



Early single sport specialization does not improve pitching velocity, motion, strength, or utilization in high school baseball pitchers



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Background: The impact of single-sport specialization on performance and injury risk in youth and adolescent athletes remains debated. The purpose of this study was to determine the incidence of single-sport specialization and its association with pitch velocity, pitcher utilization, range of motion, strength, and injury history.

Methods: High school pitchers in the Northeastern, Southeastern, Midwestern, and Western Regions of the United States were prospectively recruited. Prior to the season, pitchers were surveyed about their basic demographics, sport participation history, and injury history. At this timepoint, a standardized physical examination was performed and max pitch velocity was measured. They were then prospectively followed over the ensuing high school season, where pitch utilization and counts were followed and injuries were tracked.

Results: Across the study, 115 pitchers were recruited, of whom 53% played baseball as their only sport and 47% played other sports. Single-position specialization within baseball was uncommon as 90% of athletes played positions other than pitcher. There were no differences in range of motion, strength, or pitch velocity between multisport athletes and single-sport specialists. Within the multisport group, 26% reported a history of injury, while 38% of the single-sport specialists reported a history of injury ($P = .179$). There were no significant differences in pitcher utilization between multisport athletes and single-sport specialists. Only a single prospective injury occurred in the 115 players.

Conclusion: Although single-sport specialization is common, nearly half of all high school pitchers in this study were multisport athletes. While injury history was generally similar between the two groups, single-sport baseball players did not have the following: improved motion, increased strength, higher ball velocity, or greater pitching volumes during the high school baseball season compared to multisport athletes. Accordingly, single-sport specialization did not have a competitive advantage for these high school pitchers based on the performance factors studied. Further prospective studies are necessary to understand the association between single-sport specialization and injury risk in high school baseball players.

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Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was not required by our institutional review board. This study was performed under (1) the University of Utah Institutional Review Board as approved protocol #112443, (2) the Vanderbilt University Institutional Review Board as approved protocol #212376,

(3) the Rothman Institute Institutional Review Board as approved protocol #19D-916, and (4) the Mayo Clinic Institutional Review Board as approved protocol #19-012432.

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Young baseball pitchers are frequently injured,^{5,7,8} and the frequency of these injuries may be increasing.^{6,13,16} There are multiple factors that potentially contribute to these injuries, including high pitch velocity,^{4,5} weighted ball throwing programs,^{14,21} inadequate rest,¹¹ and increased workload.^{7,11,15}

While baseball does require strengthening and conditioning for success, it is a skill sport. Learning to pitch with command, control, and high velocity requires years of practice, and there is a substantial competitive advantage to these skills that are acquired through increased practice. Not surprisingly, there has thus been a strong trend toward single-sport specialization among baseball players, with many players only playing baseball, year-round, starting at a young age. The impact of this single-sport specialization on increasing injury incidence has been controversial.^{9,10,18–20} For instance, two prior survey studies of collegiate athletes were not able to demonstrate any association between single-sport specialization in the precollege years and injury during their college careers.^{2,22} However, several prior studies have demonstrated a relationship between single-sport specialization and injury in professional basketball players,²³ professional baseball players,²⁵ and high school athletes.^{1,17}

Based on the prior literature, it remains unclear how frequently high school pitchers are single-sport specialists, despite the documented risk for injury with this strategy. Similarly, it is unclear whether or not single-sport specialization in high school pitchers is associated with improved player characteristics (ie, utilization, range of motion, strength) and performance metrics (ie, average and peak velocity). Therefore, this study was conducted with the primary aim of better understanding the impact of single-sport specialization in high school baseball pitchers. More specifically, we sought to determine if single-sport specialization improved pitcher velocity, utilization, strength, and range of motion of the shoulder and elbow. Additionally, we aimed to better understand the relationship of single-sport specialization on injury history and future injury risk in high school baseball pitchers.

Methods

This was a prospective study performed at multiple high schools within the Northeastern, Southeastern, Midwestern, and Western regions of the United States. High school pitchers were recruited in 2020, but the study was halted because the coronavirus pandemic interrupted the season, preventing the collection of representative workload data. In 2021, the study was delayed for the same concern. In 2022, pitchers were enrolled, and within each school, a regular season took place without alteration due to the pandemic. The exclusion criteria included lack of both consent and assent for those under 18 and lack of consent for those over 18, unwillingness to participate, and current injury precluding baseball participation. A grant from Major League Baseball supported the study. The institutional review boards of each of the involved institutions approved the study, as did the appropriate officials of each of the involved schools and districts.

Prior to beginning the season, less than two weeks prior to the first game, all involved players were surveyed (Table I) and examined (Table II). First, a reliability study was conducted in which five research assistants with no *a priori* training completed a physical examination on 30 collegiate baseball players. Intra-class correlation coefficients were calculated for continuous variables, and 0.75 was set as the lower acceptable limit of reliability *a priori*. Cohen's Kappas were calculated for discrete variables, and 0.6 was set as the lower acceptable limit of reliability *a priori*. Only physical examination maneuvers that could reliably be performed with no training were performed, including shoulder and elbow range of motion, dynamometer strength testing of shoulder forward flexion

and external rotation, grip strength, plank-hold time, and single-leg squat. Pitch velocity was recorded as the average of five fastballs thrown after completing their standard warm-up via radar gun (Stalker Sport 2; Stalker, Richardson).

These players were followed for a single high school baseball season. Weekly, the trainer for each school was contacted and asked, for each player, how many in-game pitches they had thrown each day and whether they had sustained an injury. An "injury" was defined as either (1) the development of pain that led to cessation of participation in a game or practice, preventing return to that game or practice session, or (2) a pain leading to cessation of a player's customary participation.²⁴ If an injury was reported, trainers were asked to categorize it using the Major League Baseball health information tracking system categorization system.³

Sample size calculation

These data were collected to address the relationship between pitch counts, pitch velocity, and injury, and thus velocity was used to power the study. We performed a pilot study prior to our actual study to collect preliminary data to allow a power analysis. From three schools, 83 pitchers were recruited who exhibited a mean (\pm standard deviation (SD)) pitch velocity of 74 (\pm 6.6) miles per hour. We assumed a 10% injury rate based on prior experience in caring for these athletes. Based on a prior study, a velocity difference of 8 miles per hour between groups was clinically significant.⁵ Assuming a non-normal distribution and a *P* value of .05 as significant, 90 players would be necessary to achieve 80% power.

Statistical analysis

All analyses were conducted in Excel 16 (Microsoft, Redmond) and SPSS 24 (IBM, Armonk, NY, USA). Descriptive statistics were calculated. We compared the single-sport specialization group with the multisport group, with continuous variables compared using Student's *t*-tests and Mann-Whitney *U* tests as appropriate depending upon data normality as defined using the Kolmogorov-Smirnov test and discrete variables compared using chi-square tests and Fisher's exact tests as appropriate depending upon cell populations. Only a single injury occurred during the season, and thus, while initially analyses had been planned to compare prospective injury rates, these analyses could not be conducted.

Results

How frequent is single-sport specialization?

Within our study, 115 pitchers were recruited, who were a mean (\pm SD) 16.3 (\pm 1.4) years old, 71 (\pm 3) inches tall, 172 (\pm 27) pounds, and had 7.2 (\pm 2.8) years of pitching experience. Of these pitchers, 47% (53/112) played other sports. Of the 49 who reported the other sports they played, 45% (22/49) participated in basketball, 43% (21/49) participated in football, 10% (5/49) participated in golf, 6% (3/49) participated in soccer, and 4% and 2% (1/49) each participated in wrestling, hockey, roping, and swimming. Single-position specialization within baseball was uncommon, as 90% (103/114) played positions other than pitcher (Table III), for 6 (\pm 1) innings per game.

Does single-sport specialization correlate with better range of motion, strength, or pitch velocity?

There were no differences in range of motion, strength, or pitch velocity between multisport athletes and single-sport specialists (*P* > .072, Table IV), with the sole exception of shoulder external rotation strength in adduction. When analyzing based on hand

Table I
Pre-season survey data.

Questions	Potential Answers/Units
Which hand do you use to pitch with?	Right, Left
What is your height?	Feet, Inches
What is your weight?	Lbs
What is your average fastball velocity?	Miles per hour
What is your peak fastball velocity?	Miles per hour
At what age did you start pitching?	Years
How long have you been pitching?	Years
How many pitches do you throw in the average game? Warmup?	NA
Do you play for any other teams?	Yes, No
How many games did you play last season?	NA
How many games did you pitch last season?	NA
How many days a week do you play baseball?	Days
How many months per year do you play baseball?	Months
How many consecutive months off throwing did you have last year?	Months
Have you ever participated in a “showcase”?	Yes, No
Have you ever returned to the mound after being removed?	Yes, No
Do you play any positions other than pitcher? Which positions?	Yes, No Fielding positions
How many innings do you play these other positions each game?	NA
Do you play other sports? Which other sports?	Yes, No NA
Have you ever participated in a weighted ball program?	Yes, No
With which weight ball?	Heavier, Lighter
Have you used any other programs to increase your velocity? Which programs?	Yes, No NA
Have you ever been diagnosed with a pitching-related injury?	Yes, No
Describe the injury and treatment.	NA

NA, not applicable.

dominance, external rotation strength in the dominant extremity was 13.0 ± 6.0 kg in multisport athletes ($N = 53$) and 11.4 ± 3.1 kg in single-sport specialists ($N = 59, P = .043$). However, this difference was only 1 kg, which is below clinical significance.

Does single-sport specialization correlate with a history of injury, future injury, or pitcher utilization?

The initial research plan was to prospectively compare within season injury rates between groups. But only a single injury occurred during the study season, and thus, this analysis was not conducted. Regarding injury history, 26% (15/58) of the multisport group reported a history of injury compared to 38% (20/53) of the single-sport athletes ($P = .179$). There were no significant differences in pitcher utilization between multisport athletes and single-sport specialists ($P > .566$, Table V).

Discussion

In this prospective study, we found that single-sport specialization was common among high school pitchers, while single-position specialization was uncommon, as 90% of pitchers also played other positions. Single-sport specialization was not associated with improved strength, shoulder/elbow motion, pitch velocity, or increased utilization (ie, playing time) during the season. These results suggest that future guidelines for high school pitchers should target multiposition players to account for the workload associated with nonpitching games. Furthermore, there does not appear to be a competitive advantage in high school pitchers who

Table II
Physical Examination variables.

Variable	ICC [95% CI]	Included?
External rotation motion in abduction (°)	0.629 [0.379-0.779]	No
Internal rotation motion in abduction (°)	0.432 [0.049-0.661]	No
Active forward elevation motion (°)	0.772 [0.619-0.864]	Yes
Elbow extension motion (°)	0.848 [0.746-0.909]	Yes
Elbow flexion (°)	0.55 [0.246-0.731]	No
Elbow carrying angle (°)	0.759 [0.597-0.856]	Yes
Shoulder abduction strength (Kg)	0.993 [0.989-0.996]	Yes
Shoulder external rotation strength (Kg)	0.986 [0.977-0.992]	Yes
Grip strength (Kg)	0.939 [0.898-0.964]	Yes
Plank time (s)	0.487 [0.141-0.693]	No
Crossed single-leg toe-touch test (normal/abnormal)	Kappa = 0.305	No

ICC, intra-class correlation coefficient; CI, confidence interval.

All range of motion variables were active range of motion. Shoulder abduction strength was collected with the shoulder in 30° of abduction, 30° of flexion, and neutral rotation. Shoulder external rotation strength was collected with the shoulder in full adduction, neutral flexion/extension, and neutral rotation. To collect plank time, players were asked to assume a plank position and a timer was set to determine time between when the player assumed the position and when the player was no longer able to maintain their body as a flat plane. In the crossed single-leg toe-touch test, players were asked to stand on their right foot and touch their right hallux with their left index finger and visa-versa. If the player was not able to complete both sides without a trendelenberg shift of the hips, the test was considered normal.

Table III
Positions played other than pitcher by those included within the study.

Position	% (N)
1 st base	23 (26/115)
2 nd base	20 (23/115)
Short-stop	22 (25/115)
3 rd base	28 (32/115)
Left field	30 (35/115)
Center field	27 (31/115)
Right field	28 (32/115)
Catcher	12 (14/115)

single sport specialize and as such, specialization may not improve performance for the metrics assessed in this study.

In our study, single-sport specialization was common, but 47% of pitchers still played other sports. Biese et al (2021)² conducted a survey study and found that 79% of collegiate athletes were multisport athletes in high school. Rugg et al (2020)²² conducted a similar survey study of collegiate athletes and found that baseball athletes were more likely to specialize later in their careers than gymnasts, tennis players, swimmers, and soccer players. Bell et al (2016)¹ conducted a survey study of high school athletes, and 70% reported themselves as multisport athletes. Our rate of single-sport specialization is higher than either of these prior studies, suggesting that single-sport specialization may be becoming more common.^{10,18-20} Despite the increase in single sport specialization, none of the metrics recorded in this study favored those who specialized. Hence, while many may feel they are obtaining a competitive advantage by specializing, all they may be doing is increasing their risk of overuse injuries.

In our study, 90% of high school pitchers played other positions. 64% (66/103) also played positions “up the middle,” including second base, short stop, center field, or catcher. These positions have traditionally been considered to be defensively important and involve more throws each game. A long-distance throw places as much stress across the arm as a pitch from the mound.¹² Playing the

Table IV
Physical examination characteristics and pitch velocity for the included pitchers.

Variable	Multi-sport athletes	Single-sport specialists	P value
Right shoulder flexion (°)	167 ± 9	164 ± 11	.098
Left shoulder flexion (°)	169 ± 9	166 ± 10	.114
Right elbow extension (°)	0 ± 5	0 ± 4	.831
Left elbow extension (°)	0 ± 5	0 ± 5	.802
Right shoulder abduction strength (kg)	15 ± 6	13 ± 5	.056
Left shoulder abduction strength (kg)	15 ± 6	13 ± 4	.056
Right shoulder external rotation strength(kg)	13 ± 4	12 ± 3	.121
Left shoulder external rotation strength (kg)	12 ± 4	11 ± 3	.019
Right grip strength (kg)	39 ± 12	37 ± 13	.208
Left grip strength (kg)	37 ± 13	35 ± 13	.270
Pitcher-reported average fastball velocity [km/h (mph)]	126 km/h (78 mph)	121 km/h (75 mph)	.072
Pitcher-reported peak fastball velocity [km/h (mph)]	130 km/h (81 mph)	127 km/h (79 mph)	.192
Directly-measured average fastball velocity [km/h (mph)]	119 km/h (74 mph)	116 km/h (72 mph)	.520
Directly-measured peak fastball velocity [km/h (mph)]	85 km/h (53 mph)	87 km/h (54 mph)	.905

Mph, miles per hour; km/h, kilometers per hour.
Significant differences are bolded.

Table V
Pitcher utilization.

Variable	Multi-sport athletes	Single-sport specialists	P value
Total pitch count for the season	254 ± 240	266 ± 253	.851
Pitches per week	27 ± 24	31 ± 31	.705
Pitches per game	24 ± 28	28 ± 29	.566

field also requires players to warm-up, which involves additional throws. Within our study, players described throwing as many as 80 “warm-up throws” prior to play. Another study demonstrated that nearly half of all pitches are not accounted for by traditional in-game “pitch counts”.²⁶ Given that most youth pitchers play multiple positions, future guidelines may consider recommendations around rest between games pitches and games fielded.

In this study, single-sport specialization was not associated with an increased history of injury. Because only a single injury occurred during the season, no analysis was conducted to compare in-season injury rates. Prior literature is conflicting as to whether single-sport specialization increases the risk for injury.^{10,18-20} Two prior survey studies at the collegiate level were unable to find any association between injury and a history of single-sport specialization.^{2,22} However, a study of professional baseball players did demonstrate a relationship between early single-sport specialization and injury while playing professionally.²⁵ Two prior studies at the high school level have demonstrated an association between single-sport specialization and risk for injury in high school athletes.^{1,17} On balance, these suggest that single-sport specialization should be approached with caution by youth athletes and that diversification should be encouraged.

This study has several limitations. First, survey results are subject to recall bias. Second, players were only followed for a single season, and with longer follow-up, many demonstrate high rates of injury in the future. Third, physical examinations were performed by a variety of examiners at different centers, although we only collected physical examination variables that could be reliably collected without any *a priori* training. Fourth, our sample size was limited and thus we may be under-powered for some comparisons, especially given the low number of injuries that were observed. Lastly, this study did not look at differences in baseball statistical performance measures (earned run average, walks plus hits per inning pitched, etc.) due to concerns of high levels of baseline variability in those metrics in high school aged athletes.

Conclusion

Although single-sport specialization is common, nearly half of all high school pitchers in this study were multisport athletes. While injury history was generally similar between the two groups, single-sport baseball players did not have the following: improved motion, increased strength, higher ball velocity, or greater pitching volumes during the high school baseball season compared to multisport athletes. Accordingly, single-sport specialization did not have a competitive advantage for these high school pitchers based on the factors studied. Further prospective studies are necessary to understand the association between single-sport specialization and injury risk in high school baseball players.

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