High School Athletes' Health-Related Quality of Life Across Recovery After Sport-Related Concussion or Acute Ankle Injury

A Report From the Athletic Training Practice-Based Research Network

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Background: Evaluating adolescent athletes' perceived health status after a sport-related injury can provide important direction for health promotion strategies and preparation for a successful return to play. Furthermore, comparing specific injury types regarding their impact on athletes' perspectives of their global and domain-specific health perceptions allows for a more detailed understanding of an athlete's experience while also providing avenues for targeted treatment strategies.

Purpose: To compare health-related quality of life (HRQOL) between high school athletes who had sustained either a concussion or an acute ankle injury and compare how these injury types related to their global and domain-specific HRQOL across recovery.

Study Design: Cohort study; Level of evidence, 3.

Methods: Electronic medical records created by athletic trainers working in 32 high school facilities were examined, and records from 1749 patients who sustained either a sport-related concussion (n = 862) or ankle sprain (n = 887) were screened for inclusion. HRQOL was assessed by self-reported scores on the Pediatric Quality of Life Inventory (PedsQL) at 2 time points after injury (T_1 = 0-2 days; T_2 = 11-29 days). A 2-way group by time analysis of variance was conducted to examine differences in trajectories and disrupted areas of HRQOL.

Results: Overall, 85 patient cases (46 concussion, 39 ankle sprain) fit the inclusion criteria. Each injury group exhibited improved global and domain-specific PedsQL scores between their 2 measured time points ($P < .05$), indicating recovery. However, domain-specific comparisons revealed that at T_2, patients who had sustained an ankle sprain reported significantly lower PedsQL physical functioning scores (78.3 ± 19.3 vs 86.2 ± 15.7 for concussion; $P = .005$), whereas patients who had sustained a concussion reported lower scores related to their school functioning (80.0 ± 20.0 vs 90.8 ± 12.7 for ankle sprain; $P = .006$).

Conclusion: The study results indicated that in high school athletes, the trajectories and disrupted areas of HRQOL stemming from a sport-related injury may be influenced differentially when comparing concussions with ankle sprains.

Keywords: adolescent athlete; patient-report outcomes; sport injury; traumatic brain injury

High school sport participation is one of the most common extracurricular activities in the United States, where more than half of adolescents enroll in organized sport programming each year.[3,41] This high prevalence of sport involvement is accompanied by far-reaching implications for the development and well-being of participants, not only in the physical fitness and performance domains[19,36,44] but also in the promotion of psychosocial development and health.[11,59] Although the potential for sport participation to positively affect young people's physical, psychological, and social development has been supported consistently through previous research, this enriching effect is neither universal nor automatic.[4,12,18] One potential threat to athletes' positive sport experiences is occasions in which they sustain a sport-related injury (SRI).[39,51,53]

It is reasonable to expect that having an SRI would be disruptive to the physical, psychological, and social state of an adolescent athlete. Taken together, these 3 domains

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refer to an individual's health-related quality of life (HRQOL).[17,43] Although sport participation has been linked to enhanced HRQOL in athlete populations compared with nonathletes,[10,24,52] previous research has illustrated the potential for an SRI to negatively affect multiple dimensions of an athlete's perceived health status during both recovery[37,47,49] and long-term prognosis even months and years after the injury healed.[14,22,45,51]

Decreased HRQOL is troubling regardless of an injured athlete's competitive level but is of particular concern when treating adolescent athletes.[8,36,38,42] Evidence supports the notion that HRQOL can be affected negatively in an adolescent athlete with an SRI,[20,54,55] who may demonstrate deficits in perceived physical and social functioning[52-55] and indicate having increased bodily pain and fear-avoidance beliefs, when compared with athletes with less or no history of injury.[19,54,55] Further efforts to contextualize the impact of HRQOL to the situational characteristics of an adolescent athlete's SRI remain essential.

One avenue for honing our understanding of adolescent patients' perspectives after an SRI is to examine how type of injury may differentially influence the global and subdomains of HRQOL that are most affected by an SRI as well as the trajectories of these variables over the course of recovery. Sport-related concussions (SRCs) are considered an invisible injury that has limited outward symptoms but has a sequela characterized by cognitive and emotional disturbances.[5,27] Acute orthopaedic injuries, such as an ankle sprain, differ in that they often result in swelling and limited weightbearing and may influence the athlete's short- and long-term physical activity habits but are less associated with cognitive or emotional impairment.[2,13] Thus, the differential nature of these types of injuries may reasonably present differential deficits and trajectories of adolescent patients' global and domain-specific HRQOL.

Previous research supports the assertion that injury type, such as concussion or musculoskeletal, is an important distinction in understanding patients' experiences after sustaining an SRI. A comparison of collegiate athletes showed that those who had sustained an SRC exhibited significantly higher depressive symptoms but significantly lower ratings of fear of reinjury and fear of return to play when compared with those who had sustained an orthopaedic injury.[15,25,37] Variations have also been found in the trajectory and long-term prognosis of HRQOL disruption based on injury type. One study found high school athletes who had sustained an SRC exhibited no significant perception of disablement (ie, presence of symptoms and low HRQOL) at 1 year after concussion,[40] although other work has suggested that athletes at various levels who had sustained a musculoskeletal injury displayed long-term perceptions of physical disablement even after their injury recovery time passed.[39,51,60]

Better understanding adolescent patients' perspectives of their HRQOL over the course of recovery provides a practical avenue toward effectively designing treatment to meet these patients' needs. Examination of the impact of injury type, such as an SRC or acute ankle sprain, on adolescent patients' perceived health statuses has been limited, especially in the high school sport setting. Therefore, the purpose of this study was to compare patient-reported HRQOL between high school athlete patients who had sustained either a concussion or an acute ankle injury throughout their recovery. Based on the differential nature of these 2 injury types, it was hypothesized that the 2 groups would differ significantly in their trajectories and disrupted areas of HRQOL.

METHODS

Study Design

This study was granted exempt status from the university's institutional review board, as it was a retrospective analysis of deidentified patient records. Electronic medical records (EMRs) collected within the Athletic Training Practice-Based Research Network (AT-PBRN) were reviewed. The AT-PBRN and its features, including the infrastructure, EMR, clinician training, and data collection methods have been described previously.[34,35,56] In short, each clinician within the AT-PBRN documents his or her patient care in a fully functional, web-based EMR that is patient oriented and was designed by athletic trainers. Researchers then can conduct studies utilizing the deidentified patient data to answer questions, such as those surrounding practice characteristics or comparative effectiveness of interventions. Patient records for this study were documented by athletic trainers working in 32 high school facilities between 2009 and 2019.

Patients

We evaluated data from patients who were diagnosed with either a concussion or an ankle sprain and who completed the Pediatric Quality of Life Inventory (PedsQL). The PedsQL is a patient-reported outcome measure that assesses HRQOL in children and adolescents (range, 0-100 points, with lower scores indicating lower HRQOL). The overall score is divided into 5 subscales related to physical functioning, emotional functioning, social functioning, psychosocial functioning, and school functioning.[58] All

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patients completed the PedsQL at 2 time points after injury (T_1 = 0-2 days; T_2 = 11-29 days). These selected time points align with previous research that found that athletes' HRQOL may be disrupted at the onset of injury as well as before they return to play.[40,45,49] A broader window was selected for the second time point to account for the differential recovery timelines of SRCs and acute ankle injuries[5,13,27] and to maximize the potential for cases to be included. All patients were under the care of an athletic trainer participating in the AT-PBRN and were diagnosed by either an athletic trainer or a team physician.

Data Collection

Data were collected using a web-based EMR and injury surveillance system (CORE-AT EMR; www.core-at.com) by an athletic trainer who completed a formal, 2-hour training session on the use of the EMR software and proper data entry procedures prior to joining the AT-PBRN.[56] Clinicians within the AT-PBRN use the EMR database as a routine documentation system to record initial injury evaluations, daily treatment notes, injury reevaluations, and discharge summaries. The major components of the EMR and its standards (eg, Health Insurance Portability and Accountability Act compliance, Safe Harbor Method) have been described in previous investigations.[34,56]

Data Extraction

For the present study, the injury demographics and PedsQL forms within the EMR were reviewed. To ensure data integrity, the member of the research team (A.N.M.) responsible for the overall management and maintenance of the EMR's relational database reviewed patient records from AT-PBRN clinical practice sites prior to selecting and analyzing the records comprising the current study. Following standard procedures,[34,56] patient cases were first identified using ankle sprain and concussion diagnostic codes (*International Classification of Diseases, Ninth* or *Tenth Revision:* S93.409A [sprain/strain, ankle], S93.429A [sprain, deltoid ligament], S93.439A [sprain, tibiofibular ligament], S06.0X0A [concussion], S06.0X9A [concussion with loss of consciousness], and S06.0X0A [concussion, mental confusion without loss of consciousness]). Using the unique identifier (ie, injury identification number) of each patient case, all other patient case data were identified within the EMR database and extracted. For the purpose of enabling comparisons of HRQOL over the course of recovery, only patients who completed the PedsQL at T_1 and T_2 were included for analysis.

Statistical Analysis

Summary statistics (frequency, percentages, means and standard deviations, median, interquartile ranges [IQRs], range) were used to describe patient (sex, age, sport, participation level) and injury (time of injury, duration of care, self-reported function) characteristics. Duration of care was defined as the number of days from intake (ie, completion of the injury demographics form) to the last documented episode of care. A 2-way group (ankle sprain, concussion) by time (T_1, T_2) analysis of variance was conducted for each dependent variable (PedsQL total score, PedsQL subscale scores). Significance was set a priori at $P \leq .05$. Analyses were conducted using IBM SPSS Statistics software (Version 26; IBM Corp).

RESULTS

Patient and Injury Characteristics

A total of 1749 patients were diagnosed with either an ankle sprain (n = 887) or concussion (n = 862) during the study period. Of these patients, 85 met the inclusion criteria and were retained for analysis (concussion: n = 21 male, n = 25 female; age = 15.1 ± 1.1 years; ankle sprain: n = 21 male, n = 18 female; age = 15.4 ± 1.3 years) (Figure 1).

Injuries were reported most frequently by varsity-level athletes (n = 46/85; 54.1%) and occurred during in-season practice (n = 38/85; 44.7%) (Table 1). Those participating in football (n = 26/85; 30.6%), basketball (n = 22/85; 25.9%), and volleyball (n = 10; 11.8%) had the highest injury rates. Figure 2 illustrates the frequencies by sport of injured patients.

PedsQL

The average time from injury was 1.2 ± 0.7 days for T_1 (median = 1; IQR = 1-2; range = 0-2) and 15.4 ± 4.4 days for T_2 (median = 14; IQR = 13-16; range = 11-29). Scores for the overall PedsQL as well as each subscale are presented in Table 2. Overall PedsQL scores did not differ significantly between groups at T_1 (concussion = 83.2 ± 11.8; ankle sprain = 79.6 ± 15.9) or T_2 (concussion = 87.5 ± 12.1; ankle sprain 87.6 ± 12.6) ($P > .05$ for both). There was no significant group-by-time interaction for the total score or any subscale score. A significant effect for time was noted for the PedsQL total score and each subscale score, with higher scores at T_2 compared with T_1. Between-group differences at T_2 were observed for the physical functioning and school functioning subscales, with patients who had sustained an ankle sprain reporting significantly lower scores related to physical functioning (78.3 ± 19.3 vs 86.2 ± 15.7 for concussion; $P = .005$) and patients who had sustained a concussion reporting lower scores related to school functioning (80.0 ± 20.0 vs 90.8 ± 12.7 for ankle sprain; $P = .006$).

DISCUSSION

In this study, data illustrated that the perceived HRQOL in both injury groups improved over time, with 71 of the 85 (83.53%) high school athletes improving in this regard. Although no global between-group differences in HRQOL were exhibited ($P = .492$), the specific domains of HRQOL differed between the study groups at 11 to 29 days after injury (T_2): physical functioning was affected more in the patient group who had an ankle sprain ($P = .005$), whereas school functioning was lower in the patient group who had

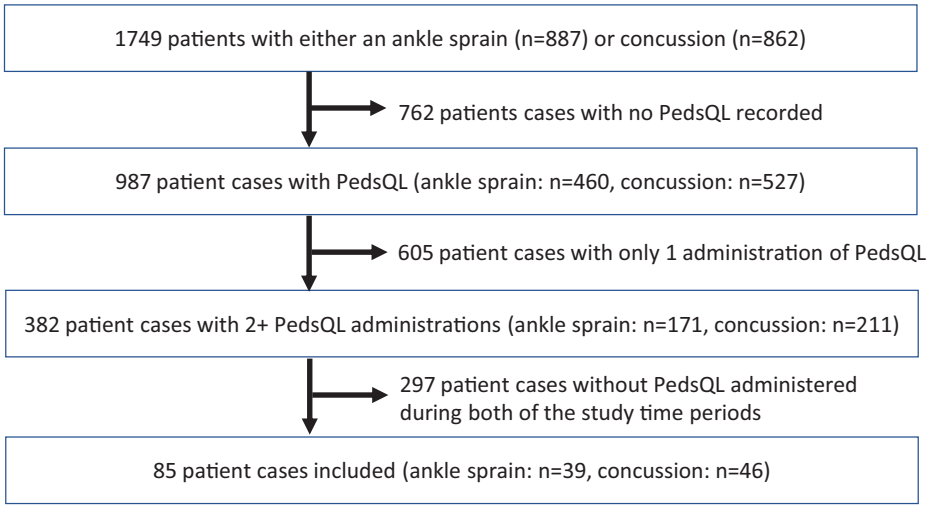

Figure 1. Flow diagram for selection of study cohort. PedsQL, Pediatric Quality of Life Inventory.

TABLE 1
Injury Demographics by Injury Type[a]

Variable	Ankle Sprain (n = 39)	Concussion (n = 46)
ICD code[b]		
S93.409A	35 (41.2)	—
S93.439A	4 (4.7)	—
S06.0X0XA	—	38 (44.7)
S06.0X9A	—	1 (1.2)
S06.0X0A	—	7 (8.2)
Time of injury		
Preseason conditioning	1 (2.6)	0 (0.0)
Preseason scrimmage	1 (2.6)	1 (2.2)
In-season practice	18 (46.2)	20 (43.5)
In-season game	10 (25.6)	19 (41.3)
Postseason practice	1 (2.6)	0 (0.0)
Off-season conditioning	0 (0.0)	1 (2.2)
Non—sport related	8 (20.5)	5 (10.9)
Participation level		
Freshman	4 (10.3)	7 (15.2)
Junior varsity	10 (25.6)	16 (34.8)
Varsity	25 (64.1)	21 (45.7)
Other	0 (0.0)	2 (4.3)

[a]Data are reported as n (%). Dashes indicate areas not applicable. ICD, International Classification of Diseases.

[b]ICD codes: S93.409A (sprain/strain, ankle), S93.439A (tibiofibular ligament sprain), S06.0X0XA (concussion), S06.0X9A (concussion with loss of consciousness), S06.0X0A (concussion, mental confusion without loss of consciousness).

a concussion ($P = .006$). No differences were found between groups regarding global or domain-specific HRQOL trajectories over the recovery time points.

Normative values for the PedsQL in athletes have been established and allow for some comparison with this study's sample.[33] In general, our total and subscale scores were lower than the age-matched normative values, with a few notable exceptions: psychosocial (normative = 88.9 ± 10.7; concussion $T_2 = 88.2 \pm 11.8$; ankle sprain $T_2 = 92.6 \pm 11.2$), emotional (normative = 88.8 ± 14.6; concussion $T_2 = 90.2 \pm 14.7$; ankle sprain $T_2 = 92.8 \pm 12.2$), social (normative = 94.0 ± 10.0; concussion $T_2 = 94.5 \pm 10.7$; ankle sprain $T_2 = 94.2 \pm 11.7$), and school (normative = 83.9 ± 15.0; ankle sprain $T_1 = 85.4 \pm 14.5$; ankle sprain $T_2 = 90.8 \pm 12.7$). Thus, we see that the PedsQL scores in our sample of patients who had experienced either concussion or ankle injury appeared to normalize regarding psychosocial functioning, emotional functioning, and social functioning by the second time point (11-29 days after injury), and patients who had sustained an ankle injury did not appear to have a deficit in school functioning at either time point. However, although patients' total scores improved, they remained lower than the normative scores at both time points (normative = 89.8 ± 9.6; concussion $T_1 = 83.2 \pm 11.8$; concussion $T_2 = 87.5 \pm 12.1$; ankle sprain $T_1 = 79.6 \pm 15.9$; ankle sprain $T_2 = 87.6 \pm 12.6$).[33]

Regardless of the type of injury, patients in this study demonstrated a positive effect of time on the improvement of their perceived HRQOL. For both the concussion and acute ankle injury patient groups, ratings of global and specific HRQOL dimensions were consistently lowest at the initial time point at which the clinician administered the PedsQL, then increased significantly in the follow-up assessment. This positive impact of time generally aligns with previous HRQOL research for adolescent athletes recovering from an SRC or an acute musculoskeletal injury.[25,40,49,53] However, research has suggested that despite this generally positive directionality, deficits to an athlete's HRQOL may persist even after the injury's typical recovery window, emphasizing the importance of effective treatment and social support to aid in mitigating a potential decline in HRQOL as the athlete attempts to move forward from an injury.[14,21,30,32]

Although global and domain-specific HRQOL showed an improvement between time points in our sample, our injury groups' differences illuminate the importance of treating HRQOL in a domain-specific sense. For instance, the

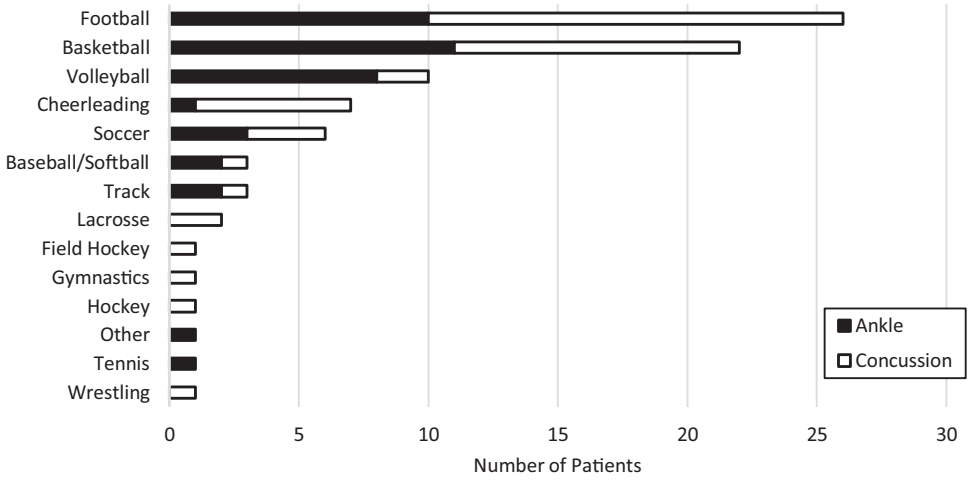

Figure 2. Injury frequency by sport.

TABLE 2
PedsQL Scores Across Time Points According to Injury Group

	Concussion		Ankle Sprain		*P* Value[a]		
PedsQL score	T_1	T_2	T_1	T_2	Time	Group	Time × Group
Total	83.2 ± 11.8	87.5 ± 12.1	79.6 ± 15.9	87.6 ± 12.6	**<.001**	.492	.188
Physical functioning	81.4 ± 16.7	86.2 ± 15.7	67.5 ± 30.1	78.3 ± 19.3	**.002**	**.005**	.231
Emotional functioning	82.9 ± 15.6	90.2 ± 14.7	83.2 ± 16.7	92.8 ± 12.2	**<.001**	.615	.457
Social functioning	91.3 ± 12.0	94.5 ± 10.7	89.7 ± 12.2	94.2 ± 11.7	**.001**	.694	.560
Psychosocial functioning	84.1 ± 12.0	88.2 ± 11.8	86.1 ± 11.8	92.6 ± 11.2	**<.001**	.170	.282
School functioning	78.2 ± 17.0	80.0 ± 20.0	85.4 ± 14.5	90.8 ± 12.7	**.025**	**.006**	.269

[a]Bolded *P* values indicate statistical significance ($P \leq .05$). PedsQL, Pediatric Quality of Life Inventory; T_1, 0-2 days post-injury; T_2, 11-29 days post-injury.

significantly lower school functioning scores in patients with an SRC indicate that boosted academic support may be a more urgent need during the acute stage of postinjury to assist in successful return to school,[48] whereas the deficits noted in physical functioning among patients with an ankle injury identify the need for a more traditional physical rehabilitation intervention emphasis. Clarifying these most salient domains of HRQOL affected by an SRI can help clinicians and sport stakeholders anticipate their patients' areas of need, while also aiding effectiveness and efficiency of treatment decisions.

Whereas the domains of significant group differences generally aligned with the nature of the athlete's injury (ie, school for concussion; physical for ankle), other domains of HRQOL measured in this study did not differ by group despite logical alignment with the differential characteristics of these injuries. For example, there were no significant differences found between the injury groups' levels and trajectories in the "psychological" domain, which would reasonably correspond to greater impact for the concussion group.[15,16,47] It is possible that the generic nature of the PedsQL used to measure HRQOL in this study lacked sufficient sensitivity to exhibit the clinical disruptions to injured patients' psychological well-being previously found in the literature.[6,15,25,28,29] Outcome measures that are more specific to domains of HRQOL can be used to further flesh out distinct clinical profiles associated with injury types such as SRCs[28,29] in conjunction with the injury comparison approach of the current study.

In this study, it was encouraging to see that both injury groups' global and domain-specific HRQOL perceptions improved over time, indicating a sense of perceived improvement in health status. However, the context of our data collection has important clinical implications, as we did not have baseline, preinjury scores for HRQOL in this patient sample. Previous research has identified barriers that patients face as they recover from various types of injuries, which may inhibit them from returning to or maintaining their preinjury HRQOL.[1,9] These barriers are evident in the physical domain such as joint and muscle pain, stiffness, or lack of flexibility[10,13,46] but also extend into the psychological and social domains such as fear of reinjury, kinesiophobia, and low quality of social support.[1,38,50,53,55] Prospective and longitudinal designs would aid in extending our understanding of potential between-group differences based on injury type as high school athletes

navigate the challenges and barriers of their long-term participation in sport and exercise.

SRIs have been shown to affect not only the physical health of athletes but also their holistic well-being and quality of life.[23,47,53-55] Understanding the degree and trajectory of disruption to adolescent athletes' HRQOL after having an SRI enables sport medicine clinicians and practitioners to develop more targeted strategies to treat areas of deficit over the course of recovery. Although the results of this study align logically with the expectation for HRQOL to increase as high school athletes recover from an SRI, the groups' universally lower perceptions for the initial HRQOL assessment indicate an important point of clinical impact: clinicians must be cognizant of the relatively lower HRQOL that their patients may exhibit early in their recovery timelines from an SRC or acute ankle injury. Previous research has shown that multiple stakeholders are typically leaned on by athletes for social support, and this need is compounded after an athlete sustains an SRI.[50,61] Facilitating communication between supporting individuals—including athletic trainers, coaches, parents, and school nurses—that emphasizes a sensitivity to domain-specific areas of potential deficits can aid in treatment while strengthening the effectiveness and efficiency of the athlete's support systems.[7,26] Additionally, these increasing trajectories of health following the recovery timeline in our study may differ from injuries with more prolonged, fluctuating recoveries or season-ending injuries, such as patients recovering from anterior cruciate ligament reconstruction.[9,25,37] Exploration of the trajectories and perceptions of HRQOL in other injury types of differential severity, recovery time, and primary domains of disruption is warranted.

Limitations

There are several limitations of this study that provide context to the results and merit consideration when interpreting our findings. First, the practical reality of the AT-PBRN includes a reliance on clinicians' self-compliance to the standard protocols for using the EMR system as well as their ability to systematically administer patient-reported outcome measures in their settings. Logistical challenges (eg, lack of interface with their patients, inability to follow-up, or time limitations) may affect their ability to fully perform these procedures, as evidenced by our study's relatively small sample size despite the multisite design over a lengthy duration of time. In-depth exploration of the facilitators and barriers for using the AT-PBRN may improve the effectiveness of data collection and provide context to the cases that were included in this study.

Secondly, while there were a large number of patients diagnosed with a concussion or ankle sprain during the time period, the PedsQL was collected only at the 2 specified time points in 85 patient cases. Concerted efforts are being employed to support athletic trainers in their use of patient-reported outcome measures during routine clinical care.[31,57] We anticipate that these efforts will ultimately increase the number of cases included in AT-PBRN studies and improve the yield of data collected for future investigations.

A third limitation was that the patient records did not include a baseline preinjury rating of the athletes' HRQOL related to global and subdomains of health. Collecting these preinjury data in future research can help identify the potential needs for treatment that extend beyond domains of physical functioning and improve our understanding of the degree to which the athlete returns to his or her prior levels of HRQOL once the injury has healed. Last, the analyses in this study did not account for characteristics of the patients' health care environment (ie, socioeconomic status, race/ethnicity, and geographic location), and studies that evaluate these factors are essential for understanding clinical patterns of all patients and for further understanding of the generalizability of these results.

CONCLUSION

These results indicate that in high school athletes, the domains of HRQOL stemming from an SRI may be influenced by the type of injury. While each group exhibited improved HRQOL between time points, indicating positive recovery, the significant domain-specific group differences suggested that the affected areas of HRQOL closely aligned with the most salient manifestations of the injury (ie, school functioning vs physical functioning). These findings underscore the importance of assessing and viewing HRQOL as a multidimensional construct to drive targeted treatment for patients to increase HRQOL in specific areas throughout the recovery process. The continued evaluation of HRQOL specific to injury type—in adolescent athlete populations as well as others—can confirm or challenge assumptions we make about a patient's experience when recovering from an SRI as well as provide a foundation for effective HRQOL promotion interventions.

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