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Clinical Practice Patterns and Beliefs in the Management of Hamstrings Strain Injuries

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Context: Hamstrings strain injuries (HSIs) are among the most commonly occurring injuries in sport and are top causes of missed playing time. Lingering symptoms, prolonged recovery, and a high reinjury rate (12%–34%) make HSI management a frustrating and challenging process for the athletic trainer (AT). The clinical practice patterns and opinions of ATs regarding HSI treatment and rehabilitation are unknown.

Objective: To examine the frequency of method use and opinions about current HSI management among ATs.

Design: Cross-sectional study.

Setting: Survey administered to registrants at the 2013 National Athletic Trainers' Association Clinical Symposia and AT Expo.

Patients or Other Participants: A total of 1356 certified ATs (691 men, 665 women; age = 35.4 ± 10.5 years, time certified = 11.92 ± 9.75 years).

Data Collection and Analysis: A survey was distributed electronically to 7272 registrants and on paper to another 700 attendees. Validity and reliability were established before distribution. Participants reported demographic information and rated their frequency of treatment and rehabilitation method use and agreement with questions assessing confidence, satisfaction, and desire for better clinical practice guidelines. Exploratory factor analysis and principal axis factor analysis were used. We also calculated descriptive statistics and χ^2 tests to assess practice patterns.

Results: The response rate was 17% (n = 1356). A 2-factor solution was accepted for factor analysis ($r = 0.76$, $r = 0.70$), indicating that ATs follow either a contemporary or traditional management style. Various practice patterns were evident across employment settings and years of clinical experience. Satisfaction with the current HSI management plan was high (73.6%), whereas confidence in returning an athlete to play was lower (62.0%). Rates of use were associated with belief in effectiveness for all methods assessed ($P < .001$). Higher confidence levels were associated with high use of several methods; we observed increased satisfaction ($\chi^2_2 = 22.5$, $P = .002$) but not increased confidence levels in more experienced ATs.

Conclusions: Our study demonstrated the lack of consensus in HSI treatment and rehabilitation and the ATs' desire for better clinical practice guidelines. Future research in which multimodal strategies, including both traditional and contemporary methods, are studied is warranted for effective management of HSI.

Key Words: muscle, athletic trainer, reinjury

Key Points

- Consensus on the management of hamstrings strain injuries among athletic trainers was lacking.
- Confidence in returning an athlete to play after injury was low.
- Evidence-based treatment and rehabilitation methods are needed to drive clinical practice.

Hamstrings strain injury (HSI) is one of the most commonly occurring soft tissue injuries in sport and recreational participants.[1–3] Authors of epidemiologic studies across various sports leagues have indicated that HSI is one of the highest ranked causes of missed playing time in both practice and competition, with an average of 8 to 24 days missed per injury.[1,4–9] Even more alarming is the reinjury rate after return to play (RTP), which ranges from 12% to 34%,[1,10] with the reinjury usually resulting in more severe symptoms and a longer recovery time than the initial injury.[2] Management of hamstrings strains is challenging to the patient and athletic trainer (AT), as the recovery and healing process is slow and symptoms usually persist for some time.[11] These injury and reinjury rates suggest that current management practices are ineffective.[12] Therefore, formulating evidence-based management strategies to decrease HSI rates is highly important.[13]

Despite the high incidence, reinjury rates, and growing interest in HSI over the last decade, empirical data and consensus on HSI management are lacking. Epidemiologic data have shown that, over the most recent decades, HSI rates have not declined despite the amount of attention received in the literature.[3,6] Although eccentric training has shown promise,[2,14] the lack of decline in HSI rates highlights the need for further investigation into prevention plans, especially because researchers[15–17] have observed that focusing specifically on prevention strategies in athletes reduced injuries such as ankle sprains and anterior cruciate ligament injuries.

Whereas the high injury rates are possibly due to poor clinical decision making or a lack of suitable prevention or rehabilitation protocols, practice patterns and opinions on clinical guidelines available for HSI management are unknown. In addition, it is unclear how the high incidence and recurrence rates of HSI affect the confidence and

Table 1. Specifications for Survey Design

Main Question Topic	Subtopic	Purpose
I. Demographic information (attribute)	Education	1. Does hamstrings strain injury management vary across settings?
	No. of years certified	2. Does experience influence hamstrings strain injury practice patterns?
	No. of hamstrings strain injuries evaluated	
	Sex	
	Age	
II. Management practices (behavior)	Assessment	1. Are athletic trainers following the recommendations of the research?
	Treatment and rehabilitation	2. Is there a consensus among athletic trainers in hamstrings strain injury management?
	Return to play	
III. Confidence/satisfaction (belief and attitude)	Satisfaction with hamstrings strain injury protocol	1. Are athletic trainers seeking better clinical guidelines for hamstrings strain injury management?
	Confidence in return-to-play decisions	2. Are athletic trainers confident in managing hamstrings strain injuries?
	Belief of effectiveness	3. Are athletic trainers using methods they believe to be effective?

satisfaction levels of ATs in caring for these patients. Therefore, the purpose of our study was to assess the clinical practice patterns of ATs, including the frequency of method use for the treatment and rehabilitation of HSI, and to examine their beliefs associated with the effectiveness of and opinions on current management practices.

METHODS

Participants

We randomly distributed a survey to 700 certified ATs at the 2013 National Athletic Trainers' Association Clinical Symposia and AT Expo. After the event, an electronic version of the survey was distributed to an additional 7272 certified ATs who were on the registrant list and may have held clinically based positions, such as head AT, assistant AT, AT, or director of sports medicine, according to the registrant information provided by the National Athletic Trainers' Association. The electronic survey was distributed via an e-mail containing a link to the survey, which was hosted on Qualtrics Online Survey Software (Provo, UT). The link was active for 4 weeks and was sent to registrants twice during this period, including the initial e-mail and a reminder e-mail sent when 10 days remained in the data-collection period. Participants implied consent by completing the paper or Web-based survey, and the Institutional Review Board of the University of Delaware approved the study.

Instrument

We developed a 71-item instrument (Hamstring Survey for Athletic Trainers) in accordance with the guidelines for survey research in athletic training suggested by Turocy[18] and an extensive review of the literature pertaining to HSI. Our survey included 6 demographic questions on the participant's age, sex, education level, number of years as a practicing AT, primary employment setting, and sports to which he or she provided clinical care. Questions pertaining to HSI management included the average number of HSIs evaluated in 1 year, use and belief in the effectiveness of specific treatment and rehabilitation methods, confidence and satisfaction with management, and importance placed on the methods used in making an RTP decision. All injury-specific and clinical practice questions were assessed through closed-ended Likert-scale questions.

Criterion-related validity was established through the design of a table of specifications, which ensured that all questions were aimed at answering a specific research question (Table 1). Face and content validity were established with the recommendations of an expert panel that consisted of experienced clinical ATs, researchers, and a physical therapist. To determine reliability of the instrument ($\alpha = .92$), a convenience sample of 12 certified ATs completed pilot testing before distribution of the survey, taking the survey twice, 2 weeks apart.

Data Analysis

We used descriptive and inferential statistics to analyze the data. Scores for the 64 variables (all nondemographic questions) ranged from 0 to 2 (0 = *never*, 1 = *sometimes*, 2 = *always*) for rates of treatment use and rehabilitation methods, from 0 (*no*) to 1 (*yes*) for belief of effectiveness of methods, and from 0 to 4 (0 = *strongly disagree*, 1 = *disagree*, 2 = *neither agree nor disagree*, 3 = *agree*, 4 = *strongly agree*) for assessing the importance of RTP methods and general clinical practice questions. Differences in item variances were equated by converting each item to a z score (0.0 ± 1.0). Thereafter, an item factor analysis was conducted. We chose exploratory factor analysis rather than confirmatory factor analysis to identify integral constructs underlying the Hamstring Survey for Athletic Trainers.

A polychoric correlation matrix was estimated from the item ratings. Factors were extracted from the polychoric correlation matrix using principal-axis factor analysis with promax rotation. We used principal-axis factor analysis because of its relative tolerance of multivariate non-normality and its superior recovery of weak factors. For both theoretical and empirical reasons, we assumed that retained factors would be correlated. Consequently, a promax rotation was used with $k = 4$. Each model was evaluated against the following 4 rules: (1) eigenvalues greater than 1.0, (2) minimal average parcels, (3) yield high internal consistency (α coefficient $\geq .70$) for unit-weighted factors, and (4) interpretability. A series of exploratory factor analyses was required. For each analysis, items were discarded when they did not show simple structure (ie, an appreciable factor loading ≥ 0.30 on only 1 factor).

Table 2. Participant Demographics[a]

Item	Value
Age, y (mean ± SD; range, 21–81)	35.4 ± 10.5
No. of hamstrings strain injuries evaluated in 1 y (mean ± SD; range, 0–500; median = 10; skewness = 10.4)	16.4 ± 23.5
Years of certification, No. (%) (n = 1353; mean ± SD = 11.92 ± 9.75)	
0–10	778 (57.5)
11–20	324 (23.9)
>20	251 (18.6)
Sex, No. (%) (n = 1356)	
Male	691 (51.0)
Female	665 (49.0)
Highest education, No. (%) (n = 1348)	
Bachelor's degree	314 (23.3)
Master's degree	992 (73.6)
Doctorate	42 (3.1)
Employment setting, No. (%) (n = 1281)	
University/college	674 (52.6)
High school	423 (33.0)
Physical therapy clinic	66 (5.2)
Professional	54 (4.2)
Other	64 (5.0)

[a] Some participants did not answer all questions.

Similarly, complex items were discarded (eg, doublets and triplets, where an item shows appreciable loadings on 2 or more factors).

We used χ^2 tests of association to assess the relationship between use of the treatment and rehabilitation methods and belief in their effectiveness and independent variables of employment setting (university/college, high school, physical therapy [PT] clinic, professional sports, other) and number of years in clinical practice (0–10, 11–20, >20). The relationships between reported clinical patterns and beliefs and confidence and satisfaction levels of ATs in the management of HSI also were assessed using χ^2 tests. We used post hoc comparisons with Bonferroni corrections. The α level was set at .05. We used SPSS (version 21; IBM Corporation, Armonk, NY) for statistical analyses.

RESULTS

The final sample of participants consisted of 1356 certified ATs (691 men, 665 women), which yielded a response rate of 17% (248 of 700 paper surveys, 1108 of 7272 electronic surveys). After the initial e-mail for electronic survey distribution, 69.76% (n = 946) of the total respondents had completed the survey, whereas the remaining 30.24% (n = 410) of our sample responded after the reminder e-mail. The most common employment settings were university/college (52.6%, n = 674 of 1281), high school (33.0%, n = 423 of 1281), and PT clinics (5.2%, n = 66 of 1281). Most participants (73.6%, n = 992 of 1348) held a master's degree as their highest level of education. Demographic data on the final sample of participants are presented in Table 2.

We determined HSI management styles of the ATs using exploratory factor analysis. A 2-factor solution composed of 38 variables satisfied the requirements for simple structure because all variables showed appreciable factor loadings and did so on only 1 factor. Alpha coefficients revealed satisfactory internal consistency reliability for the 2 dimensions (0.76 for factor I and 0.70 for factor II). The rotated pattern matrix for the 2-factor solution is presented in Table 3. The 2 factors were interpreted according to the magnitude and meaning of their salient pattern coefficients. We identified 2 HSI management styles in this population: *traditional* (factor I) and *contemporary* (factor II), meaning that ATs tended to follow one of them. *Factor I* was defined by appreciable loadings from items such as static stretching, electrical stimulation, compression, nonsteroidal anti-inflammatory drugs, and cryotherapy. *Factor II* comprised methods including muscle activation exercises, core strengthening, progressive agility, and eccentric strengthening. The correlation between the 2 factors was low ($r = 0.29$) and indicated that 8% of their variance was common (ie, $r^2 = 0.08$). This low degree of redundancy suggested the 2 factors were essentially independent of one another and did not reflect the presence of a higher-order factor.

General Practice Patterns and Beliefs

Most ATs responded that they were satisfied with their current HSI management protocol (12.6% [n = 170 of 1350] strongly agreed, 61.0% [n = 824 of 1350] agreed), yet only 8.7% (n = 118 of 1351) strongly agreed and 53.3% (n = 720 of 1351) agreed that they were confident a reinjury would not occur when they returned an athlete to play. Only 9.4% (n = 127 of 1348) strongly agreed and 45.5% (n = 614 of 1348) agreed that they consistently diagnosed HSI based on a set grading scale. Most ATs typically did not refer athletes to a team physician for further HSI evaluation, as only 1.9% (n = 25 of 1348) strongly agreed and 7.0% (n = 94 of 1348) agreed that they made referrals. Consistent with this finding, only 1.1% (n = 15 of 1347) strongly agreed and 3.0% (n = 41 of 1347) agreed that their athletes usually underwent magnetic resonance imaging (MRI) to assess HSI. Lastly, 19.5% (n = 263 of 1351) strongly agreed and 52.7% (n = 712 of 1351) agreed that better guidelines were needed to drive clinical practice in the management of HSI. Figure 1 presents all responses to the questions in this category.

Compared with ATs who had 0 to 10 years of experience, ATs who had more than 20 years of experience reported they agreed more strongly that they used MRI for assessment ($\chi^2_2 = 23.1$, $P < .001$), whereas the group with less experience reported greater agreement that better recommendations to guide clinical practice would be helpful ($\chi^2_2 = 13.7$, $P = .008$). Both the groups with 11 to 20 ($\chi^2_2 = 13.2$, $P = .01$) and more than 20 ($\chi^2_2 = 18.2$, $P = .001$) years of experience reported higher agreement that they referred patients to a team physician for further evaluation than did the group with 0 to 10 years of experience.

Use of Treatment and Rehabilitation Methods

The overall percentage use of the 23 treatment and rehabilitation methods assessed in this study are presented in Figure 2, and the ATs' beliefs in the effectiveness of these methods in managing HSIs are presented in Table 4. A positive correlation existed between the use of and belief in effectiveness of all of the treatment and rehabilitation

Table 3. Sorted Pattern Matrix of Loadings on Factors

Method	Survey Question Category	Management Style	
		Contemporary	Traditional
Muscle activation	Use	0.673	NA
Core strengthening	Use	0.648	NA
Progressive agility	Use	0.613	NA
Muscle activation	Belief in effectiveness	0.607	NA
Core strengthening	Belief in effectiveness	0.561	NA
Eccentric strengthening	Belief in effectiveness	0.560	NA
Eccentric strengthening	Use	0.554	NA
Balance/proprioception	Use	0.553	NA
Proprioceptive neuromuscular facilitation	Use	0.534	NA
Progressive agility	Belief in effectiveness	0.531	NA
Knee immobilizer	Use	0.481	NA
Joint mobilizations	Use	0.479	NA
Biomechanical assessment of lower extremity	Agreement	0.471	NA
Injection therapy	Use	0.469	NA
Neural flossing	Belief in effectiveness	0.452	NA
Physician referral	Agreement	0.419	NA
Magnetic resonance imaging assessment	Agreement	0.407	NA
Biomechanical assessment of upper extremity	Agreement	0.396	NA
Dynamic stretching	Use	0.373	NA
Massage	Use	0.366	NA
Musculoskeletal ultrasound	Agreement	0.347	NA
Graston Technique/Astym[a]	Belief in effectiveness	0.339	NA
Knee immobilizer	Belief in effectiveness	0.314	NA
Static stretching	Belief in effectiveness	NA	0.715
Electrical stimulation	Belief in effectiveness	NA	0.625
Ultrasound	Belief in effectiveness	NA	0.567
Nonsteroidal anti-inflammatory drugs	Belief in effectiveness	NA	0.550
Static stretching	Use	NA	0.532
Compression	Belief in effectiveness	NA	0.505
Isokinetic strengthening	Belief in effectiveness	NA	0.497
Electrical stimulation	Use	NA	0.464
Manual muscle testing	Agreement	NA	0.432
Heat	Use	NA	0.364
Compression	Use	NA	0.358
Nonsteroidal anti-inflammatory drugs	Use	NA	0.356
Bilateral isokinetic assessment	Agreement	NA	0.331
Cryotherapy	Use	NA	0.330

Abbreviation: NA, no appreciable loading.

[a] Graston Technique, Indianapolis, IN; Astym, Performance Dynamics, Inc, Muncie, IN.

methods (χ^2_2 range = 176–474, $P < .001$). For 16 of 23 methods assessed, higher use rates were associated with greater belief in effectiveness, whereas for 5 methods (laser, joint mobilizations, knee immobilizer, injection therapy, and neural flossing), lower use was associated with less belief in effectiveness. The remaining 2 methods (Graston Technique, Indianapolis, IN/Astym, Performance Dynamics, Inc, Muncie, IN, and isokinetic strengthening) reflected a combination of these relationships. Most participants (92.9%, 209 of 225) who reported a low level of belief in effectiveness of the Graston Technique/Astym also reported less use of this method, whereas 60.4% (560 of 927) of participants who believed the Graston Technique/Astym was effective also reported using this method. The same type of relationship was evident for isokinetic strengthening, with most participants (90.4%, 225 of 249) who reported not believing it was effective also reporting never having used this method and 67.8% (642 of 947) of participants who reported believing it was effective also reporting a high level of use of isokinetic strengthening.

Athletic trainers practicing for more than 20 years were more likely to use cryotherapy ($\chi^2_2 = 8.6$, $P = .01$), injection therapy ($\chi^2_2 = 9.0$, $P = .01$), joint mobilizations ($\chi^2_2 = 37.5$, $P < .001$), laser ($\chi^2_2 = 10.5$, $P = .005$), and ultrasound ($\chi^2_2 = 12.0$, $P = .003$) than those with 0 to 10 years of experience. Athletic trainers with 11 to 20 years of experience were more likely to use neural flossing ($\chi^2_2 = 8.8$, $P = .01$) and joint mobilizations ($\chi^2_2 = 15.4$, $P < .001$) than ATs with 0 to 10 years of experience. Participants with 0 to 10 years of experience reported greater use of balance/proprioception exercises ($\chi^2_2 = 18.7$, $P < .001$) and the Graston Technique/Astym ($\chi^2_2 = 10.7$, $P = .005$). Differences existed in treatment and rehabilitation practice patterns across employment settings for the use of 17 of the 23 methods assessed. The χ^2 post hoc comparisons by employment setting are shown in Table 5.

Belief in Effectiveness of Treatment and Rehabilitation Methods

We observed several relationships between belief in effectiveness and employment setting (Table 6). More ATs with 0 to 10 years of experience believed nonsteroidal anti-inflammatory drugs were effective than those with 11 to 20

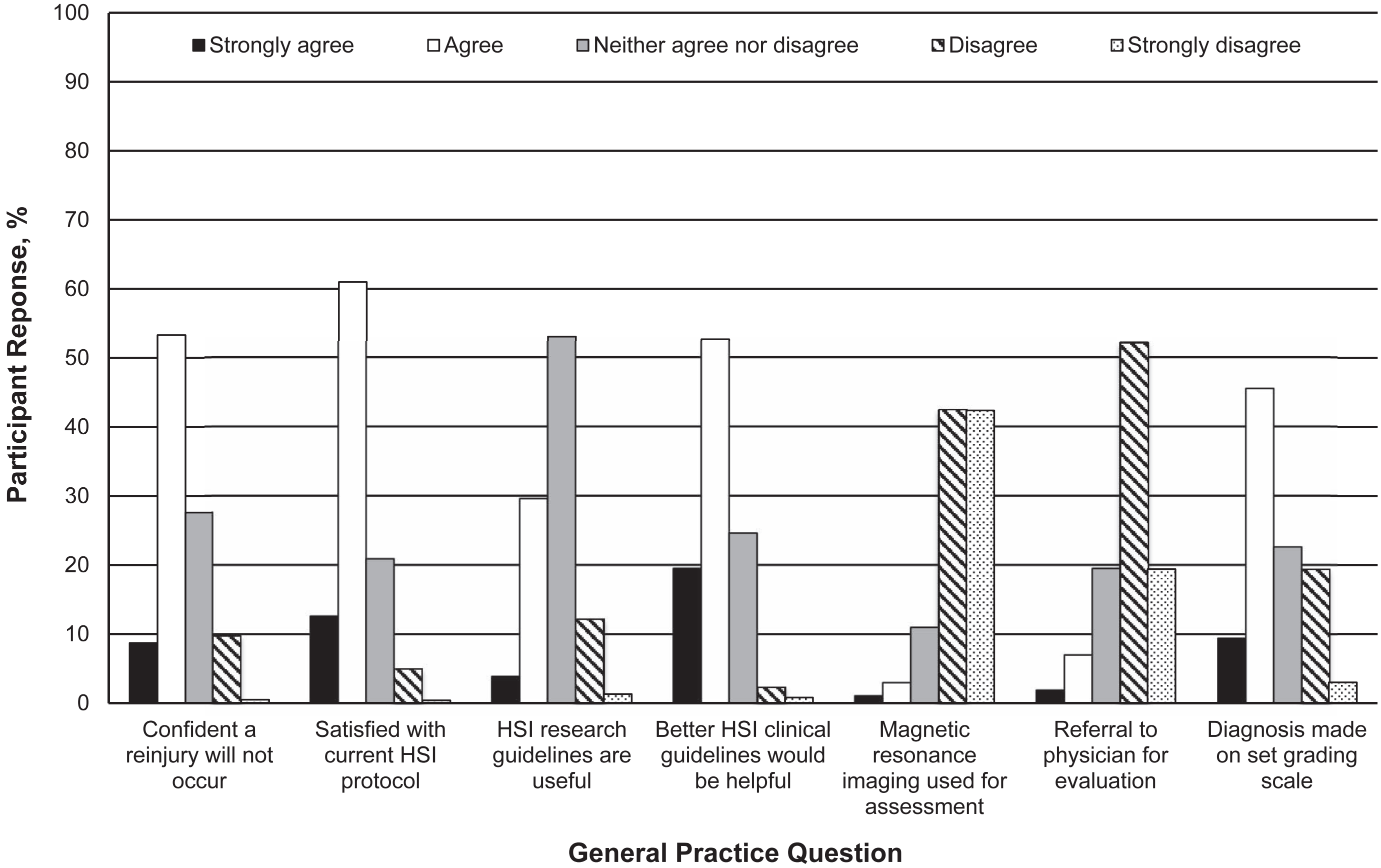

Figure 1. Athletic trainers' responses to general practice questions. Abbreviation: HSI, hamstrings strain injury.

years of experience ($\chi^2_2 = 5.9$, $P = .02$); more participants in the former group also believed the Graston Technique/Astym was effective than those in the latter group ($\chi^2_2 = 13.6$, $P < .001$). Athletic trainers practicing for more than 20 years were more likely to believe that joint mobilizations were effective than did ATs practicing for 0 to 10 years ($\chi^2_2 = 6.5$, $P = .01$).

Importance of RTP Methods

Overall responses to the importance of RTP methods are shown in Figure 3. Participants with more than 20 years of experience rated passive range of motion (ROM) as more important than did ATs with 0 to 10 years of experience ($\chi^2_2 = 19.9$, $P < .001$), whereas ATs with 11 to 20 years of experience rated an upper extremity biomechanical assessment as more important ($\chi^2_2 = 13.1$, $P = .01$). The group with 0 to 10 years of experience rated the importance of manual muscle testing (MMT) higher than did those with 11 to 20 ($\chi^2_2 = 12.6$, $P = .01$) or more than 20 ($\chi^2_2 = 22.6$, $P < .001$) years of experience. The ATs with 0 to 10 years of experience also rated bilateral isokinetic strength assessment higher than did those with more than 20 years of experience ($\chi^2_2 = 14.3$, $P = .007$).

Athletic trainers employed in professional sports rated the importance of using MRI results in RTP decisions higher than those in university/college ($\chi^2_2 = 44.7$, $P < .001$), high school ($\chi^2_2 = 36.0$, $P < .001$), or PT clinic ($\chi^2_2 = 23.2$, $P < .001$) settings. Physical therapy clinic ATs rated the importance of using a lower extremity biomechanical assessment higher than did the university ($\chi^2_2 = 23.7$, $P < .001$) and high school ($\chi^2_2 = 21.1$, $P < .001$) ATs. Bilateral isokinetic strength assessment was rated as more important by high school ATs than by professional ($\chi^2_2 = 16.1$, $P = .003$) and PT clinic ($\chi^2_2 = 19.4$, $P < .001$) ATs. Lastly, university/college ATs rated MMT as more important in their RTP decisions than PT clinic ATs did ($\chi^2_2 = 19.2$, $P < .001$).

Confidence and Satisfaction in HSI Management

More use of certain treatment and rehabilitation methods was associated with increased levels of confidence in safely returning an athlete to play without reinjury. Participants who reported always using core strengthening ($\chi^2_2 = 14.6$, $P = .006$), isokinetic strengthening ($\chi^2_2 = 13.2$, $P = .01$), joint mobilizations ($\chi^2_2 = 36.9$, $P < .001$), Graston Technique/Astym ($\chi^2_2 = 14.8$, $P = .03$), muscle-activation exercises ($\chi^2_2 = 15.6$, $P = .004$), compression ($\chi^2_2 = 21.4$, $P < .001$), or laser ($\chi^2_2 = 15.4$, $P = .02$) had an association with higher confidence levels than ATs who reported never using these methods. Participants who reported always using progressive agility were associated with higher levels of confidence than ATs who reported using this method sometimes ($\chi^2_2 = 22.3$, $P < .001$).

Athletic trainers with more than 20 years of experience had a higher level of association with satisfaction in HSI management than did ATs with 0 to 10 years of experience ($\chi^2_2 = 22.5$, $P = .002$). Satisfaction was greater in ATs who reported always using muscle-activation exercises than in ATs who reported sometimes ($\chi^2_2 = 16.7$, $P = .002$) or never ($\chi^2_2 = 15.6$, $P = .004$) using them.

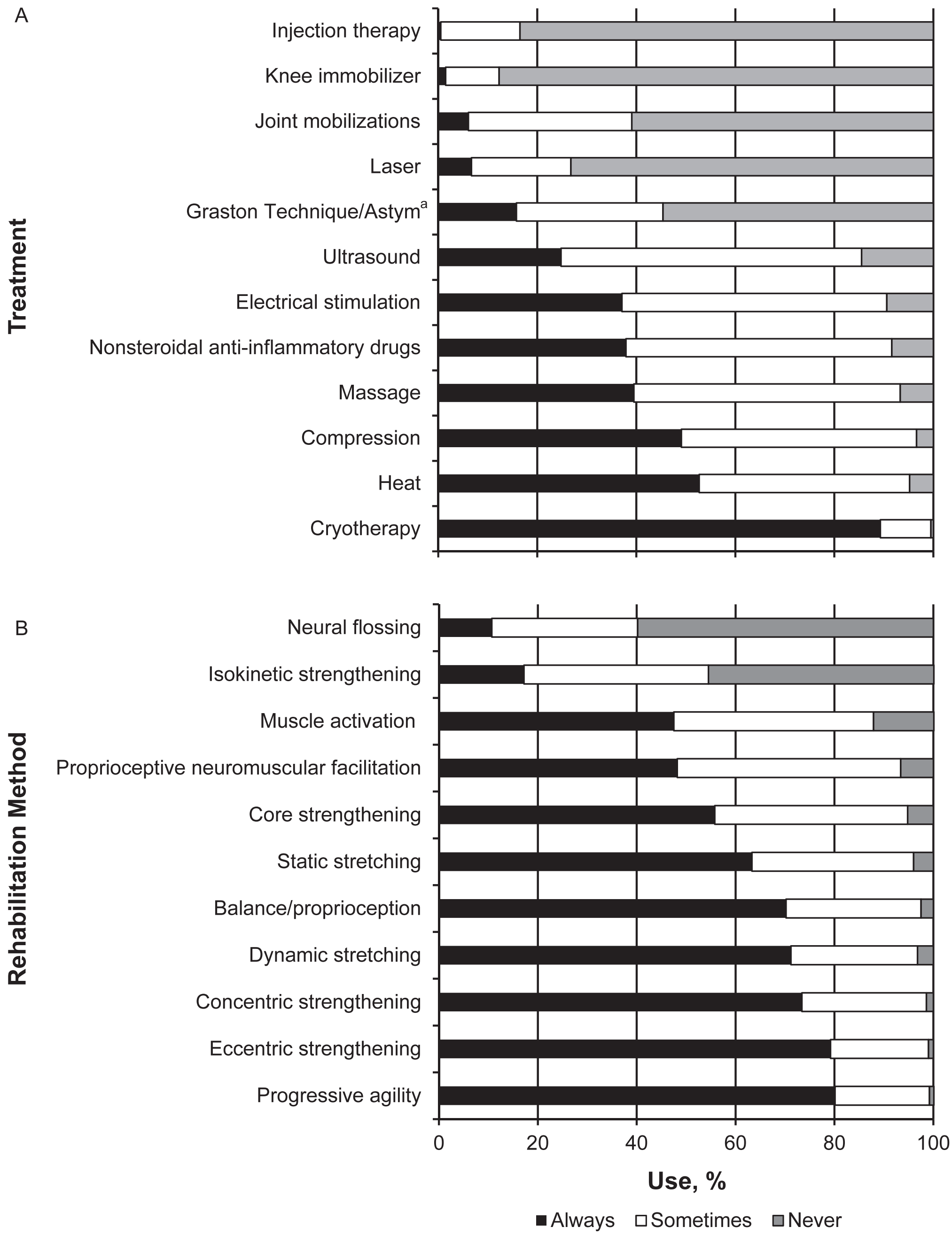

Figure 2. Use of A, Treatments, and B, Rehabilitation methods. [a] Graston Technique, Indianapolis, IN; Astym, Performance Dynamics, Inc, Muncie, IN.

DISCUSSION

We present an overview of the use rates for treatment and rehabilitation methods of ATs and associated levels of confidence and satisfaction in the management of HSIs. We conducted our survey to highlight clinical practice patterns, interpret agreement among ATs, and examine the influence that these patterns could have on HSI rates. A similar approach was implemented to emphasize the lack of consensus in treatment and the need for improved clinical practice guidelines in the management of concussions.[19] Although researchers are striving to determine risk factors and effective rehabilitation methods, considering the practices and beliefs of ATs who are directly responsible for managing HSIs is also important.

High incidence and reinjury rates of HSI are occurring, and most ATs (72%) in this study believe that better guidelines are needed to drive clinical practice. Differences observed in use rates of treatment and rehabilitation methods across employment setting and years of clinical experience represent the current disagreement among ATs about the management of HSIs. We identified additional discrepancies because our analysis showed that a portion of ATs have shifted toward a more contemporary management style, whereas others continue to follow a traditional protocol. We cannot infer which style may be more effective in managing HSIs; however, we are able to bring attention to the lack of consensus and the need for improved treatment and rehabilitation protocols.

Table 4. Belief in Effectiveness of Treatments and Rehabilitation Methods

Method, %	Is It Effective?	
	Yes	No
Treatment		
Cryotherapy	98.0	2.0
Massage	94.1	5.9
Heat	89.9	10.1
Compression	89.9	10.1
Nonsteroidal anti-inflammatory drugs	89.3	10.7
Electrical stimulation	83.2	16.8
Ultrasound	82.8	17.2
Graston Technique/Astym[a]	80.5	19.5
Joint mobilizations	51.1	48.9
Laser	50.6	49.4
Injection therapy	43.8	56.2
Knee immobilizer	21.1	78.9
Rehabilitation		
Eccentric strengthening	99.3	0.7
Progressive agility	99.1	0.9
Balance/proprioception	97.6	2.4
Concentric strengthening	96.9	3.1
Dynamic stretching	96.3	3.7
Core strengthening	95.9	4.1
Proprioceptive neuromuscular facilitation	95.8	4.2
Muscle activation	93.7	6.3
Static stretching	90.2	9.8
Isokinetic strengthening	79.1	20.9
Neural flossing	64.9	35.1

[a] Graston Technique, Indianapolis, IN; Astym, Performance Dynamics, Inc, Muncie, IN.

The severity of an HSI affects the delivery of care, but much discussion surrounds the grading of HSIs. Many classification systems have been presented in the literature based on clinical examination findings,[20,21] available ROM,[10,22] type of injury (functional or structural),[23] and imaging findings[24]; yet a validated grading system does not exist,[21] and no system correlates with prognosis.[25] Furthermore, researchers[26] have shown no difference in time to RTP for patients with a grade 1 versus grade 2 HSI based on a traditional 3-point clinical grading scale. Therefore, our survey did not differentiate among grades of HSIs in our analysis of clinical practice patterns, which is a limitation. It is interesting that our results further supported the lack of consensus and use of a standard classification system, as only 55% of respondents agreed that they consistently used a set grading scale to diagnose HSI.

Information pertaining to the type and location of HSI is also important to consider in HSI management. Askling et al[27] showed that the mechanism of injury is clinically relevant, as stretching-type injuries most often affect the semitendinosis muscle (83%) with involvement of the proximal free tendon, are typically milder at onset, and usually involve a prolonged recovery time. More commonly occurring high-speed injuries typically affect the biceps femoris muscle; longer recovery times are associated with proximity of the injury to the ischial tuberosity (with MRI examination or palpation) or involvement of the proximal free tendon.[28] Furthermore, biceps femoris injuries that disrupt the central tendon also result in longer recovery times than injuries of the musculotendinous junction or muscle belly, adding considerations to the HSI classification.[29] Therefore, we must acknowledge that such factors in HSI management may have influenced responses to our survey. Athletic trainers also likely manage acute and chronic HSIs with different treatment and rehabilitation methods, which could have affected our results.

Use of Treatment and Rehabilitation Methods

We observed a high level of use (>85% of participants always or sometimes using) for several common treatment methods despite the inconclusiveness of their actual effectiveness, including ice, heat, massage, nonsteroidal anti-inflammatory drugs, compression, and ultrasound. Evidence supporting muscle recovery after HSI, as well as specific investigations into the efficacy of these treatment methods, are lacking.[11,30–35] Participants reported using other treatment methods less frequently (Graston Technique/Astym, laser, and injection therapy), but these also lack evidence to support their clinical effectiveness.[36–39] The remaining methods (knee immobilizer and joint mobilizations) had lower use rates, yet some limited support exists for their application. A short period of immobilization after musculoskeletal injury has been recommended[26,40] because it limits connective tissue proliferation, but the ideal period has not been established, as prolonged immobilization is associated with atrophy and decreased strength and flexibility.[40,41] Limited support for joint mobilizations was provided by Cibulka et al[42] who used mobilizations of the sacroiliac joint in patients with HSIs and demonstrated greater peak torque production after injury than in a control group.

Participants did indicate a high level of use for rehabilitation methods that have shown some promise in effectively managing HSIs, such as core strengthening, progressive agility, balance training, and eccentric strengthening.[2,42–47] Sherry and Best[46] reported that patients with HSIs who were treated with a progressive agility and trunk-stabilization program had decreased injury rates in the first 2 weeks and within 1 year after RTP compared with a group that performed stretching and isolated hamstrings strengthening. Balance training has also been shown to prevent HSIs in elite soccer players through the implementation of a series of single- and double-legged balance exercises.[47] Based on previous studies,[2,43–45] eccentric strengthening of the hamstrings is the most promising method of preventing and rehabilitating HSIs. Unfortunately, we are not able to infer the specific protocols that were implemented by our participants from their use of these methods. Our results indicated a high level of use for eccentric training, but we cannot specify the dosage, type, or intensity of these rehabilitative practices, which could affect effectiveness and the ATs' satisfaction with HSI management protocols. Eccentric exercises that elongate the hamstrings by incorporating hip flexion are more effective than traditional knee-dominant exercises for decreasing the time to RTP in patients with HSIs.[14] Hence, effectiveness is not solely based on frequency of use but also on how eccentric training is implemented in the clinical setting and on patient compliance.[48]

On the contrary, we observed a high level of use for concentric strengthening, which does not appear to be recommended and may even be deleterious during HSI rehabilitation.[49] Whereas eccentric training has been shown

Table 5. Differences in Use of Treatment and Rehabilitation Methods by Employment Setting[a]

Method	χ^2_2	*P*
Eccentric strengthening		
University > high school	48.4	<.001
Professional > high school	12.2	.002
Massage		
University > high school	49.3	<.001
Physical therapy > high school	16.2	<.001
Professional > high school	58.2	<.001
Other > high school	20.2	<.001
Professional > university	22.9	<.001
Neural flossing		
University > high school	34.8	<.001
Physical therapy > high school	32.8	<.001
Professional > high school	45.8	<.001
Other > high school	32.8	<.001
Physical therapy > university	11.1	.004
Professional > university	12.1	.002
Graston Technique/Astym[b]		
University > high school	172.4	<.001
Physical therapy > high school	38.2	<.001
Professional > high school	135.0	<.001
Other > high school	17.9	<.001
Professional > university	20.4	<.001
Professional > physical therapy	20.9	<.001
Professional > other	30.2	<.001
Balance/proprioception		
University > high school	28.7	<.001
Electrical stimulation		
University > high school	60.3	<.001
University > physical therapy	17.8	<.001
University > other	53.9	<.001
Concentric strengthening		
University > other	11.6	.003
Muscle-activation exercises		
University > high school	14.6	<.001
Professional > university	20.6	<.001
Professional > high school	37.6	<.001
Physical therapy > high school	20.2	<.001
Progressive agility		
University > high school	27.2	<.001
Heat		
University > high school	12.5	.002
University > physical therapy	11.3	.004
Injection therapy		
Professional > university	35.8	<.001
Professional > high school	108.8	<.001
Professional > physical therapy	22.6	<.001
Professional > other	18.0	.001
University > high school	43.0	<.001
Joint mobilizations		
Physical therapy > university	45.4	<.001
Professional > university	39.1	<.001
Physical therapy > high school	73.8	<.001
Professional > high school	67.2	<.001
Other > high school	17.1	<.001
Laser		
University > high school	55.7	<.001
Professional > university	49.1	<.001
Professional > physical therapy	19.0	<.001
Professional > other	17.2	<.001
Physical therapy > high school	11.0	.004
Professional > high school	120.9	<.001
Other > high school	13.7	.001
Nonsteroidal anti-inflammatory drugs		
University > high school	40.6	<.001
Ultrasound		
University > high school	92.2	<.001
University > other	15.5	<.001
Physical therapy > high school	12.6	.002
Professional > high school	32.7	<.001
Proprioceptive neuromuscular facilitation		
University > high school	16.8	<.001
Core strengthening		
University > high school	14.8	<.001
Professional > university	17.1	<.001
Professional > high school	26.9	<.001
Physical therapy > high school	13.9	<.001

[a] Results of χ^2 post hoc tests using a Bonferroni correction.
[b] Graston Technique, Indianapolis, IN; Astym, Performance Dynamics, Inc, Muncie, IN.

to cause protective adaptations by allowing increased strength at longer muscle lengths through an increase in the number of sarcomeres in series,[50–53] concentric strengthening results in a decrease in sarcomeres in series.[49,54] Concentric training causes peak torque to occur at a greater angle of knee flexion (shorter muscle length)

Table 6. Differences in Belief in Treatment and Rehabilitation Effectiveness by Employment Setting[a]

Method	χ^2_2	*P*
Graston Technique/Astym[b]		
University > high school	40.6	<.001
University > physical therapy	14.8	.001
Professional > high school	14.3	<.001
Professional > physical therapy	13.4	.003
Injection therapy		
Professional > university	9.0	.003
Professional > high school	11.8	<.001
Professional > other	9.8	.002
Ultrasound		
University > physical therapy	11.3	<.001
High school > physical therapy	10.2	.001
Isokinetic strengthening		
University > professional	9.4	.002
University > physical therapy	11.3	<.001
High school > physical therapy	18.2	<.001
High school > professional	15.8	<.001
Joint mobilizations		
Professional > university	9.1	.003
Professional > high school	11.2	<.001
Physical therapy > high school	9.5	.002
Electrical stimulation		
High school > professional	10.1	.002

[a] Results of χ^2 post hoc tests using a Bonferroni correction.
[b] Graston Technique, Indianapolis, IN; Astym, Performance Dynamics, Inc, Muncie, IN.

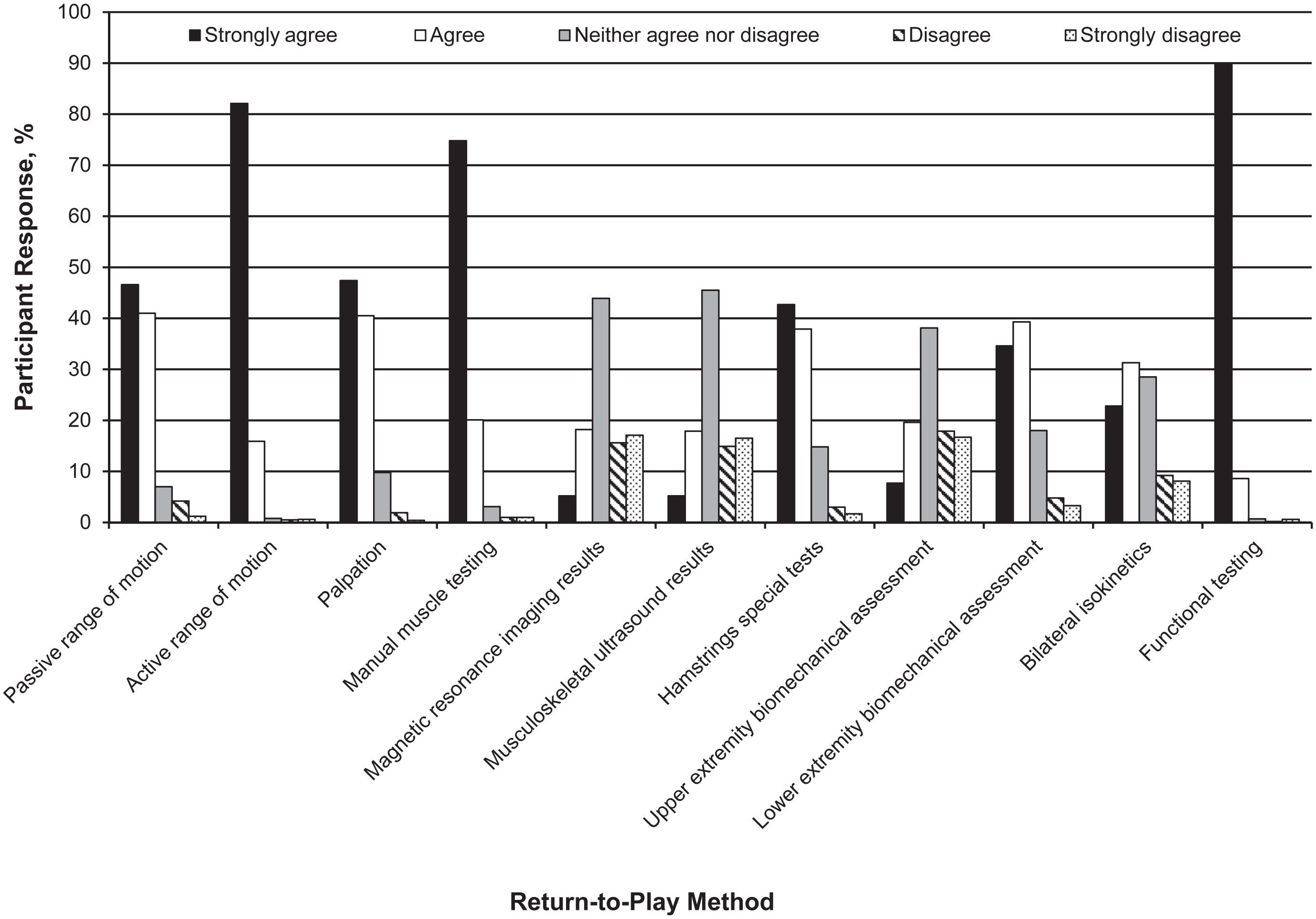

Figure 3. Athletic trainers' responses to importance of return-to-play methods.

during the gait cycle by altering the length-tension relationship of the hamstrings, and this shift in peak torque production to shorter muscle lengths is a risk factor for HSI.[55]

We observed much lower use rates of isokinetic strengthening, and although this exercise may not be a practical clinical rehabilitation method, its utility for HSI rehabilitation should be considered. Researchers have shown that patients with a history of HSI present with muscle-strength deficits[56–58] that are hypothesized to be risk factors for reinjury.[57] Specifically, an eccentric testing profile identified previously injured participants, and a compensated training program allowed for successful RTP without reinjury during a 12-month follow-up period.[57]

Lower use rates were also observed for neural-flossing techniques. Treating the nervous system after HSI, such as with slump stretching, has resulted in shorter recovery times.[59] Neurodynamic mobilizations, such as tensioners and sliders, that involve freeing nerves from their soft tissue surroundings have been shown to decrease pain, disability, and physical signs of adverse neural tension during treatment of other conditions.[60,61] Participants reported a high level of use for muscle-activation exercises, and clinical recommendations for such exercises have been provided,[62] with a specific focus on encouraging good motor patterns and activation of the gluteus maximus in isolation, as well as in conjunction with the hamstrings.[63,64] Opar et al[12] suggested that the nervous system is often overlooked after HSI, with neuromuscular inhibition after injury leading to a series of maladaptations that increase the risk for reinjury; however, treatment and rehabilitation protocols in this area remain inconclusive. Lastly, participants reported high use rates for stretching methods, but much debate surrounds the effectiveness of static, dynamic, and proprioceptive neuromuscular facilitation stretching techniques on flexibility, athletic performance, and injury prevention.[65–69] Conflicting results have been reported, but sufficient evidence does not currently exist to promote or deny the role of stretching in HSI management.[11,70]

Differences Across Employment Setting and Years of Clinical Experience

Certain relationships between use rates for treatment and rehabilitation methods and employment setting are due to the inherent nature of access to resources. Athletic trainers in the professional sports setting demonstrated more use of injection therapy, Graston Technique/Astym, and laser than those in all other settings; however, ATs who practice in other settings may have limited access to such methods because of financial constraints. As expected, traditional methods, such as ice, compression, static stretching, and dynamic stretching, did not vary across settings, as they are inexpensive and easily accessible. Several other HSI treatment and rehabilitation methods (core strengthening, muscle-activation exercises, neural flossing, joint mobilizations, massage) were used more in the professional setting than in the university and high school settings. This may be because of increased focus on manual therapy techniques, greater one-on-one time with patients, and more opportunities for continuing education courses that advance ATs' skills. However, the lack of any association between use rates for methods across employment settings and confidence or satisfaction levels could indicate the overall lack of consensus in HSI management.

Most of the relationships between use rates and clinical experience showed higher levels of use by the groups with more than 20 years or 11 to 20 years of experience than the group with 0 to 10 years of experience, suggesting that ATs use more treatment or rehabilitation methods over time. Athletic trainers with 0 to 10 years of experience reported greater use of the Graston Technique/Astym, which is concurrent with a more recent introduction of this skill into the clinical setting and education programs. The association between higher levels of satisfaction with a current HSI management plan and years of clinical practice in ATs certified for more than 20 years versus those certified for 0 to 10 years may signify that this preference is linked to experience. We do not know if this preference is correlated with a decrease in injury rates, especially given that confidence in returning an athlete to play was not associated with years of clinical experience. We would expect that more experienced ATs are more confident in returning an athlete to play after HSI, but it is plausible that consistently high reinjury rates contributed to this lack of difference.

Importance of RTP Methods

The RTP assessment methods of ROM, palpation, and functional testing were of high importance, as expected, whereas the importance of imaging studies, bilateral isokinetic testing, and hamstrings special tests was much lower. The formulation of objective criteria for making RTP decisions remains a challenging task and a critical focus of future research.[11] Authors[11,21,26,62] of several clinical commentaries have offered RTP recommendations for clinicians in HSI management. Mendiguchia and Brughelli[62] suggested an RTP algorithm that includes assessment of active ROM, MMT at long muscle length, bilateral isokinetic testing, and a review of imaging techniques. Kilcoyne et al[26] developed a novel early-mobilization rehabilitation protocol that uses bilateral isokinetic testing and functional testing (rolling sprints) as criteria in RTP decisions. Heiderscheit et al[11] recommended that RTP should occur only after full ROM, MMT (traditional position and at long muscle length), and functional testing (running, jumping, cutting) are performed without symptoms and with bilateral isokinetic testing if possible. Lastly, Lempainen et al[21] advocated for full return of ROM, symptom-free movement, and full strength (isokinetic testing) to assess readiness for RTP.

Our results showed that ATs are following such recommendations, placing high levels of importance on assessment of ROM, MMT, and functional testing. Compared with the available clinical recommendations, participants did not indicate high importance of MRI/musculoskeletal ultrasound imaging techniques or bilateral isokinetic testing. Researchers[24,28,71–73] have suggested that imaging studies are a useful supplement to clinical examination in estimating time to RTP because various MRI measures (longitudinal length, proximity to ischial tuberosity, cross-sectional area, volume of injury) have been correlated with RTP time. Nonetheless, investigators[74] using MRI and clinical findings as part of a multivariate analysis, unlike previous authors, have recently shown that MRI measures were not associated with time to RTP. However, the authors did not examine HSIs that did not show MRI abnormalities. This is important to consider, as up to 45% of patients with HSIs present with negative MRI findings,[71] which are associated with a quicker time to RTP.[72] Hence, the prognostic capabilities of MRI findings may not be as evident as previously described, and more conclusive results are still needed. Whereas musculoskeletal ultrasound has been demonstrated to be an effective tool for assessing acute HSIs, no evidence is available to support its use in making RTP decisions.[75]

Although the ATs did not place a high level of importance on bilateral isokinetic testing, it is an RTP component of clinical commentaries, and most of the available evidence supports its use. Some researchers have demonstrated bilateral deficits (peak torque, angle of peak torque) in participants with previous HSIs or have shown increased risk for future reinjury due to bilateral asymmetries[55,76,77]; however, some investigators have refuted these findings.[78,79] The use of isokinetic testing as a criterion in RTP decisions shows promise, and future research is warranted.

Beliefs Associated With Treatment and Rehabilitation Methods

The treatment and rehabilitation methods that ATs used were those that they believed were effective, whereas they reported low use of methods for those that they believed were ineffective. Overall, high use rates were associated with a high level of belief in effectiveness of the methods assessed, whereas 5 of the methods (knee immobilizer, injection therapy, joint mobilizations, laser, neural flossing) had low use rates with an associated lower belief in effectiveness. A less straightforward relationship was observed for isokinetic strengthening and the Graston Technique/Astym; a division existed between ATs who indicated high use and high belief in effectiveness and ATs who reported low use and low belief in effectiveness. Unfamiliarity with these methods of HSI management due to lack of accessibility, feasibility, or exposure may be the cause. If so, clinical practice guidelines could provide instructional and educational information to ATs, which may increase their likeliness to use or their belief in the effectiveness of these methods. Also, ATs may not have experienced success with these methods and, therefore, may not believe they are effective. In either case, further investigation is warranted to determine their efficacy in HSI management.

Overall satisfaction with current HSI management plans was relatively high (74%), yet the reported confidence level of ATs in returning an athlete to play without reinjury was lower (62%). It is alarming that just over one-half of participants agreed that they were confident when returning an athlete to play, but possible causes include previous clinical experiences with high reinjury rates or frustration with lingering symptoms in patients. Interestingly, 5 of the 8 treatment and rehabilitation methods (joint mobilizations, progressive agility, compression, core strengthening, isokinetic strengthening) that were associated with higher levels of confidence when returning an athlete to play do have limited evidence supporting their use, but the less commonly used methods of the Graston Technique/Astym, muscle-activation exercises, and laser were also related to higher confidence levels. Our results provide incentive for researchers to examine the effectiveness of these highly and less often used methods, as they were associated with higher confidence in ATs when returning an athlete to play.

Researchers need to examine the effectiveness of both traditional and contemporary treatment and rehabilitation methods that have not yet been studied. The ultimate goal of such efforts should be to design a battery of effective treatment and rehabilitation methods that can be adopted and individualized by ATs. Typically, treatment and rehabilitation methods are studied in isolation, but the clinical recommendations for and actual management of HSIs incorporate multimodal approaches. It seems appropriate to direct future investigations toward HSI management that incorporates various multimodal strategies to identify the optimal HSI plan that achieves the best patient outcomes.[80] Whereas many other prevalent sport-related injuries, such as anterior cruciate ligament tears and ankle sprains, have well-developed evidence-based protocols available for use as clinical practice guidelines,[81–83] a protocol for managing HSIs has not been established. An evidence-based approach is needed for HSI management to decrease the high injury rates plaguing athletes at this time. Although some methods have shown promise in the literature, effective care of HSIs remains unclear, as many commonly used interventions have demonstrated inconclusive results.[84] Randomized controlled trials with adequate participant numbers and injury occurrences are needed to provide clinically useful information to ATs.[85] Our findings of lower-than-desired confidence levels when returning an athlete to play are in agreement with those of other researchers,[11] identifying a need for criteria to determine a safe RTP after HSI.

Limitations

Our study is subject to the limitations of survey research. The results are subject to recall bias, and we cannot guarantee that all participants answered questions truthfully or construed the questions in the same manner because of subjective interpretation. For example, 1 AT might interpret *functional testing* used in RTP differently than another, or the lack of a chronological limit for an AT's confidence regarding RTP may have interfered with accurate results.

Our low overall response rate may have occurred because we sent the survey to more than 7000 ATs, all of whom may not hold clinical positions, or because of the typically lower response rates observed in electronic survey distribution.[86] Despite this low rate, we gathered the input of more than 1300 ATs, which we believe should be sufficient to provide an accurate representation.

CONCLUSIONS

Our results highlighted the overwhelming lack of consensus in HSI management. Many ATs want better guidelines to drive clinical management of HSIs, and most treatment and rehabilitation methods, both traditional and contemporary, lack evidence to support their use. With high incidence and reinjury rates across different clinical settings and sports, greater attention should be placed on assessing the effectiveness of treatment and rehabilitation methods to manage patients with HSIs. Given that a patient may present with a unique combination of risk factors, having a set of evidence-based treatment and rehabilitation methods will allow the AT to use his or her clinical decision-making skills to design an individualized HSI protocol. Future availability of an evidence-based battery of treatment and rehabilitation methods could lead to more confident RTP decisions and higher satisfaction levels with delivery of care, along with decreased HSI rates.

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