

# Collision and Contact Sport Participation and Quality of Life Among Adolescent Athletes

David R. Howell, PhD, ATC\*‡; Michael W. Kirkwood, PhD†§; Scott Laker, MD†§; Julie C. Wilson, MD\*‡||

\*Departments of Orthopedics, Sports Medicine Center, and Rehabilitation Medicine, Children's Hospital Colorado, Aurora; Departmens of ‡Orthopaedics, §Physical Medicine and Rehabilitation, and ||Pediatrics, University of Colorado School of Medicine, Aurora

**Context:** Researchers investigating collision and contact sport participation during high school have found mixed results. Understanding the association between current contact and collision sport participation and quality-of-life outcomes can enhance our knowledge about the risks and benefits of sport participation.

**Objective:** To examine quality-of-life outcomes among high school athletes who reported participation in collision and contact sports in the year preceding assessment compared with no- or limited-contact sport athletes.

**Design:** Cross-sectional study.

**Setting:** Preparticipation physical examination.

**Patients or Other Participants:** High school athletes 13 to 18 years of age.

**Main Outcome Measure(s):** We obtained sport participation and Patient-Reported Outcomes Measurement Information System (PROMIS) Pediatric-25 outcomes, which assess self-reported, quality-of-life domains in the preceding 7 days (ie, state assessment). Our grouping variable was collision and contact versus no- or limited-contact sport participation during the year preceding assessment. We used multivariable linear regression models to identify the associations between PROMIS scores and collision and contact sport participation and adjusted for sex; age; history of bone, muscle, ligament, or tendon injury; history of acute fracture or dislocation; and history of concussion.

**Results:** A total of 143 (51%) athletes reported collision and contact sport participation (24% female, mean age = 15.1 ± 1.7 years) and 138 (49%) reported no- or limited-contact sport participation (66% female, mean age = 15.4 ± 1.2 years). A higher proportion of collision and contact sport athletes reported a history of time loss for bone, muscle, ligament, and tendon injuries (51% versus 29%,  $P < .001$ ) and for acute fracture or dislocation (46% versus 26%,  $P < .001$ ) than did no- or limited-contact athletes. After adjusting for covariates, we found that collision and contact sport participation was significantly associated with lower state anxiety ( $\beta = -1.072$ , 95% confidence interval =  $-1.834, -0.310$ ,  $P = .006$ ) and depressive ( $\beta = -0.807$ , 95% confidence interval =  $-1.484, -0.130$ ,  $P = .020$ ) symptom scores.

**Conclusions:** Collision and contact sport athletes reported fewer anxiety and depressive symptoms in the week preceding evaluation than did no- or limited-contact sport athletes, but they had more extensive orthopaedic injury histories. Potential benefits and risks are associated with collision and contact sport participation. These data reinforce the need to examine the assumption that youth collision and contact sports are associated with negative quality of life.

**Key Words:** youth athletes, pediatric athletes, anxiety, depression, pain

## Key Points

- Compared with high school athletes participating in no- or limited-contact sports, those participating in organized contact or collision sports displayed fewer anxiety and depressive symptoms.
- Among boys with no reported history of diagnosed concussion, those involved in contact or collision sports exhibited lower levels of state anxiety than no- or limited-contact sport participants.
- A higher proportion of athletes in contact and collision sports had a history of orthopaedic injury than athletes in no- or limited-contact sports, which may reflect the physical risks of contact and collision sports.
- Potential benefits and risks exist for athletes participating in high school collision sports.

Sport participation among adolescents in the United States has continually risen over the past several decades, with approximately 8 million students reporting current sport participation during high school.<sup>1,2</sup> Physical activity and sport participation are associated with multiple benefits for youth, such as improved physical health, reduced risk of obesity, and decreased rates of smoking and drug use.<sup>3–5</sup> These benefits may be related to the environment in which children participate in sports, and factors such as the type of sport played may influence the

relative benefit gained from participation.<sup>3</sup> Sport participation also carries inherent risks for youth athletes. Due to rapid growth and maturation during adolescence, youth athletes may be vulnerable to a variety of traumatic and repetitive stress injuries.<sup>5,6</sup> The cumulative effects of multiple injuries sustained during adolescence may carry into adulthood, resulting in chronic pain, dysfunction, or repeat injury.<sup>5</sup>

Beyond general sport participation, playing collision or contact sports (or both) during high school has received

increased attention due to concerns over exposure to repetitive head impacts. Most researchers have focused on the association between collision sport participation during high school, such as football, and neurologic outcomes during adulthood. Given the importance of brain development during adolescence, examining the effect of sport participation during this time of life is important. In 1 report, researchers<sup>7</sup> observed that beginning football participation at a younger age (ie, <12 years) was associated with increased self-reported neurologic impairments among a sample of former professional football athletes, whereas another group<sup>8</sup> did not observe an association between age of football exposure and neurologic outcomes. Other studies<sup>9–13</sup> of broad samples of current and former athletes (nonprofessional) revealed no significant associations between participation in collision sports and negative neurologic outcomes. Specifically, among older adults, collision sport participation during college was not associated with neurobehavioral quality-of-life (QoL) outcomes.<sup>9</sup> Furthermore, no significant associations between participation in football before the age of 12 and neurocognitive function were found among current high school and collegiate athletes.<sup>10,11</sup> How head-impact exposures in collision and contact sports during adolescence affect QoL remains unclear, as little attention has been paid to the health quality characteristics of youth athletes during their time of active sport participation. In addition, investigations that include equal representation of female and male athletes, as well as different sports and competition levels, are needed.<sup>14</sup> Delineation of the relative benefits and risks of collision and contact sport participation compared with no- or limited-contact sport participation on QoL among a broad sample of athletes may help to inform relevant stakeholders regarding individual decisions on which sports to pursue during high school.

The primary purpose of our work was to examine whether current participation in collision and contact sports during high school was associated with short-term QoL ratings among a sample of healthy adolescent athletes undergoing a preparticipation examination relative to athletes who reported current participation in no- or limited-contact sports. We hypothesized that QoL domain scores would not be different between collision and contact and no- or limited-contact sport athletes. Secondarily, we sought to determine whether the exposure to repetitive head impacts (rather than diagnosed concussions) that are expected to occur during collision sports (ie, boys' football and lacrosse) was associated with short-term QoL outcomes relative to no- or limited-contact sport participation. We proposed that collision sport participation would not be significantly associated with QoL domain scores relative to no- or limited-contact sport participation among high school boys who reported no history of diagnosed concussion.

## METHODS

### Participants and Study Setting

We investigated high school athletes who were undergoing a preparticipation physical examination (PPE) during May 2018 and May 2019. Participants who completed the PPE were from a single school district and invited to volunteer for the study, which involved answering the study

questionnaires during the PPE. If a participant returned for a PPE during 2019, only data from his or her initial visit were included in the analysis. Before the study, the local institutional review board and local school district approved the study protocol. All enrolled participants and their parent or legal guardian provided written informed consent at the time of enrollment. Our inclusion criteria consisted of being between the ages of 13 to 18 years and receiving full clearance to participate in sport at the time of the examination (in the case of a recent injury). Our exclusion criteria consisted of a preexisting neurologic or psychiatric disorder, a recent concussion diagnosis with ongoing symptoms, or not speaking English.

### Assessment Protocol

All participants completed a set of standardized questionnaires during their PPE that documented their medical history, demographic characteristics, and QoL. The variables obtained for their history and characteristics included sex, age, average training time in sport per week, level of competition (varsity, junior varsity, C team, or D team), and the different organized sports in which they were involved during the year preceding evaluation. To assess lifetime injury history, participants filled out a questionnaire as a part of their PPE. The questions included in the current study were (1) "Have you ever had an injury to a bone, muscle, ligament, or tendon that caused you to miss a practice or a game?" (2) "Have you ever had any broken or fractured bones or dislocated joints?" and (3) "Have you ever had a head injury or concussion?" If necessary, parents were available to assist with completing the questionnaires. Height and weight were obtained and recorded by trained personnel.

### Outcome Variables

To address our primary and secondary aims, we asked participants to complete the Patient-Reported Outcomes Measurement Information System (PROMIS) version 1.1 Pediatric-25.<sup>15,16</sup> This instrument assesses 6 domains: physical function mobility, anxiety, depressive symptoms, fatigue, peer relationships, and pain interference. A single question addresses pain intensity. Each question was answered based on the participant's experience during the past 7 days. Version 1.1 Pediatric-25 is intended for self-reporting by individuals 8 to 17 years of age. Six questions have 5 response options each (ranging from 0 to 4); the pain is rated on a scale from 0 (*no pain*) to 10 (*worst pain you can think of*). The total raw score within each domain is calculated as the sum of all responses (range = 0–24), and a higher score represents more of the concept being measured (ie, zero = *with no trouble or never*, 4 = *not able to do or almost always*). With the exception of pain interference, each of the 6 domains has demonstrated acceptable levels of reliability using the static pen- and paper- short-form assessment.<sup>16</sup>

### Grouping Variable

To address our primary purpose, we divided study participants into 2 groups: collision and contact sport athletes or no- or limited-contact sport athletes. So that we could categorize the participants, we asked them to indicate

**Table 1. Demographic and Injury History Characteristics of the Sport Groups<sup>a</sup>**

Variable	Sport Group		P Value	Effect Size (95% Confidence Interval)
	Collision or Contact (n = 143)	No or Limited Contact (n = 138)		
Female athletes	34 (24%)	91 (66%)	<.001	
Male athletes	109 (76%)	47 (34%)		
Age, y <sup>b</sup>	15.2 (14.3, 16.0)	15.3 (14.5, 16.6)	.18	0.21 (-0.02, 0.45)
Age group	13–15 y: 66 (46%) 16–18 y: 77 (54%)	13–15 y: 59 (43%) 16–18 y: 79 (57%)	.63	
Height, cm	170.7 (14.6)	167.9 (8.2)	.05	0.24 (0.00, 0.47)
Weight, kg	64.6 (17.1)	63.2 (15.0)	.46	0.09 (-0.15, 0.32)
Average time training, h/wk	11.6 (4.9)	11.7 (5.0)	.85	0.02 (-0.23, 0.28)
Varsity athlete	52 (36%)	43 (31%)	.36	
History of bone, muscle, ligament, or tendon injury	73 (51%)	40 (29%)	<.001	
History of acute fracture or dislocation	65 (46%)	35 (26%)	<.001	
History of stress fracture	12 (9%)	7 (5%)	.26	
History of diagnosed concussion	35 (25%)	27 (20%)	.29	
Organized sport(s) played in the past year <sup>c</sup>	Basketball: 42 Cheerleading: 6 Diving: 2 Extreme sports: 1 Football: 74 Gymnastics: 10 Lacrosse: 10 Martial arts: 10 Rugby: 1 Soccer: 29 Water polo: 1 Wrestling: 12	Baseball: 7 Cross-country: 20 Dance: 5 Football (flag/touch): 2 Golf: 7 Horseback riding: 1 Marching band: 4 Poms: 17 Racquetball: 1 Softball: 14 Swimming: 13 Tennis: 10 Track & field: 28 Volleyball: 15		
Lifetime years playing collision and contact sports	7.8 ± 3.6	4.6 ± 3.2	<.001	0.93 (0.57, 1.30)

<sup>a</sup> Continuous variables are presented as mean ± SD; categorical variables are presented as the number included in each group (%).

<sup>b</sup> Data presented as median (interquartile range).

<sup>c</sup> Participants selected all organized sports they played in the past year, so the total n sums to >100%.

all organized sports in which they had been active over the past year. Consistent with the classification of sports according to contact provided by Rice et al,<sup>17</sup> the following were considered collision and contact sports: basketball, cheerleading, diving, extreme sports, football, gymnastics, lacrosse, martial arts, rugby, soccer, water polo, and wrestling. An athlete who reported playing multiple sports was placed in the collision and contact group if any of these sports was listed. Those who reported involvement in other sports were classified as no or limited contact (Table 1).

To address our secondary purpose, we then grouped participants who reported collision sport participation in the past year and compared them with the no- or limited-contact sport athletes. Consistent with the work of past researchers, *collision sports* were defined as those in which purposeful body-to-body collisions occurred as a part of typical gameplay, and they included football, rugby, boys' ice hockey, and boys' lacrosse.<sup>9</sup> No boys' ice hockey or rugby athletes were enrolled in our study, however, leaving only boys' football and lacrosse in this subanalysis. To determine how exposure to repetitive head impacts, rather than concussions, were associated with QoL, we also removed from this analysis participants who reported a history of a diagnosed concussion. Furthermore, as no female athletes in our study reported collision sport participation, only male athletes were included in this analysis.

### Statistical Analysis

All statistical tests were 2 sided and evaluated with a significance level of  $P < .05$ . All analyses were conducted using Stata (version 15; StataCorp, College Station, TX). Continuous variables were presented as means (95% confidence intervals [CIs]) or medians (interquartile ranges), and categorical variables were presented as the number included and corresponding percentage. We compared differences between collision and contact and no- or limited-contact sport groups for demographic, training, and injury history variables using independent-samples  $t$  tests and  $\chi^2$  analyses.

Consistent with our first purpose, the primary grouping variable was sport type (collision and contact versus no- or limited-contact sport). To assess univariable differences between sport types, we compared PROMIS domain scores between groups using Mann-Whitney U tests. We then constructed a series of multivariable linear regression models. The outcome in each model was the PROMIS domain score, the predictor variable was sport type (collision and contact versus no- or limited-contact sport), and the covariates were factors that may have affected PROMIS outcomes (sex; age; history of time loss for bone, muscle, ligament, or tendon injury; history of bone fracture or dislocation; and history of concussion).

Consistent with the secondary purpose of our study and past findings,<sup>9</sup> we then constructed multivariable linear regression models for which our grouping variable was

**Table 2. Univariable PROMIS Domain Comparisons Between Collision and Contact and No- or Limited-Contact Sport Groups**

PROMIS Domain	Sport Group				Mann-Whitney U		Effect Size (95% Confidence Interval)
	Collision and Contact		No or Limited Contact		Z Test Statistic	P Value	
	Median (IQR)	Mean ± SD	Median (IQR)	Mean ± SD			
Mobility	0 (0, 0)	0.09 ± 0.36	0 (0, 0)	0.21 ± 0.56	2.49	.013	0.26 (0.02, 0.50)
Anxiety <sup>a</sup>	0 (0, 2)	1.55 ± 2.39	2 (0, 6)	3.26 ± 3.35	4.68	<.001	0.59 (0.35, 0.83)
Depressive symptoms <sup>a</sup>	0 (0, 1)	0.82 ± 1.76	0 (0, 2)	1.88 ± 3.14	2.79	.005	0.42 (0.18, 0.65)
Fatigue	1 (0, 3)	1.67 ± 2.38	1 (0, 3)	2.16 ± 2.72	1.71	.087	0.19 (−0.05, 0.43)
Peer relationships	15 (13, 16)	13.6 ± 4.07	15 (12, 16)	13.0 ± 4.18	−1.33	.183	0.14 (−0.10, 0.37)
Pain interference	0 (0, 2)	1.32 ± 2.44	0 (0, 2)	1.53 ± 2.90	−0.23	.81	0.08 (−0.16, 0.31)
Pain scale	0 (0, 2)	1.08 ± 1.52	0 (0, 1)	0.89 ± 1.67	−1.86	.06	0.12 (−0.13, 0.36)

Abbreviations: IQR, interquartile range; PROMIS, Patient-Reported Outcomes Measurement Information System.

<sup>a</sup>  $P < .05$ .

sport type (collision sport only versus no- or limited-contact sport) and our outcome variable was each PROMIS domain score among only male athletes who reported no history of concussion. The covariates in these models were age; history of time loss for bone, muscle, ligament, or tendon injury; and history of bone fracture or dislocation. Before performing regression analyses, we assessed collinearity within each model using variance inflation factors. If 2 variables were *collinear*, defined as a variance inflation factor of  $>2.5$ , only 1 variable was included in the model.

## RESULTS

A total of 281 adolescents participated in the study, and 143 (51%) reported collision and contact sport participation in the year before the study. A greater proportion of females was in the no- or limited-contact sport group than in the collision and contact sport group (Table 1). In addition, a higher proportion of collision and contact sport athletes reported a history of time-loss bone, muscle, ligament, or tendon injury or a history of acute fracture or dislocation than did no- or limited-contact sport athletes. The groups did not differ in the proportion of athletes who had sustained a diagnosed concussion.

Univariable comparison revealed that those in the collision and contact sport group reported lower mobility, anxiety, and depressive symptom domain scores than the no- or limited-contact sport group (Table 2). After covariate adjustment, collision and contact sport participation was still significantly associated with lower anxiety and depressive symptom domain scores (Table 3). Some covariates were also significantly associated with PROMIS domain outcomes. Female sex was significantly associated with higher anxiety ( $\beta = -1.77$ , 95% CI =  $-2.52$ ;  $-1.01$ ,  $P$

$< .001$ ) and depressive ( $\beta = -0.99$ , 95% CI =  $-1.67$ ,  $-0.07$ ;  $P = .004$ ) symptom scores, whereas a history of bone, muscle, ligament, or tendon injury was significantly associated with higher pain scale scores ( $\beta = 0.69$ , 95% CI =  $0.25$ ,  $1.13$ ;  $P = .002$ ).

A total of 55 male athletes reported collision sport participation in the year preceding evaluation and no history of concussion ( $n = 45$  football,  $n = 4$  lacrosse, and  $n = 6$  football and lacrosse). Thirty-eight male athletes reported no- or limited-contact sport participation in the year preceding evaluation and no history of concussion (Table 4). After covariate adjustment, collision sport participation was significantly associated with lower anxiety scores and higher pain scale scores (Table 5). No covariates were significantly associated with PROMIS outcomes. A greater proportion of those in the collision sport group also reported a history of time-loss bone, muscle, ligament, or tendon injury than among the no- or limited-contact sport athletes (46% versus 14%,  $P = .001$ ).

## DISCUSSION

Our cross-sectional investigation of uninjured high school athletes indicated that current collision and contact sport athletes reported lower levels of current anxiety and depressive symptoms than high school athletes who were currently participating in no-contact or limited-contact sports. Additionally, we found that collision and contact sport athletes had a more extensive orthopaedic injury history than no- or limited-contact sport athletes. The PROMIS outcomes, however, reflected attitudes in the week preceding assessment and, thus, represent a situational or state assessment rather than an enduring or trait assessment, so these findings should be interpreted

**Table 3. Effect of Collision and Contact Sport Participation on Patient-Reported Quality of Life (PROMIS) Outcome Measures<sup>a</sup>**

PROMIS Domain	$\beta$ Coefficient	Standard Error	95% Confidence Interval	P Value
Mobility	−0.106	0.065	−0.235, 0.023	.11
Anxiety <sup>b</sup>	−1.031	0.388	−1.795, −0.268	.008
Depressive symptoms <sup>b</sup>	−0.753	0.346	−1.433, −0.072	.030
Fatigue	−0.190	0.347	−0.872, 0.492	.58
Peer relationships	0.430	0.574	−0.700, 1.560	.46
Pain interference	−0.120	0.371	−0.845, 0.610	.75
Pain scale	0.157	0.221	−0.278, 0.591	.48

Abbreviation: PROMIS, Patient-Reported Outcomes Measurement Information System.

<sup>a</sup> Covariates in each model were sex; age; past history of bone, muscle, ligament, or tendon injury; past history of bone fracture or dislocation; and concussion history.

<sup>b</sup>  $P < .05$ .

**Table 4. Demographic and Injury History Characteristics Between Contact or Collision Sport Athletes and No- or Limited-Contact Sport Athletes with No History of Concussion<sup>a</sup>**

Variable	Sport Group		P Value	Effect Size (95% Confidence Interval)
	Contact or Collision (n = 55)	No or Limited Contact (n = 38)		
Male athletes	55 (100)	38 (100)		
Age, y <sup>b</sup>	14.9 (14.2, 16.0)	14.9 (14.5, 16.1)	.88	0.13 (−0.28, 0.55)
Age group	13–15 y: 28 (51) 16–18 y: 27 (49)	13–15 y: 20 (53) 16–18 y: 18 (47)	.87	
Height, cm	174.2 ± 18.0	174.2 ± 7.4	.99	0.00 (−0.41, 0.42)
Weight, kg	71.1 ± 17.5	65.8 ± 19.1	.17	0.29 (−0.13, 0.71)
Average time training, h/wk	13.2 ± 5.5	10.9 ± 4.4	.06	0.46 (−0.03, 0.95)
Varsity athlete	19 (35)	8 (21)	.16	
History of bone, muscle, ligament, or tendon injury	25 (45)	5 (13)	.001	
History of acute fracture or dislocation	24 (44)	9 (24)	.05	
History of stress fracture	5 (9)	2 (5)	.48	
Organized sports played in the past year	Football: 45 (82) Football and lacrosse: 6 (11) Lacrosse: 4 (7)	Baseball: 2 (5) Cross-country: 8 (21) Golf: 5 (13) Marching band: 2 (5) Swimming: 4 (11) Tennis: 7 (18) Track & field: 10 (26)		
Lifetime years playing collision/contact sports	7.3 ± 3.0	4.1 ± 3.0	.001	1.09 (0.43, 1.74)

<sup>a</sup> Continuous variables are presented as mean ± SD; categorical variables are presented as the number included in each group (%).

<sup>b</sup> Data presented as median (interquartile range).

accordingly. Finally, we observed that among boys who reported no history of diagnosed concussion, collision sport participation (ie, football or lacrosse or both) was significantly associated with less reported anxiety but higher pain levels than those in no- or limited-contact sports. Given the cross-sectional design of our study, we cannot infer causation from these findings. Nevertheless, the results provide insights into the relative benefits and risks of participation in collision and contact sports during high school compared with no-contact or limited-contact sports.

The association between sport type and QoL outcomes in high school athletes is likely multifactorial and complex. Our finding that collision and contact sport participation in the year before the assessment was associated with reduced current anxiety and depressive symptom ratings relative to no- or limited-contact sport participation is therefore likely to be due to many factors, some of which we did not investigate (eg, socioeconomic status, sport availability at school, or race and ethnicity). Sports of all types allow youth to experience challenges and enjoyment and can help to increase self-esteem and decrease stress.<sup>18</sup> Team-

oriented sports may offer added benefits, as researchers<sup>19</sup> documented fewer anxiety symptoms (eg, panic and agoraphobia) among these athletes than among athletes in individual sports. The collision and contact sport group primarily consisted of athletes who were involved in team sports, so the benefits of teamwork may be one source of possible differences in anxiety and depressive symptoms. Also, individuals who choose collision and contact sports may inherently have fewer anxiety and depressive symptoms than those who choose no- or limited-contact sports. For example, a higher proportion of female athletes were in the no- or limited-contact sport group than in the collision and contact sport group. Female athletes may have a higher prevalence of anxiety symptoms than male athletes,<sup>20</sup> and this group may have been more prone to reports of anxiety due to the proportional difference in sex. Although we adjusted for this variable in our multivariable analysis, the effects of sport participation and inherent traits such as biological sex should be considered when interpreting the association between QoL and sport participation.

In contrast to the potential benefit of fewer anxiety and depressive symptoms among the collision and contact sport

**Table 5. Effect of Contact or Collision Sport Participation (Football and Lacrosse) on Patient-Reported Quality of Life (PROMIS) Outcome Measures Among Male Participants with No Reported History of Concussion<sup>a</sup>**

PROMIS Domain	β Coefficient	Standard Error	95% Confidence Interval	P Value
Mobility	−0.125	0.083	−0.289, 0.039	.13
Anxiety <sup>b</sup>	−1.219	0.426	−2.066, −0.373	.005
Depressive symptoms	−0.522	0.265	−1.048, 0.004	.05
Fatigue	−0.281	0.521	−1.065, 1.009	.96
Peer relationships	0.739	1.039	−1.326, 2.805	.48
Pain interference	0.112	0.485	−0.853, 1.077	.82
Pain scale <sup>b</sup>	0.672	0.273	0.128, 1.215	.016

Abbreviation: PROMIS, Patient-Reported Outcomes Measurement Information System.

<sup>a</sup> Covariates in each model were age; history of bone, muscle, ligament, or tendon injury; and history of bone fracture or dislocation.

<sup>b</sup> P < .05.

athletes, the risks of participating in these sports were also evident in our findings. Specifically, a higher proportion of these athletes reported a history of time-loss orthopaedic injuries than did the no- or limited-contact athletes. This result aligns with the findings of other epidemiologic researchers<sup>21,22</sup> who described a greater prevalence of bone, joint, and muscle injuries among collision and contact athletes than among no- or limited-contact athletes. As such, it appears that collision and contact sport participation may be associated with both a greater risk of orthopaedic injury and fewer anxiety and depression symptoms. Interestingly, the proportion of participants within each group who reported a history of a diagnosed concussion did not differ. This was surprising given past studies<sup>23,24</sup> that demonstrated a higher risk of concussion among collision and contact sport high school athletes than among no- or limited-contact sport athletes. However, concussions can occur from a variety of sport- and recreation-related injuries in childhood and adolescence,<sup>25</sup> potentially leading to the similar proportions of those with a past concussion. The fact that we relied on self-reporting of a head injury or concussion rather than requiring a medically diagnosed concussion or brain injury could have influenced these results as well.

For our secondary purpose, we compared male athletes with no lifetime concussions who participated in collision sports and those who participated in no- or limited-contact sports. Unexpectedly, our results indicated that the collision sport athletes reported less anxiety than the no- or limited-contact sport athletes. It is evident that a concussion during adolescence can cause QoL alterations and that the effects can be long-lasting,<sup>9,26,27</sup> but the effects of repetitive head impacts are less clear. In our sample, collision sport participation was not associated with worse QoL during high school in the absence of a diagnosed concussion and, in fact, was associated with fewer anxiety symptoms. Causality cannot be inferred from this finding, however, as it suggests that either less anxious athletes are more likely to play collision sports or participating in collision sports is potentially beneficial, possibly due to the positive effects of team sports, or both.<sup>19</sup> Yet any potential benefit must be weighed against the potential relative risks. The higher pain scale scores among the collision sport male athletes may relate to their greater proportion of past orthopaedic injuries than among the no- or limited-contact male athletes. Given the small sample in this secondary analysis, future researchers need to confirm these results, but they do suggest that potential benefits and risks exist during high school collision sports.

Our study had a number of limitations, and our interpretation of the findings must be considered in light of them. The cross-sectional nature of the study eliminates the ability to establish any causality related to the effect of sport participation on QoL outcomes. Additionally, our participants were from a single school district. As such, our results cannot be generalized or extrapolated to other geographic locations. No female athletes reported collision sport participation in the year preceding assessment, so we could only examine boys in our secondary purpose. Future investigators should pursue valid comparisons by sex. Finally, our reliance on self-reported injury histories may have influenced the findings. Prospective injury-monitoring

approaches may permit causation to be established between the factors we observed.

## CONCLUSIONS

High school athletes who were currently participating in organized collision and contact sports reported fewer anxiety and depressive symptoms than those currently participating in no- or limited-contact sports. Furthermore, among boys with no reported history of diagnosed concussion, current collision sport participation was associated with lower state anxiety levels than among boys who participated in no- or limited-contact sports. However, our study design prohibited any interpretation related to long-term QoL in this cohort. Yet our results reinforce the need to reexamine assumptions that youth collision and contact sports are necessarily associated with negative QoL. The higher proportion of those with a history of orthopaedic injury among collision and contact sport athletes suggests that there may be physical risks to participation in these sports. Future researchers should better understand any causal relationship between contact sports and psychological well-being in young athletes, both in the short and long term, and determine the risks and benefits of playing different types of sports during high school.

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*Address correspondence to David R. Howell, PhD, ATC, Sports Medicine Center, Children’s Hospital Colorado, Department of Orthopedics, University of Colorado School of Medicine, 13123 East 16th Avenue, B060, Aurora, CO 80045. Address email to David. Howell@CUanschutz.edu.*