JSES Reviews, Reports, and Techniques 1 (2021) 90–95

Contents lists available at ScienceDirect

JSES Reviews, Reports, and Techniques

journal homepage: www.jsesreviewsreportstech.org

The association of sport participation behaviors with throwing-arm health in Little League Baseball pitchers

Eric G. Post, PhD, ATC [a,*], Michael D. Rosenthal, DSc, PT [b], Andrew T. Pennock, MD [c], Mitchell J. Rauh, PhD, PT, MPH, FACSM [d]

[a] Department of Applied Medicine and Rehabilitation, Indiana State University, Terre Haute, IN, USA
[b] College of Allied Health, University of Nebraska Medical Center, Omaha, NE, USA
[c] Rady Children's Hospital, San Diego, CA, USA
[d] Doctor of Physical Therapy Program, San Diego State University, San Diego, CA, USA

ARTICLE INFO

Keywords:
Shoulder
Elbow
Pediatric sports medicine
Injury prevention
Baseball

Level of evidence: Level III

Background and Hypothesis: There is increasing concern about the role sport specialization might play in the increasing injury rates observed among youth baseball pitchers. However, existing research on specialization in baseball has focused on high school and professional baseball populations. We hypothesized that pitchers who were highly specialized, reported pitching more than eight months in the past year, received private coaching, or pitched with pain or fatigue in the previous year would report worse throwing-arm health.

Methods: One-hundred eighty-four Little League pitchers (boys N = 181, age 9.8 ± 1.6 years old) between 7 and 12 years of age completed an anonymous, online questionnaire with their parents' assistance. The questionnaire consisted of participant demographics, sport specialization status, months of pitching per year, whether they traveled regularly to participate in showcases, if they received private coaching, whether they pitched with elbow or shoulder pain, whether they pitched with fatigue, and the Youth Throwing Score (YTS), a valid and reliable patient-reported outcome measure for youth baseball players. The associations between variables of interest and YTS were examined using multivariable linear regression, adjusting for covariates.

Results: Sport specialization, pitching year-round, and receiving private coaching were not associated with the YTS ($P > .05$). Pitching with pain in the previous year was associated with a worse YTS score than pitching without pain (least square mean [standard error]: 49.6 [1.8] vs. 57.8 [1.1], $P < .001$). Similarly, pitching with fatigue in the previous year was associated with worse YTS scores (least square mean [standard error]: 52.1 [1.4] vs. 55.3 [1.3], $P = .01$). Pitchers who reported traveling regularly for showcases scored worse on the YTS compared with those who did not travel regularly for showcase events (least square mean [standard error]: 51.0 [2.0] vs. 56.4 [0.9], $P = .01$).

Conclusions: Pitching with pain or fatigue was associated with worse throwing-arm health in Little League baseball pitchers. While traveling at least once a month to participate in showcases was also associated with worse throwing-arm health, specialization and private coaching were not related to worse throwing health. Clinicians working with pediatric patient populations should be aware that while the factors examined in this article were reported relatively infrequently, screening for Little League pitchers who participate in showcases or pitch with pain or fatigue may be an effective strategy for identifying these individuals who are at higher risk of injury.

More than 4 million children between the ages of 6 and 12 years participated in youth baseball in 2018.[31] Pitching has been identified as a baseball position that presents unique risks for injury among youth and professional baseball players. A recent meta-analysis concluded that being a pitcher was a significant risk factor for elbow injury in youth baseball players.[1] Owing to the increasing incidence of ulnar collateral ligament sprains among youth players and the immense burden represented by

This study was approved by the Institutional Review Boards at San Diego State University. (Study HS-2019-0107).

* Corresponding author: Eric G. Post, PhD, ATC, Indiana State University, 567 N 5th Street, Terre Haute, IN 47809, USA.
E-mail address: eric.post@indstate.edu (E.G. Post).

https://doi.org/10.1016/j.xrrt.2021.02.001

throwing-related injuries at all levels of baseball, there has been a significant amount of research focused on identifying injury risk factors among youth baseball pitchers. Previously identified risk factors for injury among youth pitchers include excessive pitching volume (pitches per game or innings per year), pitch velocity, deficits in shoulder range of motion or strength, age, and arm fatigue.[1,3,17,26]

Across youth sports generally and within the youth baseball community specifically, there has been increasing concern regarding year-round intensive focus in a single sport at the exclusion of other sports, also known as sport specialization.[15,32] While sport specialization has been identified as a risk factor for lower extremity overuse injuries among athletes from a variety of sports, there has been limited research examining the potential risks of specialization among baseball pitchers.[4] Findings from several studies examining year-round pitching as a risk factor for injury among adolescent pitchers have been equivocal.[7,18,30] A series of magnetic resonance imaging studies among asymptomatic Little League baseball athletes found that year-round baseball participation, specialization in baseball, and private coaching were associated with elbow or shoulder magnetic resonance imaging abnormalities.[11,12,20,21,24] To our knowledge, there have been no reported findings on the association of specialization with injury specifically among Little League pitchers, which may be partially attributed to the difficulties inherent in collecting reliable injury data in younger populations.

Therefore, the purpose of this article was to determine whether factors related to sport specialization were associated with throwing-arm health among Little League baseball pitchers. We hypothesized that pitchers who were highly specialized reported pitching more than eight months in the past year, received private coaching, or pitched with pain or fatigue in the previous year would report worse throwing-arm health.

Materials and methods

Participants

This study was approved by the Institutional Review Board at San Diego State University. Twelve Little League organizations in Southern California were recruited to send e-mails between June and December 2019 to parents whose children participated in their organization. Parents received an e-mail with a link to an anonymous, online questionnaire for their child to complete. To participate in the study, the child had to have been between the ages of 7 and 12 years and had to have participated on an organized baseball team in the previous 12 months. The requirement for signed informed consent was waived owing to the anonymous nature of the survey, but by reading the informational page at the start of the questionnaire and choosing to continue, participants were considered to have provided consent. Parents were encouraged to help their child complete the survey in case their child had any questions. Of the 246 Little League athletes who completed the questionnaire, 184 (74.7%) indicated that they had pitched for their team in the previous year and were included in the study's final analysis.

Questionnaire

The questionnaire consisted of three sections: (1) participant demographics (including age, sex, and year in school), (2) baseball participation information (including primary baseball position, sport specialization status, and baseball participation volume), and (3) the Youth Throwing Score (YTS). The questionnaire was designed to be completed in less than 10 minutes and was written at a Flesch-Kincaid Grade Level of 2.9.

Participants were classified as either low, moderate, or highly specialized using a validated specialization Jayanthi scale that was recently modified to improve its accuracy.[16] Throwing-arm health was assessed using the YTS, a validated and reliable 14-item outcome measure for youth baseball players.[2] The YTS was originally developed to provide a tool to assess the upper extremity health of younger baseball players via self-report.[2] Responses on the YTS generated a score between 14 and 70, with higher scores indicating better arm health.[2] Participants were asked whether they traveled overnight regularly (at least once a month) for baseball showcases, if they received coaching outside of their Little League team, and to indicate the number of months in the previous year that they played baseball and the number of months that they pitched. Participants were also asked whether they had ever pitched with elbow or shoulder pain in the previous year and if they had pitched with fatigue during the past year. Finally, participants were asked to provide the number of innings they had pitched in the previous year, and the average number of pitches they threw during a typical game. As only 101 of the pitchers (54.9%) responded to these final two questions, these two variables were only presented in the univariate analyses and not included in the final regression analysis.

Statistical analysis

Data were summarized using means and standard deviations, medians and interquartile ranges, and frequencies and proportions (%). Univariate parametric analyses (independent t-tests, one-way analyses of variance) and bivariate correlations (Pearson's r) were used to examine mean differences and associations of YTS based on variables of interest. Cohen's d effect sizes (ES) were calculated with 95% confidence intervals (95% CIs) for differences in YTS between categorical variables, with ES < 0.20 considered a small effect, ES = 0.50 considered a medium effect, and ES > 0.80 considered a large effect.[14]

Multivariable linear regression was used to examine the association between variables of interest and YTS. Least square mean (LS-Means) estimates with standard errors (SE) were calculated for the variables of interest from the linear regression model, adjusting for covariates. Selection of factors to include in the model consisted of any variable that was significant in the univariate analysis. The final model consisted of specialization status, age, regular travel for showcases, pitching with pain in the previous year, and pitching with fatigue in the previous year. The multivariable linear regression model was assessed to determine whether it met the assumptions of linear regression using the Global Validation of Linear Models Assumptions package[19] in R and via visual inspection of quantile-quantile and residual plots. Comparisons of LS-Mean estimates of YTS between levels of the variables of interest were conducted using post hoc pairwise Tukey's honestly significant difference tests. Statistical significance was set at 2-sided a priori $P < .05$, and all analyses were performed in R statistical software (R Foundation for Statistical Computing, Vienna, Austria).

Results

One-hundred eighty-four Little League pitchers (boys N = 181, age 9.8 ± 1.6 years) completed the questionnaire. Participant demographics and sport participation characteristics are presented in Table I. Approximately 1 in five (20.8%) participants reported that pitching was their primary baseball position. Only 15.8% of the pitchers were classified as highly specialized and only 16.4% reported pitching more than eight months in the previous year. Approximately 1 in ten (9.8%) pitchers reported pitching with pain

in the previous year, while 1 in four (26.1%) pitchers reported pitching with fatigue in the previous year.

Univariate differences in YTS based on categorical baseball participation variables are presented in Table II. Highly specialized athletes scored significantly worse on the YTS compared with low specialization athletes (57.0 ± 9.2 vs. 61.4 ± 7.9, $P = .03$). There were no significant differences in YTS between pitchers who reported pitching as their primary position and those who did not, between those that reported receiving private coaching and those who did not, or between those that reported pitching year-round in the last year and those who did not ($P > .05$). Pitchers who reported traveling regularly for showcases had worse scores on the YTS than those who did not travel regularly for showcases (53.6 ± 10.4 vs. 61.0 ± 7.6, $P = .03$). Pitchers who reported pitching with pain sometime in the previous year had worse scores on the YTS compared with those who did not pitch with pain (50.3 ± 6.6 vs. 61.5 ± 7.3, $P < .001$). Similarly, those who reported pitching with fatigue in the previous year had worse scores than those who did not (55.9 ± 7.5 vs. 62.0 ± 7.6, $P < .001$).

Correlations of continuous baseball participation characteristics with YTS are presented in Table III. Increased age (Pearson's r [95% CI]: −0.16 [−0.30 to −0.02], $P = .03$), increased innings pitched in the previous year (Pearson's r [95% CI]: −0.23 [−0.41 to −0.04], $P = .02$), and increased average pitches thrown per game (Pearson's r [95% CI]: −0.27 [−0.44 to −0.08], $P = .01$) were all associated with worse YTS scores. Pitchers' age was also positively correlated with innings pitched in the previous year (Pearson's r [95% CI]: 0.37 [0.19 to 0.53], $P < .001$) and with average pitches per game (Pearson's r [95% CI]: 0.44 [0.26 to 0.59], $P < .001$).

After adjusting for all other factors in the model, the multivariate model indicated that pitching with pain in the previous year was associated with a worse YTS score (LS-Means [SE]: 49.6 [1.8] vs. 57.8 [1.1], $P < .001$) (Table IV). Similarly, pitching with fatigue in the previous year was associated with a worse YTS score (LS-Means [SE]: 52.1 [1.4] vs. 55.3 [1.3], $P = .01$). Pitchers who reported traveling regularly for showcases scored worse on the YTS compared to those who did not (LS-Means [SE]: 51.0 [2.0] vs. 56.4 [0.9], $P = .01$). No significant associations were found between age or sport specialization status with YTS after adjusting for all other factors in the model ($P > .05$).

Table I
Participant demographics and sport participation characteristics (N = 184).

Variable	N (%), mean (SD), or median (IQR)
Sex	
Male	181 (98.4%)
Female	3 (1.6%)
Age	9.8 (1.6)
Baseball start age	5.3 (1.6)
Years of baseball participation	4.5 (2.0)
Mo/Y of organized baseball	7.8 (2.7)
Primary position	
Pitcher	38 (20.8%)
Catcher	37 (20.2%)
First base	26 (14.2%)
Second base	23 (12.6%)
Shortstop	26 (14.2%)
Third base	13 (7.1%)
Outfield	20 (10.9%)
Specialization scale	
Low	86 (46.7%)
Moderate	69 (37.5%)
High	29 (15.8%)
Youth Throwing Score (YTS)	60.4 (8.0)
Travel overnight regularly for showcases	
Yes	13 (7.1%)
No	171 (92.9%)
Receive private coaching outside of League	
Yes	70 (38.0%)
No	114 (62.0%)
Pitched >8 mo per y	
Yes	30 (16.4%)
No	153 (83.6%)
Pitched with pain in previous y	
Yes	18 (9.8%)
No	166 (90.2%)
Pitched with fatigue in previous y	
Yes	48 (26.1%)
No	136 (73.9%)
Innings pitched in previous y*	25 [9-41]
Average pitches per game in previous y*	41.4 (18.4)

* Includes responses from only N = 101 participants.

Discussion

The primary findings of this article were that pitching with fatigue or pain and traveling regularly for showcases were associated with worse throwing-arm health in Little League pitchers. No associations were observed between specialization and year-round pitching with throwing-arm health. To our knowledge, this is the first study to directly examine the association of factors related to sport specialization with a valid and reliable patient-reported measure of throwing-arm health in preadolescent baseball pitchers.

Significant research attention has been directed recently toward the topic of specialization in youth sports.[4,6,15] Among a wide range of youth sports, specialization has been repeatedly identified as a risk factor for lower extremity overuse injuries.[4,10,22,27] This has resulted in a number of medical organizations and sport-governing bodies, including USA Baseball and Major League Baseball, to recommend that youth athletes delay specializing in a single sport for as long as possible.[5,6,8,15,32] However, the evidence regarding the risks of specialization has been more mixed in studies of baseball athletes. In particular, there have been conflicting results between studies of adolescent baseball players as to whether pitching year-round is a risk factor for injury.[7,18,30] The results of our study indicated that there were no significant differences in YTS between pitchers who reported pitching year-round vs. those who did not pitch year-round in the previous year.

There has been limited research among youth baseball using more formal methods of classifying specialization status, such as the Jayanthi specialization scale. A recent study of high school baseball players found that highly specialized pitchers were more likely to report a previous throwing arm overuse injury and scored worse on the YTS compared with low specialization athletes.[23] In contrast, we found no significant differences in YTS based on specialization status after adjusting for covariates. Additional research is needed to determine why these results differed between high school and Little League pitchers. We theorize that the physical effects of specialization may not manifest until the athlete is older. We also suggest that highly specialized high school pitchers may simply have more opportunities to pitch than Little League pitchers and therefore have increased throwing volume, potentially resulting in fatigue and injury.

Receiving private coaching in the previous year was not associated with throwing-arm health, but traveling at least once a month for showcases was associated with lower (worse) scores on the YTS. In a study of 26 asymptomatic Little League baseball players, Pennock et al[21] found that working with a private coach was associated with abnormal MRI findings in the throwing elbow. The difference between this result and our findings may be attributed to the high variability in private coaching quality. Although not assessed in our study, we suggest that high-quality coaching may reduce the likelihood of injury, whereas

Table II
Univariate differences in YTS based on categorical baseball participation characteristics.

Variable	Youth Throwing Score, mean (SD)	Effect size (95% CI)	*P* value
Specialization		0.4 [−0.03 to 0.8]	.03
Low	61.4 (7.9)		
Moderate	60.7 (7.3)		
High	57.0 (9.2)		
Pitcher primary position		0.1 [−0.3 to 0.4]	.74
Yes	60.1 (8.6)		
No	60.6 (7.9)		
Regular travel for showcases		0.7 [0.2 to 1.3]	.03
Yes	53.6 (10.4)		
No	61.0 (7.6)		
Private baseball coaching		0.1 [−0.2 to 0.4]	.45
Yes	59.9 [7.9]		
No	60.8 [8.0]		
Pitch >8 mo		0.1 [−0.3 to 0.5]	.62
Yes	59.8 [8.0]		
No	60.6 [8.0]		
Pitched with pain in previous y		1.7 [1.2 to 2.2]	<.001
Yes	50.3 [6.6]		
No	61.5 [7.3]		
Pitched with fatigue in previous y		0.8 [0.5 to 1.2]	<.001
Yes	55.9 [7.5]		
No	62.0 [7.6]		

YTS, Youth Throwing Score; *SD*, standard deviation; *CI*, confidence interval.

Table III
Correlations of continuous baseball participation characteristics with YTS.

Variable	Pearson's r (95% CI)	*P* value
Age	−0.16 (−0.30 to −0.02)	.03
Baseball start age	−0.12 (−0.26 to 0.02)	.09
Yr of baseball participation	−0.02 (−0.16 to 0.13)	.79
Mo/Y of pitching	−0.10 (−0.24 to 0.05)	.20
Innings pitched in previous y*	−0.23 (−0.41 to −0.04)	.02
Average pitches per game in previous y*	−0.27 (−0.44 to −0.08)	.01

YTS, Youth Throwing Score; *CI*, confidence interval.
* Includes responses from only N = 101 participants.

lower-quality coaching may increase the risk of injury. Therefore, until additional studies can better examine this relationship (eg, assess if certain methods used by coaches are more effective to reduce elbow or shoulder injury), whether or not the use of a private coach may help to minimize a youth pitcher's injury risk remains unclear.

In a study of Little League baseball players, Register-Mihalik et al[25] reported that travel and showcase participation was associated with arm pain and injury, while a more recent study of high school baseball players by Post et al[23] found no association between regular travel for showcase participation and throwing-arm health. Our results are in agreement with the study of Little League athletes by Register-Mihalik et al[25] and suggest that showcase participation at an early age may raise a youth baseball pitcher's risk of injury. Recent discussion regarding sport specialization has highlighted the fact that specialization behavior is likely different between various sports and that the Jayanthi specialization scale may not be the most accurate measure of specialization for all sports.[13] Owing to the unique aspect of showcase participation in baseball as a venue for highly competitive teams or athletes, it is possible that frequent travel for showcase participation may be a better marker of specialized sport behavior among youth baseball athletes than other measures of specialization, such as the Jayanthi scale.

Two recent systematic reviews concluded that pitching with fatigue[17] and a history of pitching with pain[1] are clear risk factors of injury in youth baseball. We also found that both factors were associated with lower (worse) scores on the YTS, even after adjusting for all potential covariates. Furthermore, in the univariate analysis, pitching with pain and pitching with fatigue in the previous year both demonstrated large effect sizes in YTS differences between groups. As a result of the increasing burden of elbow injuries, specifically ulnar collateral ligament sprains, at all levels of baseball, significant research efforts have been dedicated to identifying risk factors for injury.[9,29] These potential risk factors have included physical factors or adaptations, training volume or workload, sport and baseball participation history, and biomechanical factors.[1,3,26,28] Our results, in combination with the studies examined in the systematic reviews previously indicated, suggest that asking whether the youth athlete has pitched with pain or fatigue may represent a simple screening question for identifying athletes at greater risk of injury that would benefit from an individualized injury prevention program.

We acknowledge several limitations in our study. The primary limitation of this study is that we used a cross-sectional study design. Therefore, we cannot establish causality between our variables of interest and throwing-arm health. However, owing to the limited amount of data regarding sport specialization in preadolescent baseball pitchers, we felt that this limitation was acceptable in efforts to increase our ability to assess a larger sample (ie, nearly 200) of Little League pitchers. Second, we only surveyed athletes from Little League organizations in Southern California. Therefore, our results may not be representative of Little League athletes nationwide and from different backgrounds. In addition, we encouraged parents to assist their child in completing the survey, which may have resulted in the child not answering honestly on all aspects of the survey. However, we felt that most participants would not find the questions too sensitive and that having the parents to help clarify any question may provide more valid answers. We also felt that having the parent assist the participant allowed us more access to investigate a younger population that has not been extensively examined in the sport specialization literature. Unfortunately, only half of the pitchers were able to provide a response regarding their number of innings in the previous year and average pitches per outing and therefore that data were not able to be included in the final regression analysis. This is likely a result of the young age of our participants and having to rely on parents to assist their child in responding to the questionnaire. Finally, we were not able to calculate a response rate owing to our survey distribution methodology. All surveys were distributed by

Table IV
Least square mean estimates for YTS based on multivariate linear regression*.

	YTS least squares mean estimate (SE)	*P* value
Sport specialization scale		
Low	54.6 (1.4)	.97†
Moderate	54.3 (1.4)	.37‡
High	52.2 (1.6)	.26§
Regular travel for showcases		
Yes	51.0 (2.0)	.01
No	56.4 (0.9)	
Pitched with pain in previous y		
Yes	49.6 (1.8)	<.001
No	57.8 (1.1)	
Pitched with fatigue in previous y		
Yes	52.1 (1.4)	.01
No	55.3 (1.3)	

YTS, Youth Throwing Score.
Adjusted R^2 for model: 0.24.
* Model includes specialization, age, regular travel for showcases, pitching with pain in previous year, and pitching with fatigue in previous year.
† Comparison between low and moderate specialization categories.
‡ Comparison between moderate and high specialization categories.
§ Comparison between low and high specialization categories.

the 12 Little League administrators to parents in their organization. We felt that having the administrators send out the survey would improve our credibility with members of that organization. However, this also meant that we did not have direct control over the exact number of individuals who had access to the survey.

Conclusion

Traveling at least once a month to participate in showcases and pitching with either pain or fatigue were all associated with worse throwing-arm health in Little League pitchers. Specializing in baseball, pitching year-round, and receiving private coaching were not associated with throwing arm health. Clinicians working with pediatric patient populations should be aware that while the factors examined in this article were relatively rare, screening for Little League pitchers who participate in showcases or pitch with pain or fatigue may be an effective strategy for identifying these high risk individuals.

Conflicts of interest

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

Funding

This study was supported by a grant that was funded by the Far West Athletic Trainers' Association, but this sponsor played no role in study design, collection/analysis/interpretation of data, writing of the manuscript, and decision to submit the manuscript for publication.

References

1. Agresta CE, Krieg K, Freehill MT. Risk factors for baseball-related arm injuries: a systematic review. Orthop J Sport Med 2019;7:2325967119825557. https://doi.org/10.1177/2325967119825557.
2. Ahmad CS, Padaki AS, Noticewala MS, Makhni EC, Popkin CA. The Youth Throwing Score. Am J Sports Med 2017;45:317-24. https://doi.org/10.1177/0363546516667503.
3. Bakshi NK, Inclan PM, Kirsch JM, Bedi A, Agresta C, Freehill MT. Current workload recommendations in baseball pitchers: a systematic review. Am J Sports Med 2020;48:229-41. https://doi.org/10.1177/0363546519831010.
4. Bell DR, Post EG, Biese K, Bay C, Valovich McLeod T. Sport specialization and risk of overuse injuries: a systematic review with meta-analysis. Pediatrics 2018;142:e20180657. https://doi.org/10.1542/peds.2018-0657.
5. Bergeron MF, Mountjoy M, Armstrong N, Chia M, Côté J, Emery Ca, et al. International Olympic Committee consensus statement on youth athletic development. Br J Sports Med 2015;49:843-51. https://doi.org/10.1136/bjsports-2015-094962.
6. Brenner JS, Council on Sports Medicine and Fitness. Sports specialization and intensive training in young athletes. Pediatrics 2016;138:154-7. https://doi.org/10.1542/peds.2016-2148.
7. Chalmers PN, Sgroi T, Riff AJ, Lesniak M, Sayegh ET, Verma NN, et al. Correlates with history of injury in youth and adolescent pitchers. Arthroscopy 2015;31:1349-57. https://doi.org/10.1016/j.arthro.2015.03.017.
8. DiFiori JP, Güllich A, Brenner JS, Côté J, Hainline B, Ryan E, et al. The NBA and Youth Basketball: recommendations for promoting a healthy and positive experience. Sports Med 2018;48:2053-65. https://doi.org/10.1007/s40279-018-0950-0.
9. Erickson BJ, Nwachukwu BU, Rosas S, Schairer WW, McCormick FM, Bach BR, et al. Trends in medial ulnar collateral ligament reconstruction in the United States: A retrospective review of a large private-payer database from 2007 to 2011. Am J Sports Med 2015;43:1770-4. https://doi.org/10.1177/0363546515580304.
10. Hall R, Barber Foss K, Hewett TE, Myer GD. Sport specialization's association with an increased risk of developing anterior knee pain in adolescent female athletes. J Sport Rehabil 2015;24:31-5. https://doi.org/10.1123/jsr.2013-0101.
11. Holt JB, Pedowitz JM, Stearns PH, Bastrom TP, Dennis MM, Dwek JR, et al. Progressive elbow magnetic resonance imaging abnormalities in little league baseball players are common: a 3-year longitudinal evaluation. Am J Sports Med 2019;7:0363546519888647. https://doi.org/10.1177/0363546519888647.
12. Holt JB, Stearns PH, Bastrom TP, Dennis MM, Dwek JR, Pennock AT. The curse of the all-star team: a single-season prospective shoulder MRI study of little league baseball players. J Pediatr Orthop 2020;40:e19-24. https://doi.org/10.1097/BPO.0000000000001391.
13. Jayanthi N, Kliethermes SA, Côté J. Youth sport specialisation: the need for an evidence-based definition. Br J Sports Med 2020;54:196-7. https://doi.org/10.1136/bjsports-2019-101256.
14. Lakens D. Calculating and reporting effect sizes to facilitate cumulative science: a practical primer for t-tests and ANOVAs. Front Psychol 2013;4:1-12. https://doi.org/10.3389/fpsyg.2013.00863.
15. LaPrade RF, Agel J, Baker J, Brenner JS, Cordasco FA, Côté J, et al. AOSSM early sport specialization consensus statement. Orthop J Sport Med 2016;4:1-8. https://doi.org/10.1177/2325967116644241.
16. Miller M, Malekian S, Burgess J, LaBella C. Evaluating a commonly used tool for measuring sport specialization in young athletes. J Athl Train 2019;54:1083-8. https://doi.org/10.4085/1062-6050-379-18.
17. Norton R, Honstad C, Joshi R, Silvis M, Chinchilli V, Dhawan A. Risk factors for elbow and shoulder injuries in adolescent baseball players: a systematic review. Am J Sports Med 2019;44:982-90. https://doi.org/10.1177/0363546518760573.
18. Olsen SJ, Fleisig GS, Dun S, Loftice J, Andrews JR. Risk factors for shoulder and elbow injuries in adolescent baseball pitchers. Am J Sports Med 2006;34:905-12. https://doi.org/10.1177/0363546505284188.
19. Peña EA, Slate EH. Global validation of linear model assumptions. J Am Stat Assoc 2006;101:341-54. https://doi.org/10.1198/016214505000000637.
20. Pennock AT, Dwek J, Levy E, Stearns P, Manning J, Dennis MM, et al. Shoulder MRI abnormalities in asymptomatic little league baseball players. Orthop J Sport Med 2018;6:2325967118756825. https://doi.org/10.1177/2325967118756825.
21. Pennock AT, Pytiak A, Stearns P, Roocroft JH, Dwek J, Kruk P, et al. Preseason assessment of radiographic abnormalities in elbows of little league baseball players. J Bone Joint Surg 2016;98:761-7. https://doi.org/10.2106/JBJS.15.01017.
22. Post EG, Biese KM, Schaefer DA, Watson AM, McGuine TA, Brooks MA, et al. Sport-specific associations of specialization and sex with overuse injury in youth athletes. Sports Health 2020;12:36-42. https://doi.org/10.1177/1941738119886855.
23. Post EG, Struminger AH, Hibberd EE. Sport specialization is associated with upper-extremity overuse injury in high school baseball players. J Shoulder Elbow Surg 2020;29:1775-82. https://doi.org/10.1016/j.jse.2020.01.092.
24. Pytiak AV, Stearns P, Bastrom TP, Dwek J, Kruk P, Roocroft JH, et al. Are the current little league pitching guidelines adequate?: A single-season prospective MRI study. Orthop J Sport Med 2017;5:1-7. https://doi.org/10.1177/2325967117704851.
25. Register-Mihalik J, Oyama S, Marshall S, Mueller F. Pitching practices and self-reported injuries among youth baseball pitchers: a descriptive study. Athl Train

Sport Health Care 2012;4:11-20. https://doi.org/10.3928/19425864-20110331-01.
26. Reiman MP, Walker MD, Peters S, Kilborn E, Thigpen CA, Garrigues GE. Risk factors for ulnar collateral ligament injury in professional and amateur baseball players: a systematic review with meta-analysis. J Shoulder Elbow Surg 2019;28:186-95. https://doi.org/10.1016/j.jse.2018.08.018.
27. Sheppard M, Nicknair J, Goetschius J. Early sport specialization and subjective hip and groin dysfunction in collegiate ice hockey athletes. J Athl Train 2020;55:232-7. https://doi.org/10.4085/1062-6050-0375-19.
28. Sprengeler O, Buck C, Hebestreit A, Wirsik N, Ahrens W. Sports contribute to total moderate-to-vigorous physical activity in school children. Med Sci Sports Exerc 2019;51:1653-61. https://doi.org/10.1249/MSS.0000000000001948.
29. Trofa DP, Obana KK, Swindell HW, Shiu B, Noticewala MS, Popkin CA, et al. Increasing burden of youth baseball elbow injuries in US emergency departments. Orthop J Sport Med 2019;7:2325967119845636. https://doi.org/10.1177/2325967119845636.
30. Yang J, Mann BJ, Guettler JH, Dugas JR, Irrgang JJ, Fleisig GS, et al. Risk-prone pitching activities and injuries in youth baseball: Findings from a national sample. Am J Sports Med 2014;42:1456-63. https://doi.org/10.1177/0363546514524699.
31. State of Play 2020: Pre-Pandemic Trends Ages 6-12. Aspen Inst Proj Play. Available at: https://www.aspenprojectplay.org/state-of-play-2020/ages-6-12. Accessed January 7, 2021.
32. Pitch Smart. Major Leag Baseb. Available at: https://www.mlb.com/pitch-smart/pitching-guidelines. Accessed December 18, 2020.