JSES Reviews, Reports, and Techniques 3 (2023) 499–505

Contents lists available at ScienceDirect

JSES Reviews, Reports, and Techniques

journal homepage: www.jsesreviewsreportstech.org

Quantitative and qualitative disparities exist between baseball and softball peer-reviewed pitching-related literature: a systematic review from 1990 to 2020

Gabrielle Gilmer, BChE[a,b], Albert Lin, MD[a], Michael Shannon, BS[a], Asher Mirvish, BA[a], Nicholas Aloi, BS[a], Forrest Shooster, BS[a], Justin J. Greiner, MD[c,*]

[a]Freddie Fu Sports Medicine Center, Department of Orthopaedic Surgery, University of Pittsburgh Medical Center, Pittsburgh, PA, USA
[b]Medical Scientist Training Program, University of Pittsburgh School of Medicine, Pittsburgh, PA, USA
[c]University of Nebraska Medical Center, Department of Orthopedic Surgery, Omaha, NE, USA

ARTICLE INFO

Keywords:
Shoulder
Elbow
Inequality
Rotator cuff
Gender disparity
Title IX
Bias

Level of evidence: Level IV; Systematic Review & Meta-Analysis

Background: Baseball and softball are popular sports with similar rates of injury, especially among pitchers. However, parity between the two sports is lacking, as baseball receives greater research attention than softball. The purpose of this study was to describe the discrepancy between baseball and softball in terms of quantity and quality of research. We hypothesized baseball literature would outnumber softball literature, be published in higher-impact journals, and be of higher quality.

Methods: A systematic review was performed to identify original research articles related to baseball and softball from 1990 to 2020. Articles pertaining to pitching were identified via literature searches of PubMed, the Physiotherapy Evidence Database, the Cumulative Index to Nursing and Allied Health Literature, and the Cochrane Central Register of Controlled Trials and further screened by two independent reviewers. Age group studied, journal impact factor, type of research, and level of evidence were compared between pitching-related baseball and softball articles. Injury-related studies were also sub-analyzed, and a meta-analysis was performed to assess rates of shoulder and elbow injuries between baseball and softball pitchers.

Results: There were 813 baseball publications and 158 softball publications that met our inclusion criteria. More baseball articles were published per year than softball (5:1, $P < .001$). Baseball had 368 articles related to pitching, while softball had significantly fewer at 49, and there were more baseball pitching articles published per year than softball pitching articles (7.5:1, $P < .001$). Pitching-related baseball articles were published in journals with a higher mean impact factor than softball pitching articles (3.1 vs. 2.0, $P = .049$). There was no difference in methodological index for non-randomized studies criteria for rigorous reporting ($P = .678$), and among all groups, most articles were level III evidence. Baseball pitching articles included more clinical articles than softball pitching articles (63% vs. 43%, $P = .004$). Despite the fact that softball pitchers have an odds ratio of shoulder and elbow injury slightly higher than baseball (4.02 vs. 3.60), injury-related studies focused on baseball outnumbered softball studies 7 to 1.

Conclusion: Softball is under-represented in the literature when compared to baseball with over 5 times fewer peer-reviewed research articles, despite having slightly higher shoulder and elbow injury rates than baseball. Pitching-related softball articles are nearly 8 times less frequent compared to baseball pitching articles and published in journals with a lower impact factor. Further research directed at softball is important to provide evidence-based injury prevention, practice guidelines, and treatment decisions.

Baseball and fast-pitch softball are popular sports in the United States, with annual youth participation exceeding 1 million for each sport.[6,16,26] At the high school level, a 2018-2019 National Federation of State High School Associations survey revealed that baseball and fast-pitch softball were the fourth and fifth most popular sports for boys and girls, with over 480,000 baseball participants and

Institutional review board approval was not required for this systematic review and meta-analysis.

*Corresponding author: Justin J. Greiner, MD, Department of Orthopedic Surgery, University of Nebraska Medical Center, 4014 Leavenworth St., Omaha, NE 68105, USA.

E-mail address: greinerjj@gmail.com (J.J. Greiner).

https://doi.org/10.1016/j.xrrt.2023.07.003

360,000 fast-pitch softball participants, respectively.[1] Similarly, in adult recreational leagues, baseball and softball are among the top five most popular sports.[32] At higher levels of competition, however, the popularity of baseball begins to exceed that of fast-pitch softball, as evidenced by the success of Major League Baseball in contrast to less popular professional softball leagues.

Understanding and preventing injuries have been the primary focus of baseball and softball research efforts. Research in injury prevention has been skewed between baseball and softball, with a greater focus on baseball, culminating in the establishment of the Pitch Smart Guidelines in 2014.[3] In contrast to the successful implementation of Pitch Smart guidelines in many youth baseball leagues, guidelines for softball have lagged behind baseball and are not widely adopted in youth softball leagues.[3,8,17]

Title IX was established in 1972 to provide female athletes with an equal opportunity to their male counterparts for sport participation.[4] While advancements have been made for female athletics, inequalities still persist both in sport and beyond. The discrepancies seen within sports parallel those observed in the orthopedics community, as disparities between female and male orthopedic surgeons exist.[11,12,27] Orthopedic surgeons have an opportunity to play an intimate role in rectifying the inequality that exists between men and women, not only in the work setting but also in sport, by ensuring equal emphasis in research efforts between sports typically played by men and women.

Obvious disparities exist between softball and baseball with regard to regulations, guidelines,[8] and popularity in the media.[21] The discrepancy between the two sports is also present in the research setting, yet the degree of disparity has yet to be quantified. As such, the purpose of this study was to quantify the disparities that exist in the peer-reviewed literature between softball and baseball. The primary hypothesis was that softball articles, when compared to baseball articles, would be significantly fewer in the peer-reviewed literature for all article types, including pitching-specific articles. Secondarily, we analyzed the subset of literature aimed at assessing shoulder and elbow injuries amongst baseball and softball pitchers.

Materials and methods

Systematic review

A systematic review of the literature was performed using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement and protocol (Supplementary File S1) and the Cochrane Handbook for Systematic Reviews of Interventions.[10,20,28,33] Included manuscripts were screened with Population, Exposure, Comparison, Outcome criteria.[18] Specifically, the Population, Exposure, Comparison, Outcome included manuscripts studying competitive fast-pitch softball in female athletes or baseball in male athletes (P), any exposure (E), control group of softball or baseball athletes (C), and clinical outcomes and biomechanical descriptors (O). Additionally, studies were only included if they were an original research study, published in a peer-reviewed journal, written in English, and published between 1990 and 2020. Studies including uncommon variations of softball and baseball, such as slow pitch, women's baseball, and men's softball, were not included to produce homogeneous study populations.

On August 18, 2021, the following electronic databases were searched for "softball" and "baseball": PubMed, Physiotherapy Evidence Database, Cumulative Index to Nursing and Allied Health Literature, and Cochrane Central Register of Controlled Trials. A manual search on Google Scholar was also performed. Two independent reviewers assessed the eligibility of each article by screening titles, abstracts, and full texts under the guidelines of the Cochran Handbook recommendations.[10] Screening steps were performed in predesigned Excel spreadsheets, and disagreements between the two reviewers were addressed with the opinion of a third reviewer.

Two independent reviewers categorized articles into three groups based on the sport(s) studied: baseball, softball, or combined baseball and softball. Articles were further categorized as to whether pitching or pitcher-related data was included. Pitching-related articles had data extracted including year of publication, age group studied (youth, high school, collegiate, and professional), impact factor of publishing journal, level of evidence, type of study (clinical, biomechanical, or both), and modified methodological index for non-randomized studies (MINORS) criteria.[30] Youth athletes were defined as being younger than 14 year old, high school athletes were defined as being ages 14-18; collegiate/recreational athletes were defined as being ages 18+; and professional athletes were defined as being noted to be professional athletes in the article. Type of study (clinical, biomechanical, or both) was determined by the outcome variables collected. Specifically, biomechanical studies were defined as having documentation of biomechanical metrics related to pitching (eg, range of motion, kinematics, motion capture), while clinical studies were defined as having documentation of clinical metrics (eg, injury rates, magnetic resonance imaging, surgical outcome variables). The modified MINORS criteria included rating whether or not studies included a statement of study aim, inclusion criteria, prospective collection of data, endpoint appropriate to study aim, unbiased evaluation of end points, prospective calculation of sample size, and statistical analysis appropriate for study design.[30] Each category was scored as "clearly insufficient", "unclear if sufficient", or "clearly sufficient".

Among the pitching-related articles, those focused on upper extremity injury as a primary outcome were further categorized. A single reviewer quantified whether articles were studying injury rates, risks, prevention, outcomes, surgical outcomes, or specific injuries. Injury rate data were then compiled and quantified, independent of age group, for meta-analysis.

Statistical analysis

All statistical analyses were performed in SPSS Statistics for Windows, version 28.0 (IBM Corp., Armonk, NY, USA). Friedman ANOVA was performed to assess differences in the number of all articles as well as pitching-specific articles between baseball, softball, and combined groups. The Kruskal-Wallis test was used to assess the differences in journal impact factors among baseball, softball, and combined pitching articles. Chi-square tests were used to assess the differences in the modified MINORS criteria, study design, type of study for pitching-related articles, and proportions of injury-related studies. Meta-analysis was performed to assess the rates of shoulder and/or elbow injury among baseball and softball pitchers. Assumptions for each respective statistical test were checked prior to usage. An alpha level was set *a priori* to 0.05.

Results

All included studies

After completion of title, abstract, and full-text screening, there were 813 (71.3%) baseball-specific articles, 158 (13.8%) softball-specific articles, and 170 (14.9%) combined articles (Fig. 1). All full-text articles that were included in this literature review are listed with respective categories and reason for exclusion in Supplementary Table S1. Among the articles related to baseball, 444 (54.6%) were not related to pitching, and 368 (45.3%) were related to pitching. Among the articles related to softball, 109 (69.0%) articles were not related to pitching, and 49 (31.0%) articles were related to pitching. Among the combined articles, 142

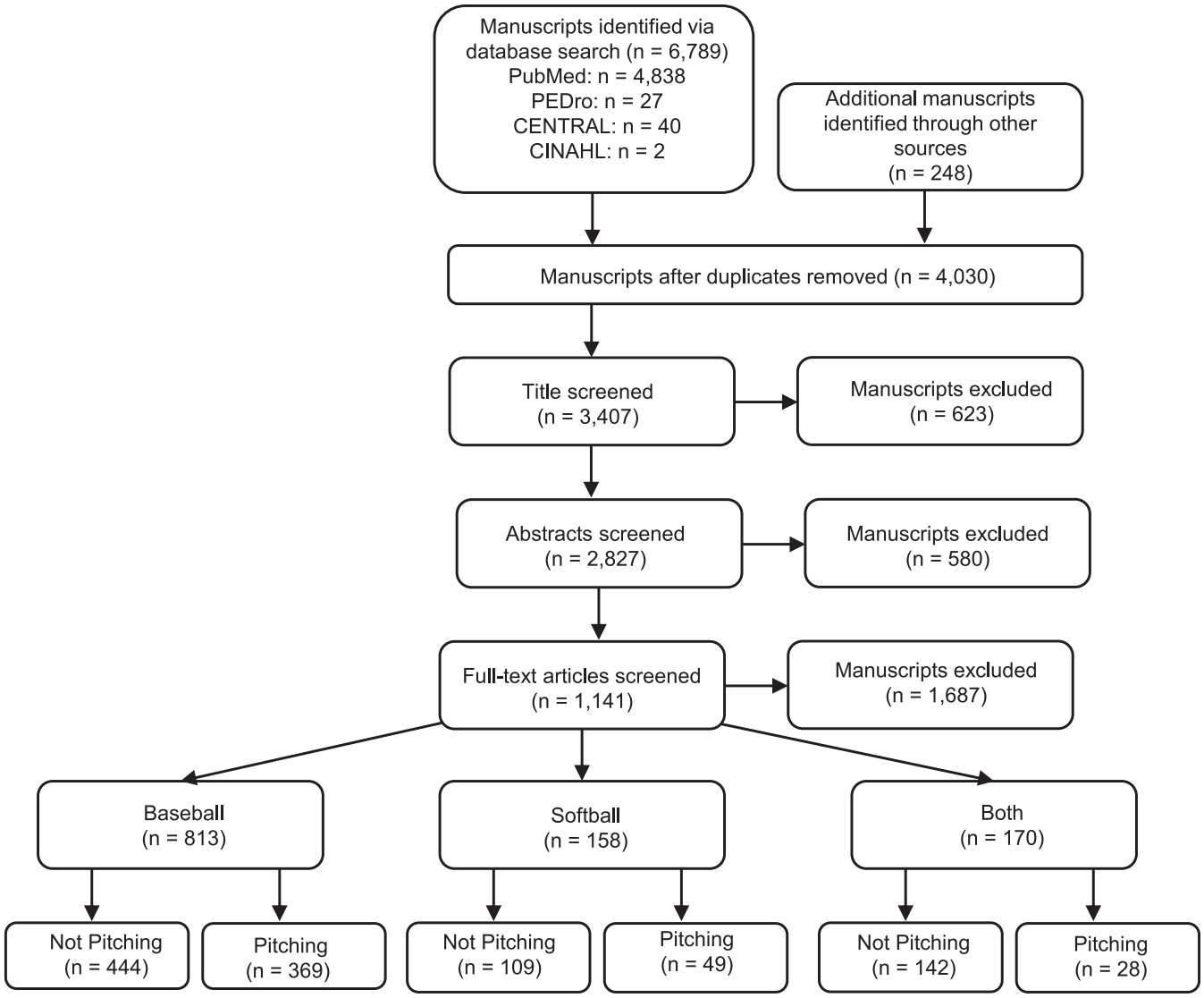

Figure 1 Systematic review resulted in 813 articles related to baseball, 158 articles related to softball, and 170 related to both. Title and abstract screening resulted in 3407 articles eligible for full-text screening. Of those screened, 1141 articles were deemed eligible for inclusion in this review. In total, 1141 articles were included in this review.

(83.5%) were not related to pitching, and 28 (16.5%) were related to pitching. There were significantly more baseball-specific articles published per year compared to softball-specific articles and combined articles ($P < .001$). Similarly, for pitching-specific articles, there were significantly more baseball-specific articles published per year compared to softball-specific articles and combined articles ($P < .001$). The distribution of all published articles per year is shown in Figure 2, *A* and pitching-specific articles is shown in Figure 2, *B*.

Pitching-related studies

A comparison of pitching-related baseball, softball, and combined articles is shown in Table I. There was no significant difference between baseball, softball, and combined pitching-related articles ($P = .650$) when comparing the percentage of articles at the youth, high school, collegiate/recreational, and professional levels.

There was a statistically significant difference in the mean impact factor of the journal in which articles were published between baseball, softball, and combined articles ($P = .049$). Baseball articles had a higher mean journal impact factor (3.1 ± 0.6) than softball articles (2.0 ± 0.9) and combined articles (2.7 ± 0.5). There was no difference in modified MINORS score when comparing baseball, softball, and combined articles ($P = .678$) (Table II).

There was a statistically significant difference in the type of research performed based on the article type. Baseball articles (n = 232, 63%) included more clinical articles than softball (n = 21, 43%) and combined articles (n = 4, 15%), while combined (n = 22, 78%) included more biomechanical articles compared to baseball (n = 110, 30%) and softball (n = 27, 44%) ($P = .004$).

The most common level of evidence was Level III for baseball (n = 152, 41.1%), softball (n = 27, 55.8%), and combined articles (n = 17, 59.4%). There was a statistically significant difference in the level of evidence of the included articles. Specifically, there was a higher percentage of Level II and III studies among softball (n = 47, 97.1%) and combined (n = 28, 97.5%) articles than baseball (n = 287, 77.7%) articles. Conversely, the percentage of Level IV studies among baseball (n = 72, 19.6%) articles was higher compared to softball (n = 0, 0%) specific and combined (n = 1, 1%) groups ($P = .008$).

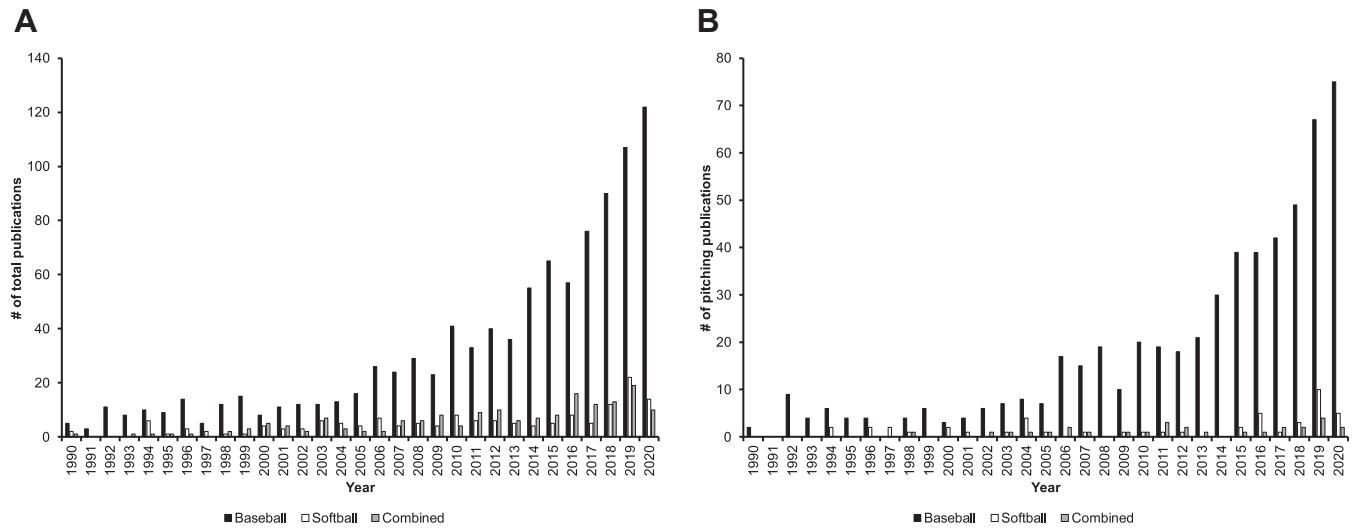

Figure 2 The number of baseball related publications greatly outnumbers the number of softball and combined publications. (**A**) The total number of baseball, softball, and combined publications per year ($X^2 = 48.245$, $P < .001$, $N = 31$, $df = 2$). (**B**) The number of pitching-related publications in baseball, softball, and combined per year ($X^2 = 46.547$, $P < .001$, $N = 31$, $df = 2$).

Table I
Breakdown of age group, type of study, and level of evidence among pitching-related articles for baseball, softball, and combined articles.

	Baseball	Softball	Combined
Age group			
Youth	47 (11.6)	6 (12.5)	3 (9.8)
High school	131 (35.7)	19 (39.7)	8 (29.4)
College	164 (44.6)	26 (52.9)	16 (57.8)
Professional	143 (38.8)	16 (31.8)	10 (36)
Statistical information	Chi-square test	$P = .658$	$X^2 = 4.936$
Type of study			
Clinical	232 (63)	21 (43)	4 (15)
Biomechanical	110 (30)	27 (44)	22 (78)
Both	26 (7)	2 (3)	2 (7)
Statistical information	Chi-square test	$P = .004$	$X^2 = 10.128$
Level of evidence			
I	7 (2)	1 (2.9)	0 (0)
II	135 (36.6)	20 (41.3)	11 (38.5)
III	152 (41.1)	27 (55.8)	17 (59.4)
IV	72 (19.6)	0 (0)	1 (2.1)
Statistical information	Chi-square test	$P = .008$	$X^2 = 7.793$

Data shown as n (%).

Upper extremity injury-related studies

We next turned our attention to focus specifically on articles that studied upper extremity injuries in pitchers (Table III, Supplementary Table S2). Among articles studying pitching, 72 (16.2% of pitching-related articles) had primary outcomes related specifically to upper extremity injuries. Of these, there were proportionally more baseball pitching articles focused on injury ($P < .001$). Specifically, 56 (77.8% of injury articles) articles were focused on baseball pitchers, 8 (11%) articles were focused on softball pitchers, and 8 (11%) articles were focused on both baseball and softball pitchers. In looking more closely at the type of study, proportionally more softball articles (n = 6, 75%) focused on reporting injury rates than baseball (n = 14, 25%) and combined articles (n = 4, 50%). Conversely, proportionally more baseball articles assessed risk for injury (baseball [B]: 42.8%, softball [S]: 37.5%, combined [C]: 25%), injury prevention (B: 14.2%, S: 0%, C: 0%), reported outcomes postinjury (B: 14.3%, S: 0%, C: 0%), and reported surgical outcomes (B: 17.9%, S: 0%, C: 0%).

We next aimed to assess the rates of shoulder and elbow injuries between baseball and softball pitchers as reported in this subset of our included articles (Fig. 3, Supplementary Table S3). Meta-analysis revealed that the odds ratio (OR) of shoulder and/or elbow injury amongst baseball athletes is 3.60 (95% CI [2.09, 6.20]), while the OR of shoulder and/or elbow injury amongst softball athletes is 4.02 (95% CI [1.54, 10.46]).

Discussion

This systematic review demonstrated a significant disparity in peer-reviewed literature between fast-pitch softball and baseball across all age groups. Baseball publications were over five times more frequent in the literature when compared to softball. Discrepancies between baseball and softball were also identified with pitching-specific research, as baseball had nearly 8 times more pitching-related articles and were published in higher impact factor journals when compared to softball. In addition, despite the fact that softball pitchers had slightly higher odds ratios of shoulder and/or elbow injuries than baseball pitchers, we found seven times as many frequent articles on injury in baseball pitchers than softball pitchers. Our findings here are in line with a more general evaluation of research into male and female sports, indicating that studies evaluating male sports were between 3.2-18.2 more common than female sports.[23]

Although there are similarities between the games of softball and baseball, there are distinct differences including size of ball, size of field, spacing between bases, and height of pitching mound.[5] Differences in pitching mechanics also exist between fast-pitch softball and baseball, with the softball pitch occurring in a windmill motion and the baseball pitch being performed overhand.[7,34] These differences make valid comparison of clinical research on injuries challenging and highlight the importance of detailed reporting of mechanism of injury, injury rates, and promising treatment modalities. Despite the difference in throwing motion, biomechanical analyses have demonstrated similar forces at the shoulder and elbow when comparing a windmill softball pitch to an overhand baseball pitch,[2,34] and our findings suggest that these similar forces result in comparable shoulder and elbow injury rates amongst baseball and softball pitchers. Thus, further investigation into the exact pathomechanical drivers of these injury rates, especially in the windmill pitch, is warranted given the limited literature that is available.

Table II
Ranking of methodological index for non-randomized studies criteria categories for baseball, softball, and combined pitching-related article types.

n (%)	Baseball			Softball			Both		
	Unsatisfactory	Unclear if satisfactory	Satisfactory	Unsatisfactory	Unclear if satisfactory	Satisfactory	Unsatisfactory	Unclear if satisfactory	Satisfactory
State aim of study	0 (0)	0 (0)	368 (100)	0 (0)	0 (0)	49 (100)	0 (0)	0 (0)	28 (100)
Inclusion criteria	28 (7.7)	45 (12.3)	294 (80)	4 (8.5)	7 (15.8)	37 (75.7)	2 (6.7)	4 (13.4)	22 (79.9)
Prospective collection of data	131 (35.6)	37 (10)	200 (54.4)	20 (40.8)	6 (11.4)	23 (47.8)	11 (37.5)	3 (12.3)	14 (50.2)
Endpoint appropriate to study aim	0 (0)	54 (14.6)	314 (85.4)	1 (1.4)	9 (17.9)	40 (80.7)	0 (0)	4 (13.4)	24 (86.2)
Unbiased evlaution of end points	77 (21)	170 (46.1)	121(32.9)	12 (23.7)	25 (51.3)	12 (25)	7 (24.5)	16 (56.7)	5 (18.8)
Proscpective calculation of sample size	328 (89)	19 (5.2)	21 (5.8)	45 (92.3)	2 (4.5)	2 (3.2)	25 (90.9)	2 (6.7)	1 (2.4)
Statistical analysis appropriate for study design	74 (20.1)	210 (57.1)	84 (22.8)	11 (22.3)	28 (58)	10 (19.7)	5 (18.6)	15 (54.5)	8 (26.9)
	Statistical test	Chi-square	*P* value	0.678	Statistical value	$X^2 = 2.301$			

Table III
Summary of the literature aimed at studying shoulder and/or elbows among baseball, softball, or both pitcher groups.

	Baseball	Softball	Combined
Articles focused on upper extremity injuries in pitchers	56 (77.2)	8 (11)	8 (11)
Statistical information	Chi-square test	$P < .001$	$X^2 = 4.437$
Reported injury rates	14 (25)	6 (75)	4 (50)
Statistical information	Chi-square test	$P < .001$	$X^2 = 5.937$
Assessed risk for injury	24 (42.8)	3 (37.5)	2 (25)
Statistical information	Chi-square test	$P = .049$	$X^2 = 2.789$
Injury prevention	8 (14.2)	0 (0)	0 (0)
Statistical information	Chi-square test	$P < .001$	$X^2 = 9.619$
Reported outcomes Postinjury	8 (14.3)	0 (0)	0 (0)
Statistical information	Chi-square test	$P < .001$	$X^2 = 9.623$
Reported surgical outcomes	10 (17.9)	0 (0)	1 (12.5)
Statistical information	Chi-square test	$P < .001$	$X^2 = 10.444$
Studied specific injuries	2 (3.6)	2 (25)	2 (25)
Statistical information	Chi-square test	$P = .036$	$X^2 = 2.476$

Data shown as n (%).

There are additional differences in the structure of youth leagues between softball and baseball. Youth athletes are an important demographic when considering injury prevention and were studied eight times more frequently in baseball compared to softball in the literature. Of the articles we identified aimed at assessing injury prevention among baseball and softball pitchers, 100% of these were studying baseball pitchers. Baseball teams utilize 9-11 pitchers on average, while softball teams use approximately 7-8 pitchers.[8,9] As a result, softball pitchers more frequently have exceedingly high pitch counts and pitch on multiple sequential days without rest compared to baseball pitchers.[8,9] This important difference between softball and baseball can lead to skewed findings and injury rates, as one study demonstrated that 50% of softball pitchers sustained an injury, yet represented only 28.5% of total injuries sustained on the team.[29] Therefore, while fewer total pitchers may be injured in softball, the individual softball pitcher is still at high risk for injury. The concern for injury in both softball and baseball pitchers suggests that both groups of athletes should be adequately studied to limit injury rates.

Injury prevention for throwing athletes is a primary focus of sport medicine research and is especially important in baseball and softball given the high rates of injury in both sports. In a prospective study of high school athletes, injury rates between softball and baseball were similar, at 0.96 and 0.95 per 1000 athletic exposures, respectively,[14] and our findings of similar OR of shoulder and elbow injuries between the two populations are in line with this previous work. Differences exist between injury patterns among pitchers and nonpitchers in baseball and softball, however, with pitchers demonstrating higher injury rates.[29,31] In addition, nonpitchers frequently sustain lower extremity injuries, while pitchers more often injure the shoulder and elbow.[15,22,29,31] In a recent scoping review, Mine et al detailed risk factors for shoulder and elbow injuries in baseball and concluded that limited range of motion and field position were consistent risk factors for shoulder injury and being a pitcher or catcher were risk factors for elbow injuries.[19] In another systematic review, Hoppe et al concluded that nonmodifiable risk factors for shoulder injury include playing position and gender, while modifiable risk factors include shoulder rotation strength, scapular dyskinesis, and injury prevention program access.[13] However, these types of original research articles and ultimate reviews that focus on softball injury rates and preventions are largely lacking in the literature. Comparisons of injury rates between baseball and softball have shown conflicting results, as one study demonstrated a 27% higher injury rate in softball pitchers compared to baseball, though severe injuries were more frequent in baseball pitchers.[24] In contrast, other reports have demonstrated higher rates of shoulder and elbow injuries in baseball compared to softball.[15,25,29] Our meta-analysis of shoulder and elbow injury rates among baseball and softball pitchers supports the conclusion that rates of injury are comparable between the two populations. Raising awareness of the potential for injury in softball is necessary to help stimulate research and provide sport-specific recommendations that are driven by scientific evidence.

Although this systematic review does add to an important body of literature, it does have limitations. Within our meta-analysis, we did not control for age, combined shoulder and/or elbow injuries together, and did not assess injuries in other areas of the body. This systematic review did not perform a risk of bias analysis or assess publication bias within the literature. This is largely due to infeasibility with the number of studies included and the heterogeneity of study types.

Conclusion

A significant disparity has existed in the published literature between baseball and softball in the last 30 years. There is a large gap in the number of published articles, with baseball far

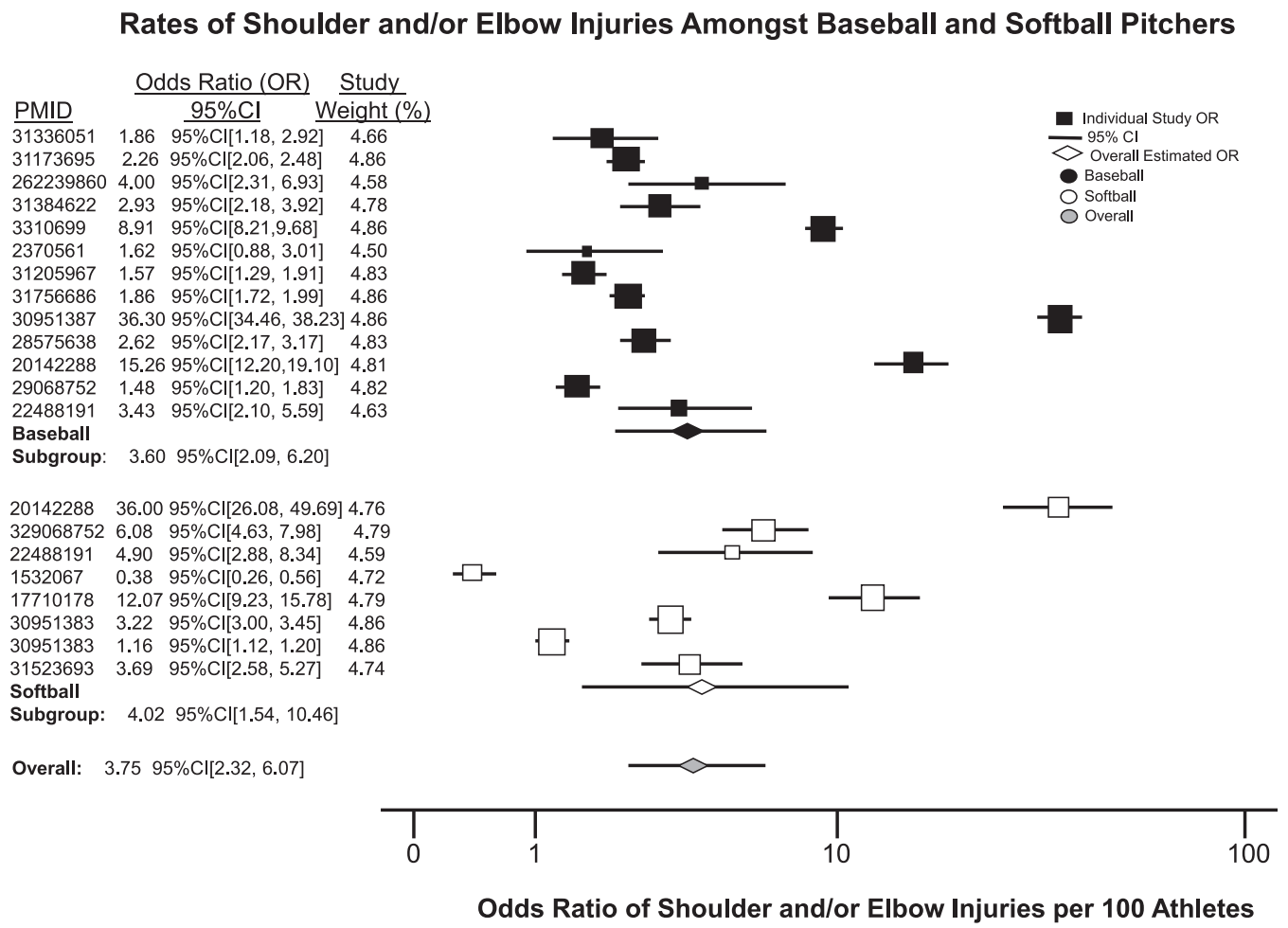

Figure 3 Meta-analysis reveals the rates of shoulder and/or elbow injury are comparable between baseball and softball pitchers. The odds ratio (OR) of shoulder and/or elbow injury reported by individual studies is represented by a square, with baseball studies shown in black and softball studies shown in white. The diamond represents the overall OR among the baseball subgroup (black), softball subgroup (white), and all studies combined (gray). The lines represent the 95% confidence interval (CI), and the size of the icon represents the study weight within the meta-analysis, with weighting determined based on sample size. *PMID*, PubMed Unique Identifier.

exceeding the number of softball publications. Further, there are dramatically fewer pitching-related articles in softball compared to baseball, with softball articles being published in journals with lower impact factors compared to baseball and even fewer injury-related articles among the softball literature. The disparity between the two sports is concerning, as both baseball and softball athletes sustain shoulder and/or elbow injuries at similar rates. Efforts to narrow the gap that exists between softball and baseball, such as specific issues within peer-reviewed journals focused on softball/female athletes and funding designated to specifically address this gap, should be a focus of future research efforts.

Disclaimers:

Funding: Research reported in this publication was supported by the National Institute of General Medical Sciences of the National Institutes of Health under Award Number T32GM008208 for F.S. and the Pitt Integrated Clinical and Geroscience Research Training Program (Grant Number: 5T32AG021885-19) for G.G. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.
Conflicts of interest: The authors, their immediate families, and any research foundation 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.

Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.xrrt.2023.07.003.

References

1. Associations NFoSHS. 2018-2019 high school athletics participation survey. https://www.nfhs.org/media/1020412/2018-19_participation_survey.pdf. Accessed July 6, 2022.
2. Barrentine SW, Fleisig GS, Whiteside JA, Escamilla RF, Andrews JR. Biomechanics of windmill softball pitching with implications about injury mechanisms at the shoulder and elbow. J Orthop Sports Phys Ther 1998;28:405-15.
3. Baseball ML. Pitch smart guidelines. https://www.mlb.com/pitch-smart. Accessed July 18, 2022.
4. Bassett AJ, Ahlmen A, Rosendorf JM, Romeo AA, Erickson BJ, Bishop ME. The biology of sex and sport. JBJS Rev 2020;8:e0140. https://doi.org/10.2106/JBJS.RVW.19.00140.
5. Briskin SM. Injuries and medical issues in softball. Curr Sports Med Rep 2012;11:265-71. https://doi.org/10.1249/JSR.0b013e3182699489.
6. Committee USOP. USA softball. https://www.teamusa.org/USA-Softball/Play-ASA/Youth. Accessed July 11, 2022.
7. Escamilla RF, Fleisig GS, Groeschner D, Akizuki K. Biomechanical comparisons among fastball, slider, curveball, and changeup pitch types and between balls

and strikes in professional baseball pitchers. Am J Sports Med 2017;45:3358-67. https://doi.org/10.1177/0363546517730052.
8. Greiner JJ, Trotter CA, McGuine TA, Walczak BE, Baer GS. Pitching behaviors in youth fast-pitched softball: high pitching volumes with unequal pitch counts among pitchers are common. J Pediatr Orthop 2022;42:e747-52. https://doi.org/10.1097/BPO.0000000000002182.
9. Greiner JJ, Trotter CA, Walczak BE, Hetzel SJ, Baer GS. Pitching behaviors in youth baseball: comparison with the pitch smart guidelines. Orthop J Sports Med 2021;9:23259671211050127. https://doi.org/10.1177/23259671211050127.
10. Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, et al., editors. Cochrane handbook for systematic reviews of interventions. 6.3 ed. Chichester, UK: John Wiley & Sons; 2022.
11. Hinkle AJ, Brown SM, Mulcahey MK. Gender disparity among NBA and WNBA team physicians. Phys Sportsmed 2021;49:219-22. https://doi.org/10.1080/00913847.2020.1811065.
12. Hoof MA, Sommi C, Meyer LE, Bird ML, Brown SM, Mulcahey MK. Gender-related differences in research productivity, position, and advancement among academic orthopaedic faculty within the United States. J Am Acad Orthop Surg 2020;28:893-9. https://doi.org/10.5435/JAAOS-D-19-00408.
13. Hoppe MW, Brochhagen J, Tischer T, Beitzel K, Seil R, Grim C. Risk factors and prevention strategies for shoulder injuries in overhead sports: an updated systematic review. J Exp Orthop 2022;9:78. https://doi.org/10.1186/s40634-022-00493-9.
14. Knowles SB, Marshall SW, Bowling JM, Loomis D, Millikan R, Yang J, et al. A prospective study of injury incidence among North Carolina high school athletes. Am J Epidemiol 2006;164:1209-21. https://doi.org/10.1093/aje/kwj337.
15. Krajnik S, Fogarty KJ, Yard EE, Comstock RD. Shoulder injuries in US high school baseball and softball athletes, 2005-2008. Pediatrics 2010;125:497-501. https://doi.org/10.1542/peds.2009-0961.
16. Little League. Little League softball. https://www.littleleague.org/downloads/softball-brochure. Accessed July 11, 2022.
17. Medicine AOSfS. Stop sports injuries. https://www.ncys.org/safety/stop-sports-injuries/. Accessed July 18, 2022.
18. Methley AM, Campbell S, Chew-Graham C, McNally R, Cheraghi-Sohi S. PICO, PICOS and SPIDER: a comparison study of specificity and sensitivity in three search tools for qualitative systematic reviews. BMC Health Serv Res 2014;14:579. https://doi.org/10.1186/s12913-014-0579-0.
19. Mine K, Milanese S, Jones MA, Saunders S, Onofrio B. Risk factors of shoulder and elbow injuries in baseball: a scoping review of 3 types of evidence. Orthop J Sports Med 2021;9:23259671211064645. https://doi.org/10.1177/23259671211064645.
20. Moher D, Liberati A, Tetzlaff J, Altman DG, Group P. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Ann Intern Med 2009;151:264-9. https://doi.org/10.7326/0003-4819-151-4-200908180-00135. W64.
21. Oliver GD. Baseball pitching and softball pitching: why the perplexity? Open Access Text 2020;7:1-3. https://doi.org/10.15761/JTS.1000392.
22. Patel N, Bhatia A, Mullen C, Bosman E, Lear A. Professional women's softball injuries: an epidemiological cohort study. Clin J Sport Med 2019;31:63-9. https://doi.org/10.1097/JSM.0000000000000698.
23. Paul RW, Sonnier JH, Johnson EE, Hall AT, Osman A, Connors GM, et al. Inequalities in the evaluation of male versus female athletes in sports medicine research: a systematic review. Am J Sports Med 2022:3635465221131281. https://doi.org/10.1177/03635465221131281.
24. Powell JW, Barber-Foss KD. Sex-related injury patterns among selected high school sports. Am J Sports Med 2000;28:385-91.
25. Pytiak AV, Kraeutler MJ, Currie DW, McCarty EC, Comstock RD. An epidemiological comparison of elbow injuries among United States high school baseball and softball players, 2005-2006 through 2014-2015. Sports Health 2018;10:119-24. https://doi.org/10.1177/1941738117736493.
26. Rice SG, Congeni JA, Council on Sports Medicine and Fitness. Baseball and softball. Pediatrics 2012;129:e842-56. https://doi.org/10.1542/peds.2011-3593.
27. Scerpella TA, Spiker AM, Lee CA, Mulcahey MK, Carnes ML. Next steps: advocating for women in orthopaedic surgery. J Am Acad Orthop Surg 2022;30:377-86. https://doi.org/10.5435/JAAOS-D-21-00932.
28. Shamseer L, Moher D, Clarke M, Ghersi D, Liberati A, Petticrew M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. BMJ 2015;350:g7647. https://doi.org/10.1136/bmj.g7647.
29. Shanley E, Rauh MJ, Michener LA, Ellenbecker TS. Incidence of injuries in high school softball and baseball players. J Athl Train 2011;46:648-54. https://doi.org/10.4085/1062-6050-46.6.648.
30. Slim K, Nini E, Forestier D, Kwiatkowski F, Panis Y, Chipponi J. Methodological index for non-randomized studies (minors): development and validation of a new instrument. ANZ J Surg 2003;73:712-6. https://doi.org/10.1046/j.1445-2197.2003.02748.x.
31. Smith MV, Davis R, Brophy RH, Prather H, Garbutt J, Wright RW. prospective player-reported injuries in female youth fast-pitch softball players. Sports Health 2015;7:497-503. https://doi.org/10.1177/1941738115606058.
32. NPR, Robert Wood Johnson, Foundation, Harvard T.H. Chan School of Public Health, June 2015. Available at: https://media.npr.org/documents/2015/june/sportsandhealthpoll.pdf.
33. Vesterinen HM, Sena ES, Egan KJ, Hirst TC, Churolov L, Currie GL, et al. Meta-analysis of data from animal studies: a practical guide. J Neurosci Methods 2014;221:92-102. https://doi.org/10.1016/j.jneumeth.2013.09.010.
34. Werner SL, Jones DG, Guido JA Jr, Brunet ME. Kinematics and kinetics of elite windmill softball pitching. Am J Sports Med 2006;34:597-603. https://doi.org/10.1177/0363546505281796.