critical friend" to question and discuss the decision-making process.[12] To identify inconsistencies within organizations in reported barriers to implementation, staff were matched by team. The number of teams with inconsistent reporting between colleagues (ie, in which at least 1 member of staff reported barriers within the organization while other staff stated no barriers were present) was totaled and presented as a percentage of responding teams.

RESULTS

Responses

Of the 91 respondents, 77 (85%) completed all sections of the survey. Nine reported demographic data but did not complete any other sections of the survey. Two respondents provided demographic data and answered questions related to first-time HSI risk factors but not for recurrent injury. Three respondents provided demographic data and completed all questions related to risk factors but not prevention strategies. Respondents and their answers were retained for all survey sections completed; any data from incomplete sections were excluded from analysis.

Demographics

A total of 91 responses with complete demographic data were received. A total of 90 (99%) respondents identified as male, and 1 (1%) identified as female. At least 1 practitioner from 28 of 30 MLB teams responded to the survey. Participants were primarily ATs (60%, n = 55), whereas 23% (n = 21) were PTs and 17% (n = 15) were S&C coaches. A total of 55 (60%) respondents reported additional related qualifications (eg, dual accreditation). Seventeen (19%) respondents reported having worked in nonbaseball elite sports or environments, with level of play varying from national representative teams to junior teams. Participants had been qualified in their primary role for a median of 11 years (interquartile range [IQR], 3.5–20 years; range, 1–34 years) and had worked in baseball for a median of 14 years (IQR, 6.5–20 years; range, 1–38 years).

Risk Factors

According to respondents from 27 of the 28 teams, HSI risk factors were screened for during spring training and in-season periods; the remaining team's respondent reported that injury risk factors were not routinely screened for. The top 5 perceived most important intrinsic and extrinsic risk factors for both first-time and recurrent HSIs are presented in Figure 1.

Respondents considered tolerance to high-speed running or sprinting to be the most important intrinsic risk factor for first-time HSI and previous hamstring injury to be the most important for recurrent HSI. The perceived most important extrinsic risk factor for both first-time and recurrent injury was internal communication (ie, within the respective organization). Four of the 5 top-ranked intrinsic risk factors were consistent for both first-time and recurrent HSI. Full rankings for intrinsic and extrinsic risk factors are presented in Supplemental Figures 2 and 3, respectively.

Prevention Strategies

Of the 77 respondents who completed the prevention strategies section, 72 (94%) reported they were involved in the design or implementation of HSI prevention programs. Respondents from 23 (82%) of 28 teams reported that both team and individual exercise-based protocols were used, and 5 (18%) organizations used individual-only protocols.

The HSI prevention strategies perceived by participants to be most effective are shown in Figure 2. The top 5 perceived most effective strategies were managing overall workload, regular exposure to high-speed running or sprinting, periodization, managing hydration, and eccentric-only training exercises. Active strategies tended to be favored over passive or manual strategies, which featured in the bottom half of all rankings.

The top 5 most used HSI prevention strategies were core or lumbopelvic strengthening, traditional resistance-training exercises, managing overall workload, eccentric-only training exercises, and regular exposure to high-speed running or sprinting (Figure 3 and Supplemental Figure 4). A breakdown of exercises used by respondents for the exercise-based strategies is presented in Supplemental Table 1. A discrepancy existed between the perceived most effective strategies and the most frequently used strategies. For example, although respondents reported core or lumbopelvic strengthening as the seventh most effective HSI prevention strategy, this was the most frequently used option.

Players' maximum running speed was measured by 77% (n = 20/26) of teams for planning HSI prevention protocols, typically via in-stadia computerized tracking (44%, n = 12/27) and speed or light gates (30%, n = 8/27). Respondents measured maximum speed during both spring training and

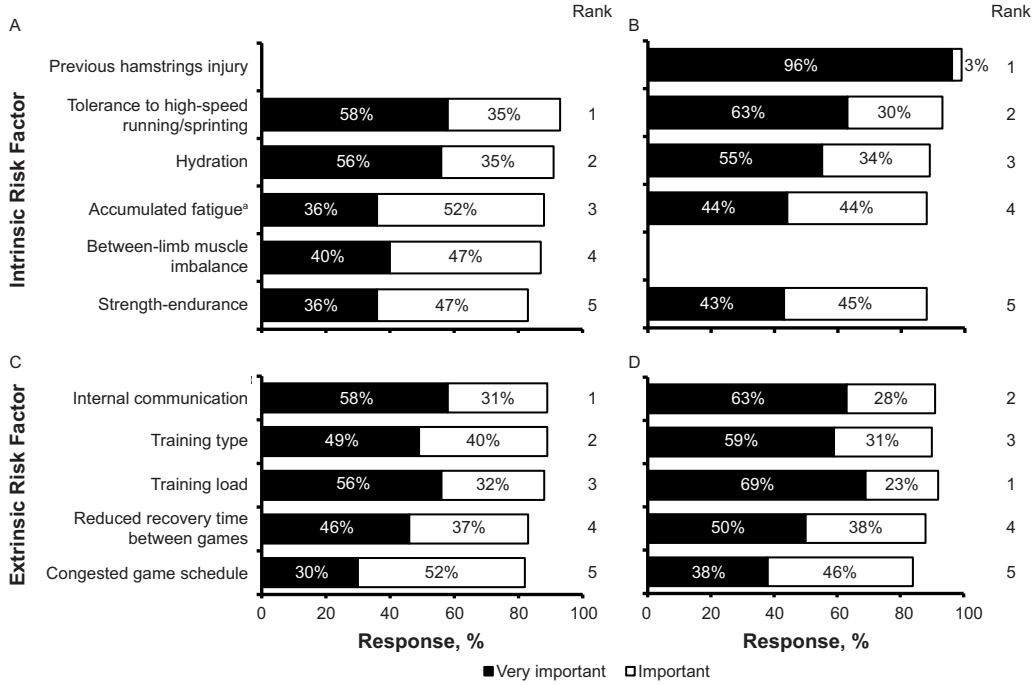

Figure 1. The 5 perceived most important risk factors (based on total score) for intrinsic (A and B) and extrinsic (C and D) risk factors for both first-time (A and C) and recurrent (B and D) injuries, with the total ranking score shown and by overall importance for first-time injury. [a] Through a season.

in-season. The median threshold for classifying high-speed running was 85% of a player's maximum speed (IQR, 80%–90%; range, 65%–100%). High-speed running efforts were routinely monitored by 92% (n = 24/26) of teams for HSI prevention.

Barriers to Implementation of Strategies

Of the 72 respondents who answered the questions relating to barriers, 38 (53%) practitioners identified barriers within their organization to implementation of perceived effective HSI prevention strategies. Inconsistencies between staff responses were present in 15 (54%) of responding organizations (ie, at least 1 member of staff reported barriers within the organization, while other staff stated no barriers were present).

The predominant themes for barriers were buy-in, compliance, workload management, and scheduling (Figure 4). Buy-in from both players and coaching staff was related to the perceived effectiveness of program content. Compliance was generally related to the player's completion of programs, particularly in the off-season. Workload management related to both the principle of managing load and the construction of training therein (eg, the content and volume of different tasks across the training day). Scheduling was also considered a barrier due to the large number of games played in the competitive season and the demands of travel, both contributing to reduced recovery time. Representative quotations are presented in Supplemental Table 2.

DISCUSSION

We are the first to investigate the beliefs and practices of MLB practitioners relating to HSI risk factors and prevention strategies, with practitioners from 28 of the 30 MLB

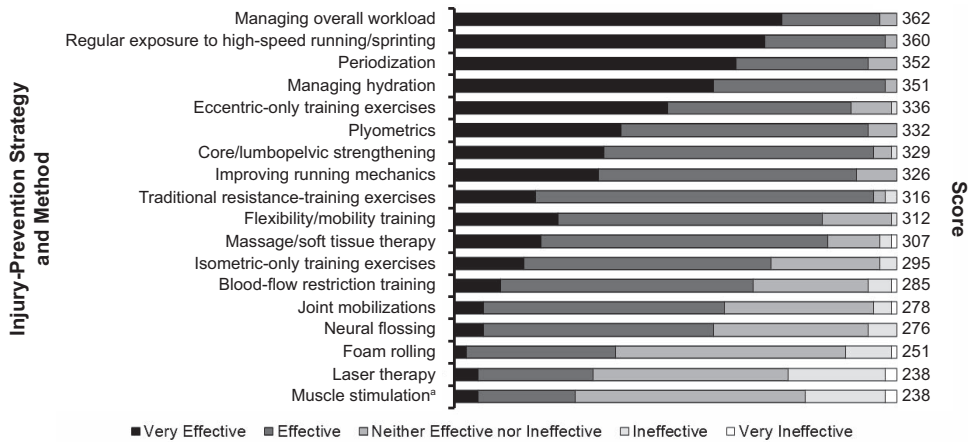

Figure 2. Injury prevention strategies and methods ranked from the perceived most effective (top) to least effective (bottom), showing the proportion of responses per effectiveness category (ie, *very effective*, *effective*) and total ranking score. [a] For example, Compex.

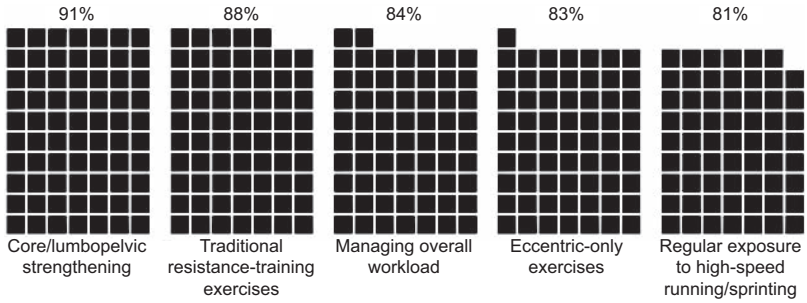

Figure 3. The top 5 hamstring strain injury prevention strategies, ordered from most to least frequently used.

teams responding. Most respondents identified as male and were ATs. Only 1 organization did not screen for HSI throughout the season. Four of the top 5 perceived most important intrinsic HSI risk factors were consistent for both first-time and recurrent injuries: tolerance to high-speed running or sprinting, hydration, accumulated fatigue (ie, through a season), and strength-endurance. Internal communication (ie, between staff), training type, training load, reduced recovery between games, and congested game schedule were identified as the perceived most important extrinsic risk factors. Strengthening exercises (ie, core or lumbopelvic strengthening, traditional resistance-training exercises, and eccentric-only training exercises), managing overall workload, and regular exposure to high-speed running or sprinting were the most used prevention strategies, although inconsistencies versus the perceived most effective prevention strategies were present. Approximately half of respondents also highlighted barriers to implementing effective prevention strategies.

Intrinsic Risk Factors

Tolerance to high-speed running or sprinting was perceived to be an important risk factor for first-time (ranked first) and recurrent (ranked third) HSI. Exposure to high-speed running has been associated with future injury risk in Australian Rules footballers, with very low and very high exposure linked to increased risk.[13,14] Unaccustomed exposure to high hamstring loads during high-speed running, particularly in terminal swing, may contribute to muscle damage.[15] However, the running demands associated with baseball have not been reported, and the effect of high-speed running exposure on HSI risk has not been demonstrated in this population.

Previous HSI was ranked as the most important risk factor for reinjury. In a recent systematic review and meta-analysis capturing 8319 HSIs (967 recurrences) in 71 324 athletes, Green et al reported that previous HSI was the strongest independent predictor for reinjury.[5] The mechanism(s) underpinning high recurrence rates are not fully understood. However, previously injured hamstrings can have persistent deficits in function (eg, reduced voluntary activation and knee-flexor strength and between-limb strength imbalances), which may increase the risk of reinjury.[5,16]

For the remaining risk factors, several discrepancies existed when comparing the beliefs and practices in other team sports with those in baseball. Strength-endurance was perceived to be an important risk factor for HSI in our survey but not in earlier practitioner surveys.[9,11] Single-legged hamstring bridge endurance (first-time injury) and time to exhaustion on a prone leg curl (first-time and recurrent injury) have been associated with increased HSI risk in football codes.[5,17,18] Strength-endurance may contribute to HSI incidence through modulation of intramuscular coordination and load sharing of the hamstrings during active lengthening.[18] However, future work is required to determine if strength-endurance is a risk factor for HSI in baseball athletes.

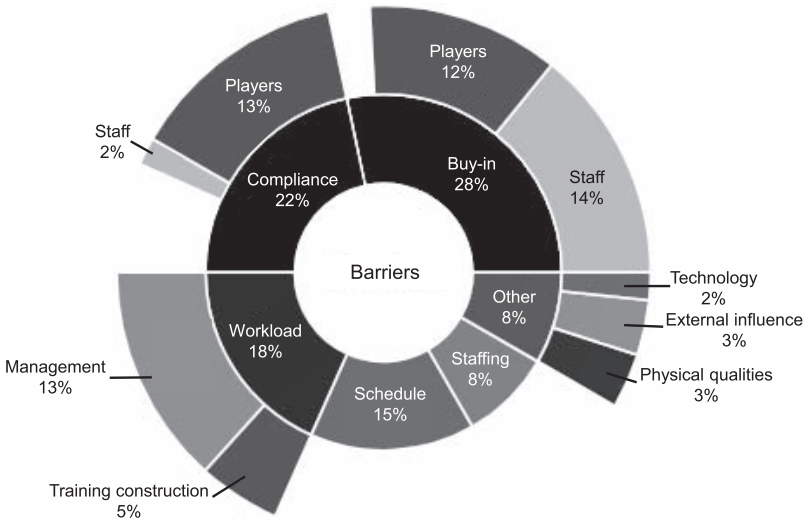

Figure 4. Perceived barriers to implementation of effective hamstring strain injury prevention strategies. The inner ring (white text) represents the overall themes, with the outer ring (black text) representing the subthemes in which these concerns were identified.

In our study, hydration was perceived to be important for both first-time and recurrent HSI. However, this has not been proposed as a risk factor in similar practitioner surveys, and researchers have not explored the role of hydration in causing HSI. Consequently, the relevance of hydration as a direct risk factor for HSI is unclear.

Baseball practitioners considered several previously reported HSI risk factors to have low importance. Age, playing position, and internal hamstring muscle architecture featured among the lowest ranked risk factors for HSI (Supplemental Figure 2), despite evidence of their association with HSI in nonbaseball populations.[5,19–21] Playing position has been linked to HSI frequency in MLB and Minor League Baseball, with pitchers sustaining HSIs at relatively greater rates than position players.[1] Despite the low perceived ranking of such risk factors, baseball practitioners ideally should still consider them in their profiling.

Extrinsic Risk Factors

Although some extrinsic factors have been examined in baseball (eg, game duration, weather), many potential risk factors have received little attention.[22] Training load and type were perceived to be important extrinsic risk factors for first-time and recurrent HSI, and monitoring overall workload was considered an important prevention strategy. Medical officers in elite soccer reported training load as the second most important extrinsic risk factor for injury.[9] In support, large increases in high-speed running volume have been shown to increase the risk of HSI in football codes.[13,14,23] However, the optimal training loads for baseball athletes are unclear, and training construction must ensure that athletic performance is balanced with injury prevention work.[24] Prospective research should be conducted to identify if associations exist between training load and HSI risk in baseball.

Reduced recovery time between games and a congested game schedule were perceived to be important risk factors for both first-time and recurrent HSI (ranked fourth and fifth, respectively). Chalmers et al reported that injury rates were not different before versus after the All-Star break-induced rest period, and Okoroha et al reported that HSI rates were highest in the initial 2 months of the competitive season.[1,25] These findings suggest that the accrual of games may not be directly linked to injury. However, in soccer, the risk of muscle injury has been reported to increase with a gap of <6 days between matches played.[26] Time between games is much shorter in a typical MLB season, with each team playing 162 games across approximately 185 days. Therefore, further investigation is required to determine if scheduling and shorter postgame recovery time are linked to injury in professional baseball.

Internal communication among organization members was perceived as an important extrinsic risk factor for both first-time and recurrent HSI, which is consistent with results in soccer.[8] The quality of communication between staff in soccer has been related to injury burden and incidence (ie, more injuries in poorly communicating teams) alongside player availability (ie, lower availability in poorly communicating teams).[27] However, this concept also remains unexamined in baseball and is another area for future research.

Prevention Strategies

In our survey, discrepancies existed between the perceived most effective prevention strategies and those most frequently used. Although the use of core or lumbopelvic strengthening exercises for HSI prevention was reported by 91% of respondents, it was ranked seventh most effective. The strength of evidence for using core or lumbopelvic exercises is limited.[28] Further investigation is required to establish the effectiveness of these interventions to reduce HSI risk in baseball. In addition, 78% of respondents reported managing hydration as a prevention strategy despite no evidence for or against its application in preventing HSI. Traditional resistance-training exercises were ranked the second most frequently used strategy but ninth in perceived effectiveness, although it may be associated with other strategies with greater perceived effectiveness (eg, periodization: third most effective strategy; eccentric-only training exercises: fifth most effective). The large choice of exercises linked to traditional resistance training (Supplemental Table 1) also makes it a useful vehicle for providing necessary training stimuli.

Regular exposure to high-speed running or sprinting was ranked as the second most effective strategy for reducing HSI but the fifth most frequently used. Interestingly, tolerance to high-speed running or sprinting was perceived to be the most important risk factor for first-time HSI in our cohort. In Delphi studies of European soccer practitioners and Australian Rules football performance coaches, researchers reported 100% consensus for the perceived effectiveness of high-speed running exposure for reducing muscle-injury incidence.[8,10] Most (92%) teams with responding practitioners reported monitoring high-speed running efforts for HSI prevention, and the reported threshold for categorizing high-speed running efforts (85% of players' maximum speed) was similar to a previous survey.[10] However, although the measurement methods of maximum speed were identified in our survey, it remains unclear if the same methods are used for monitoring high-speed running efforts in games and training. The hamstrings experience high loads and strain during high-speed running; consequently, programming progressive increases in distance and intensity may effectively improve tolerance and reduce injury risk, although this has not been demonstrated in baseball.[13–15,23]

Eccentric-only training exercises were perceived to be the fifth most effective and the fourth most frequently used strategy by respondents. Seagrave et al demonstrated that an eccentric Nordic hamstring exercise intervention reduced the frequency of HSI and halved the days missed due to injury between seasons at one MLB organization.[6] In large-scale randomized controlled trials using the Nordic hamstring exercise, researchers reported 50% to 70% reductions in HSI rates in other team sports when athletes were adherent.[7] However, several barriers may restrict the application of eccentric-only strategies in the professional baseball environment. The inability to implement the perceived most effective strategies may contribute to the maintenance of high HSI rates in baseball.

Barriers to Implementation of Strategies

Approximately half of respondents highlighted barriers to the implementation of perceived effective HSI prevention strategies, including player and staff buy-in, compliance, scheduling, and differing opinions on training content. However, in more than half (54%) of responding organizations,

responses from staff conflicted regarding the presence of barriers to implementation, which suggests MLB staff may interpret the same environments differently.

Buy-In and Compliance. Buy-in and compliance accounted for half of all barriers. Buy-in of players and coaches represented 28% of key themes listed by respondents who highlighted barriers. Comments concerned player hesitancy to complete required activities, from either fear of injury or soreness, and pushback from coaches due to beliefs regarding training strategies (Supplemental Table 2). These comments echo those from soccer practitioners, who reported using various education strategies to engage players and coaches to improve compliance.[9] Coaches preferred an explanation of strategy effects relating to an athlete's performance, presented via methods they deemed most accessible, and this may present a method for improving coach engagement.[29] Player buy-in may influence compliance to prevention strategies. Our participants expressed concern over off-season content completion, possibly due to player hesitancy. Consistent with the opinions of soccer and Australian Rules practitioners, players' fear of injury during high-speed running in training was a barrier to player engagement with high-speed running exposure.[9,10] However, underexposure to progressively overloaded running strategies can increase the risk of injury.[13,14] Despite the favorable results after eccentric training, concerns remain from players and coaches regarding potential soreness and the exercise's subsequent effect on game readiness.[6] Repeated exposure to eccentric exercise and sprinting during the off-season and spring training would allow for adaptation without the interfering effects of soreness during in-season competition. Compliance with HSI prevention strategies in soccer is similarly mixed, and additional player education may be warranted.[9,30]

Workload and Schedule. A source of contention for respondents was disagreements with coaches and other staff regarding ideal training content. Participants commented on the balance of on- and off-field–related work and the general variation in workload during training and games across a given week. This theme has links to compliance and buy-in, as practitioners might encounter resistance when modifying training for injury prevention, which affects athlete workload.

The MLB in-season schedule itself was reported as a barrier to effective implementation of prevention strategies, as respondents reported having inadequate time to execute perceived effective strategies. Soccer practitioners typically ensured a 48-hour recovery window between prevention strategies and subsequent games; however, owing to the number of games in series in MLB competition and travel requirements, such windows are not feasible.[11] In addition, the busy in-season schedule may hinder practitioners' ability to remain up to date on the current evidence base.

Limitations and Future Research

Responses were received from practitioners at 28 of 30 MLB teams, with differing numbers of respondents from each organization. Consequently, not all practitioner types from all organizations were captured. In addition, whereas most respondents identified their primary role as an AT, we are unable to demonstrate whether this voluntary sample is representative of the league, as the breakdown of practitioner types within the league is unknown. Given the nuance associated with the implementation of prevention strategies (eg, programming variables and application of recovery strategies), a survey may not fully capture the complexity of participant responses, requiring further qualitative investigation. Respondents identified training type and load as important injury risk factors; however, the survey did not determine which types of training were included. Further qualitative studies to understand the importance of training type and load are needed, given their specification as risk factors, strategies, and barriers. In addition, regular exposure to high-speed running or sprinting was similarly implicated as an important risk factor, noted as a key prevention strategy, and mentioned in comments about barriers to implementation. However, although the survey captured the periods in which testing is conducted, we are unable to report the frequency of maximum running speed measurement during each period. Further work is required to investigate the frequency of risk factor screening in MLB and the implications of regular screening for injury prevention within baseball. To date, no prospective studies have been done to investigate the association between intrinsic or extrinsic risk factors and future HSI in baseball. Therefore, to what extent the perceived most important factors affect injury risk remains unclear.

We only examined the beliefs of MLB ATs, PTs, and S&C coaches, without input from adjacent members of the medical and performance teams and Minor League Baseball practitioners. The beliefs of players and coaches are likely very important, and these groups were linked to implementation barriers. Understanding players' perceptions of barriers that reduce buy-in and compliance to prevention programs is crucial. The athlete-related barriers presented in the literature are typically reported by practitioners rather than athletes themselves, which may not provide a complete overview of athlete opinions.[9,10]

The distinct absence of baseball athlete and baseball game characteristics described in the literature has limited some conclusions of this survey. For example, high-speed running during games is undocumented, is important in the physical preparation of athletes, and is directly related to practitioners' beliefs regarding risk factors and prevention. Descriptive studies are needed to understand the game demands and provide clear data from which to build preparatory training.

CONCLUSIONS

We are the first to examine the beliefs and practices of MLB practitioners in relation to HSI. Several intrinsic and extrinsic risk factors were identified as being important for HSI, but practitioners appear to use some prevention strategies they perceived to be suboptimal and few that are supported by empirical evidence. Application of HSI prevention strategies may be hindered by several barriers, such as the competitive season schedule, the compliance and buy-in required from players and coaching staff, and the construction of training. While some discrepancies exist between the beliefs of MLB practitioners and those in other sports, little to no baseball-related HSI data exist from which to draw conclusions. Our survey results provide a novel direction for future work focusing on understanding the HSI risk factors in professional baseball, assessing the effectiveness of prevention strategies, and ameliorating perceived barriers to implementation.

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SUPPLEMENTAL MATERIAL

Supplemental Figure 1. Survey structure. The survey content began with question 5.

Supplemental Figure 2. Intrinsic risk factors for A, first-time and B, recurrent hamstring strain injury ranked from perceived most important (top) to least important (bottom), with the proportion of responses per importance category (ie, *very important*, *important*) and total ranking score. [a] Side-to-side difference. [b] Through a season. [c] Resistance to fatigue. [d] Toward the end of a game. [e] For example, in an individual inning. [f] For example, mood, fatigue, and muscle soreness. [g] For example, stiffness. [h] For example, fascicle length. [i] For example, muscle volume or cross-sectional area. [j] For example, blood and saliva.

Supplemental Figure 3. Extrinsic risk factors for A, first-time and B, recurrent hamstring strain injury ranked from perceived most important (top) to least important (bottom), with the proportion of responses per importance category (ie, *very important*, *important*) and total ranking score. [a] Consistency of staff group.

Supplemental Figure 4. Hamstring strain injury prevention strategies ordered from most to least frequently used. Percentages represent the proportion of respondents who reported using each strategy.

Supplemental Table 1. Most commonly programmed exercises or areas of focus for prevention strategies.[a]

Supplemental Table 2. Barriers to effective implementation of hamstring strain injury prevention strategies.

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Address correspondence to Stephanie L. Lazarczuk, MSc, GSR, School of Health Sciences and Social Work, Griffith University, G02 Clinical Sciences 2, Gold Coast Campus, 1 Parklands Drive, Southport, QLD, Australia, 4215. Address email to stephanie.lazarczuk@griffithuni.edu.au.