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Shoulder and Elbow Symptoms in Dutch High School Baseball Pitchers: Results of a Two-Season Prospective Study

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Context: Baseball pitching requires fast and coordinated motions of the whole body to reach high ball speeds, putting considerable strain on the musculoskeletal system, particularly the shoulder and elbow.

Objective: To describe musculoskeletal symptoms and the functional status of the shoulder and elbow in male high school baseball pitchers.

Design: Descriptive epidemiology study.

Setting: Dutch baseball talent academies.

Patients or Other Participants: One hundred twenty-five male high school baseball pitchers aged 12 to 18 years who participated in 1 of the 6 Dutch baseball talent academies and the Dutch National U-18 team were recruited and enrolled.

Main Outcome Measure(s): Musculoskeletal symptoms, functional status of the shoulder and elbow were registered for each player every 6 months over 2 consecutive baseball seasons through self-assessment questionnaires, including the Kerlan-Jobe Orthopaedic Clinic (KJOC) and the Western Ontario Shoulder Instability Index (WOSI) questionnaires.

Results: Five hundred seventy musculoskeletal (MSS) symptoms in 93 of the 125 players were reported. The average 6-month prevalence for symptoms of the throwing shoulder was 37% (95% CI = 33%–41%), and for the elbow 37% (95% CI = 31%–42%), followed by the lower back with 36% (95% CI = 26%–45%). The baseball pitchers who experienced only shoulder symptoms had an average KJOC score of 80.0 (95% CI = 75.3–84.7) points, whereas those with only elbow symptoms reported a score of 90.2 (95% CI = 89.2–95.3). On the WOSI questionnaire, baseball pitchers scored an average of 421.2 (95% CI = 200.1–642.4) points.

Conclusions: In a cohort of Dutch high school baseball pitchers, one-third reported shoulder and elbow symptoms on the throwing side, with reduced functional status and lower back symptoms. Future efforts should focus on developing preventive strategies through early symptom detection, aiming to prevent symptom progression and, ultimately, the development of severe injuries.

Key Words: fastball pitching, injury prevention, symptom monitoring, upper extremity

Key Points

- Shoulder and elbow symptoms on the throwing side and lower back symptoms dominated the musculoskeletal symptoms reported by our high school baseball pitchers.
- One-third of our baseball pitchers who reported shoulder and elbow symptoms also reported a decreased functional status.

In baseball, the pitcher is the most important defensive player, and attempting to reach pitching velocities of 100 mph is one of the most important skills.[1] Fast pitches give batters less time to plan and execute their swing, reducing their chances of hitting the ball into or out of the field. Baseball pitches require fast and coordinated whole-body motion to reach high ball speeds.[2–4] Pitches require maximum effort and high (rotational) body segment velocities, putting the musculoskeletal system under stress. Moreover, pitchers must practice regularly to perform well during a baseball season, alongside the 40 to 70 pitches required during games.[5] As a result, due to the strenuous pitching motion and high pitch count, recreational and professional baseball pitchers have a high shoulder and elbow injury rate.[6,7]

In National Collegiate Athletic Association men's baseball, pitchers suffered the most injuries (557 of all reported injuries, 31.0%) during pitching (331 of all reported injuries, 18.0%).[8] Most reported injuries during the study period comprised shoulder and elbow injuries, mostly caused by noncontact and overuse mechanisms.[8] In another recent study on National Collegiate Athletic Association student-athletes, baseball pitchers as opposed to other positions reported the most shoulder injuries (194 of all reported injuries, 42.5%) during pitching (180 of all reported injuries, 39.4%), followed by elbow injuries (176 of all

reported injuries, 63.5%), also mostly during pitching (170 injuries of all reported injuries, 61.4%).[6] These studies highlight upper extremity injuries in baseball pitchers. However, injury definitions, especially for the shoulder and elbow, strongly influence injury rates. Researchers performing epidemiologic studies frequently rely on medical-attention or time-loss injury definitions.[8] These definitions are often linked to the occurrence of more severe overuse injuries, which are common among baseball pitchers.[8] However, the more serious conditions usually start slowly with mild symptoms, whereas many of the mild symptoms will not develop into more serious ones. Thus, the medical-attention or time-loss injury definitions may underestimate baseball pitchers' problems, indicating that symptom monitoring is needed to better reflect the upper extremity musculoskeletal symptoms these overhead athletes face during sports participation.[9,10] Because these athletes often have other functional impairments and disabilities, such as instability, weakness, or fatigue in the upper extremities, monitoring their functional or performance status by self-reported questionnaires—in addition to symptom monitoring—may potentially help to identify a group of baseball pitchers who are at greater risk for developing upper extremity problems.[9,10]

The injury prevalence in Dutch baseball pitchers remains unknown within the current literature. Thus, the purpose of this study is to present data regarding musculoskeletal symptoms and functional status, particularly concerning the shoulder and elbow, aiming to fill this gap in knowledge. In line with this objective, a hypothesis is formulated positing that a significant portion of Dutch baseball pitchers experience musculoskeletal symptoms and reduced functional status in the shoulder and elbow regions, thereby highlighting the necessity for preventive strategies. In this study, we examine the epidemiology of baseball-related musculoskeletal symptoms, particularly shoulder and elbow symptoms, and the self-reported shoulder and elbow functional status in Dutch baseball pitchers over 2 consecutive competition seasons.

METHODS

Study Design and Study Population

In this prospective, open cohort study, male high school baseball pitchers, aged 12 to 18 years who participated in 1 of the 6 Dutch baseball talent academies, and the Dutch National U-18 team were observed for 1.5 years. Pitchers participated in several activities besides bullpen pitching drills, including strength and flexibility exercises and endurance training. Measurements occurred at the beginning and end of 2 consecutive baseball competition seasons (ie, March 2015, October 2015, March 2016, and October 2016). The Faculty of Behavioral and Movement Sciences' local ethics committee of Vrije Universiteit Amsterdam approved the study (protocol number ECB-2013-53). According to the university policy, all participants or their legal representatives gave their written consent after being fully informed about the study's content and purpose. The STROBE [Strengthening the Reporting of Observational Studies in Epidemiology] guidelines were used to ensure the reporting of this observational study.[11]

Procedure and Data Collection

Each participant was asked to complete several questionnaires on the measurement day (in March 2015, October 2015, March 2016, and October 2016) at their local training facility. A general questionnaire contained questions concerning their age, arm dominance, baseball and pitching exposure, and years of experience playing baseball and pitching, followed by an adapted Dutch translation of the Standardized Nordic Questionnaire used for a more in-depth assessment of musculoskeletal symptoms.[12] The Kerlan-Jobe Orthopaedic Clinic (KJOC) and the Western Ontario Shoulder Instability Index (WOSI) questionnaires were additionally administered to collect information about the functional status of the upper extremity. The WOSI questionnaire was administered only if participants reported episodes in the past 6 months in which they did not play or played less baseball or when they consulted a (para)medical care provider, such as a general practitioner, specialist physician, physiotherapist, or another practitioner, due to shoulder symptoms. At the training facility, body mass and body height were measured, and body mass index was calculated.

Musculoskeletal Symptoms. At the time of completing the questionnaire, participants were asked to report whether they had experienced symptoms (in line with the questionnaire defined as a trouble, pain or discomfort) in the past 6 months at their neck, upper back, lower back, left or right shoulder, left or right elbow, left or right wrist/hand, left or right hip/thigh, left or right knee, or left or right ankle/foot.[13] For each body region, the participants could reply with *Yes, once or twice*; *Yes, regularly*; *Yes, long-lasting*; or *No, never*. In addition, a slightly adapted Dutch translation of the Standardised Nordic Questionnaire was used for a more in-depth assessment of symptoms (in line with the questionnaire defined as trouble, ache, pain, or discomfort) during the past 6 months for the shoulder and elbow, respectively.[12] More specifically, it asked when they had experienced symptoms in the past 6 months, how often they had experienced separate episodes of symptoms (1 time, 2–4 times, more than 4 times) and how many days in total, throughout all separate episodes, they experienced symptoms (1–7 days, 1–4 weeks, 4 weeks to 3 months, 3–6 months). Finally, pain intensity was assessed by asking the participant to indicate their worst pain in the past 6 months and their average pain in the past 6 months, using visual analog scales ranging from *no pain* to *the most intense pain possible*.[14]

Shoulder and Elbow Functional Status Registration. A Dutch version of the KJOC questionnaire, a 10-item subjective visual analog scale ranging from 0 to 100 mm, including a 5-item function and a 5-item performance subscale, was used to evaluate overhead athletes' shoulder and elbow function and performance during the past 6 months at each of the 4 measurements.[15,16] The measured score on each question is expressed to 1 decimal point (eg, a score of 92 mm is expressed as 9.2 of 10). The 10 questions yield an unweighted maximum score of 100 points, which signifies the best shoulder and elbow functional status possible relative to the worst score of 0 points, corresponding with the worst shoulder and elbow functional status. The functional status is divided into 2 subscales, function and performance, which are weighted equally, and each represent 50% of the total score. The KJOC demonstrates good test-retest reliability (intraclass correlation coefficient = 0.84) and strong concurrent validity (Pearson correlation, r = 0.84) versus the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire.[15]

The Dutch version of the WOSI questionnaire was used to evaluate overhead athletes with shoulder symptoms during the past 6 months.[17–19] The WOSI provides a 21-item subjective

visual analog scale ranging from 0 to 100 mm and includes the subscales physical symptoms and pain (10 items); sports, recreation, and work (4 items); lifestyle and social functioning (4 items); and emotional well-being (3 items). The total score is represented by a maximal unweighted summed score of 2100, which signifies the worst shoulder-related quality of life relative to a score of 0, corresponding with no decrease in shoulder-related quality of life. The Dutch version of the WOSI demonstrates excellent overall internal consistency (Cronbach $\alpha = 0.95$), excellent test-retest reliability (intraclass correlation coefficient = 0.91), and strong concurrent validity ($r = 0.77$) versus the DASH.[17,19]

Statistical Analysis

Statistical analysis was conducted in R (version 4.1.1, 2020) with ggplot2 (version 3.3.5) to design the boxplots.[20,21]

Musculoskeletal Symptoms. The prevalence of reported musculoskeletal symptoms was calculated for each of the 4 measurements by dividing the reported symptoms by the respondents' total numbers. These calculations were conducted separately for each body region and the throwing and nonthrowing sides. Average prevalences were calculated as the mean prevalence over the 4 measurements with the corresponding 95% CIs, in line with the methodology outlined by Clarsen et al.[22] The medians of the requested average pain intensity and worst pain intensity scores were calculated for each of the 4 measurements. Again, average medians were calculated as the mean of the 4 medians over the 4 measurements with corresponding 95% CIs. All continuous data are presented as means with 95% CIs or SDs or as medians with interquartile ranges (IQRs) when nonnormally distributed.

Shoulder and Elbow Functional Status Registration. The unweighted summed KJOC scores were calculated separately for each participant who reported shoulder or elbow symptoms and those who reported symptoms in both regions. These unweighted summed scores were also calculated for the different levels of play, which consisted of (1) playing without any arm trouble, (2) playing but with arm trouble, and (3) not playing due to arm trouble. These calculations were conducted only for the throwing side. The median unweighted summed KJOC scores were finally calculated for each of the 4 measurements. The 4 medians were expressed as means of the 4 measurements with corresponding 95% CIs.

The unweighted summed WOSI scores were calculated for each participant who reported shoulder symptoms and met the definitions of a medical-attention health problem or time-loss health problem. The unweighted summed scores were also calculated for the domains (1) physical symptoms and pain; (2) sport, recreation, and work; (3) lifestyle and social functioning; and (4) emotional well-being. These calculations were also conducted only for the throwing side. The median unweighted summed WOSI scores were calculated for each of the 4 measurements. The 4 medians were expressed as means over the 4 measurements with corresponding 95% CIs.

RESULTS

Study Population and Response to Musculoskeletal Symptoms Questionnaires

A total of 96 of the 125 participating players (76.8%) completed at least 1 of the 4 measurements. Forty-one players (32.8%) completed all 4 measurements, 19 respondents (15.2%) completed 3 measurements, 24 (19.2%) completed 2, and 12 (9.6%) completed only 1. The mean ± SD player age at the first measurement was 14.7 ± 1.7 years, with an average body mass index of 21.7 ± 3.2 (Table 1). Players had, on average, 6.8 ± 2.6 years of pitching experience. A mean of 12.2 ± 2.8 hours per week of baseball exposure was observed across the 4 follow-up measurements, of which, on average, 3.1 ± 2.1 hours were spent explicitly on pitching.

Table 1. Participant Characteristics at Their First Measurement

Characteristic	Value
No.	96
Age, mean ± SD, y	14.7 ± 1.7
Body height, mean ± SD, cm	177.7 ± 10.7
Body mass, mean ± SD, kg	69.2 ± 14.9
Body mass index, mean ± SD, kg/m^2	21.7 ± 3.2
Right-handed, No. (%)	102 (84.3)
Pitching experience, y	6.8 ± 2.6
Average exposure, ± SD, h/wk	
Baseball	12.2 ± 2.8
Pitching	3.1 ± 2.1

Six-Month Prevalence of Musculoskeletal Symptoms

For the 4 measurements, a total of 570 reports of musculoskeletal symptoms experienced in the past 6 months were reported by 93 of the 125 players (Table 2). The highest number of musculoskeletal symptoms was reported for the throwing shoulder (mean measurement 6-month prevalence = 37%; 95% CI = 33%, 41%) and the throwing elbow (mean prevalence = 37%; 95% CI = 31%, 42%), followed by the lower back (mean prevalence = 36%; 95% CI = 26%, 45%). Of all reported symptoms, 365 (64.0%) were occasional symptoms (ie, once or twice), 140 (24.6%) were regular symptoms, and 65 (11.4%) were long-lasting symptoms.

Six-Month Throwing Shoulder and Elbow Symptoms

Of all 85 reported shoulder symptoms experienced in the past 6 months for the 4 measurements, 71 (87.7%) concerned the throwing shoulder. For the throwing elbow, this was true for 60 of 67 reported symptoms (89.6%). There was a total of 16 reported symptoms in the past 6 months for the 4 measurements at both the throwing shoulder and elbow, of which 71 concerned the throwing shoulder (22.5%) and 67 the throwing elbow (23.9%; Table 3). Per measurement, on average, 12% (95% CI = 7%, 17%) reported having had elbow symptoms on the throwing side more than 4 times in the past 6 months, and 15% (95% CI = −2%, 31%) reported having had both shoulder and elbow symptoms more than 4 times in the past 6 months. For the throwing shoulder, on average, 64% (95% CI = 49%, 78%) per measurement reported having had symptoms only once in the past 6 months, which was followed by the throwing elbow, for which, on average, 58% per measurement reported having had symptoms in the past 6 months. As for the duration of symptoms in the past 6 months, on average, 47% (95% CI = 19%, 74%) per measurement reported having had symptoms for 1 to 4 weeks at both the shoulder and elbow of the throwing side, which was about the same compared with only the throwing shoulder, as on average 46% (95% CI = 32%, 61%) per measurement reported having had symptoms for 1 to 4 weeks at only the throwing shoulder. Of these symptoms, the highest median score reported was, on average, 32 (95% CI = 21, 44)

Table 2. Absolute Numbers and Mean Prevalences of Reported Symptoms for Each Body Region[a]

	All Symptoms	Occasional Symptoms	Frequent Symptoms	Long-Term Symptoms
No. of symptoms	570	365	140	65
Prevalence, % (95% CI)				
Neck	11.7 (8.7, 14.8)	9.6 (6.3, 13.0)	1.7 (0.4, 3.0)	0.4 (0.0, 1.1)
Upper back	14.8 (9.5, 20.1)	10.3 (7.0, 13.7)	3.5 (1.2, 5.7)	1.0 (0.4, 1.7)
Lower back	35.5 (26.0, 45.0)	21.8 (16.1, 27.6)	12.2 (9.2, 15.2)	1.4 (0.0, 3.1)
Shoulder				
Throwing	37.0 (32.6, 41.4)	22.4 (15.4, 29.3)	9.3 (6.5, 12.1)	5.3 (2.5, 8.1)
Nonthrowing	5.0 (2.0, 7.9)	3.9 (1.9, 5.9)	0.7 (0.0, 1.5)	0.4 (0.0, 1.1)
Elbow				
Throwing	36.5 (30.8, 42.3)	23.7 (16.0, 31.3)	8.4 (4.2, 12.6)	4.5 (1.8, 7.1)
Nonthrowing	2.5 (0.5, 4.5)	1.4 (−0.2, 2.9)	0.8 (−0.1, 1.7)	0.3 (0.0, 0.9)
Wrist/hand				
Throwing	4.5 (1.9, 7.2)	3.9 (2.0, 5.8)	0.0 (0.0, 0.0)	0.6 (0.0, 1.9)
Nonthrowing	2.9 (0.8, 4.9)	1.7 (0.2, 3.3)	0.4 (0.0, 1.1)	0.7 (0.0, 1.6)
Hip/thigh/groin				
Throwing	5.6 (3.6, 7.5)	4.1 (1.9, 6.3)	1.1 (0.0, 2.4)	0.4 (0.0, 1.1)
Nonthrowing	3.2 (1.8, 4.7)	2.5 (1.4, 3.5)	0.3 (0.0, 0.9)	0.4 (0.0, 1.3)
Knee				
Throwing	15.4 (13.6, 17.1)	8.5 (7.0, 9.9)	3.7 (1.7, 5.8)	3.2 (1.4, 5.0)
Nonthrowing	15.9 (12.5, 19.3)	7.5 (4.3, 10.7)	4.3 (2.1, 6.5)	4.2 (1.7, 6.6)
Ankle/foot				
Throwing	7.8 (2.4, 13.2)	6.5 (2.3, 10.6)	1.3 (0.0, 3.1)	0.0 (0.0, 0.0)
Nonthrowing	7.9 (2.0, 13.7)	5.2 (1.9, 8.5)	2.3 (0.2, 4.5)	0.3 (0.0, 0.9)

[a] Data are expressed as the mean prevalence (%) of the 4 consecutive measurements, with the corresponding 95% CI.

per measurement for the average pain intensity and 58 (95% CI = 47, 70) for the worst pain intensity experienced in the past 6 months when only the throwing shoulder was concerned. For the throwing elbow, the highest median score reported was, on average, 31 (95% CI = 16, 46) per measurement for the average pain intensity and 49 (95% CI = 49, 62) for the worst pain intensity experienced in the past 6 months when the throwing shoulder was also reported.

Six-Month Functional Status of the Throwing Shoulder and Elbow

A total of 65 of the 125 players (52.0%) completed the KJOC questionnaire at least once at 1 of the 4 measurements to register their performance and function of the throwing shoulder and elbow in the past 6 months. Five players (7.7%) completed the questionnaire for all 4 measurements, 8 respondents (12.3%) completed 3 measurements, 20 (30.8%) completed 2, and 32 (49.2%) completed only 1. Per measurement, on average, the lowest median total score of 67 (95% CI = 64, 71) out of 100 (best score possible) was scored at the time of administration when only throwing-elbow symptoms were reported in the past 6 months and participants played with arm trouble (in line with the KJOC questionnaire; Table 4). The highest median total score when only throwing-elbow symptoms in the past 6 months were reported and participants played without any arm trouble (in line with the KJOC questionnaire) was, on average, 95 (95% CI = 92, 97) per measurement, followed by the throwing shoulder, with a median total score of 90 (95% CI = 87, 94) and a score of 89 (95% CI = 81, 96) when throwing-side symptoms in the past 6 months were reported at both regions. Across the 4 follow-up

Table 3. Characteristics of Reported Symptoms on the Throwing Side in the Past 6 Months, Derived From 2 Region-Specific Musculoskeletal Questionnaires (Shoulder and Elbow)[a]

	Shoulder Symptoms Only	Elbow Symptoms Only	Both Shoulder and Elbow Symptoms	
No. of reported symptoms in the past 6 months at throwing side	55	44	16	
Region of reported symptoms	Shoulder	Elbow	Shoulder	Elbow
Frequency of symptoms, % (95% CI)				
Once	57.9 (50.2, 65.6)	63.6 (49.2, 77.9)	45.4 (28.3, 62.6)	54.6 (21.5, 87.7)
2–4 times	32.8 (23.4, 42.3)	24.7 (6.5, 43.0)	48.3 (37.5, 59.2)	30.8 (9.6, 52.1)
>4 times	9.3 (5.2, 13.3)	11.7 (7.0, 16.5)	6.2 (0.0, 18.5)	14.6 (0.0, 31.4)
Duration of symptoms, % (95% CI)				
1–7 d	38.9 (29.2, 48.7)	38.5 (19.9, 57.0)	43.3 (21.8, 64.9)	30.8 (23.7, 38.0)
1–4 wk	46.4 (32.3, 60.5)	36.5 (23.4, 49.5)	46.7 (19.0, 74.3)	43.4 (21.8, 64.9)
4 wk–3 mo	7.3 (1.1, 13.5)	14.2 (7.1, 21.2)	5.0 (0.0, 14.8)	14.6 (0.0, 31.4)
>3 mo	7.3 (0.0, 18.0)	9.1 (7.5, 10.7)	5.0 (0.0, 14.8)	11.2 (0.0, 24.1)
Pain intensity score, median (95% CI) (0 = best, 100 = worst)				
Average pain intensity	32 (21, 44)	23 (15, 30)	28 (20, 37)	31 (16, 46)
Worst pain intensity	58 (47, 70)	43 (34, 51)	39 (25, 53)	49 (36, 62)

[a] Symptom frequency and duration are expressed as the mean prevalence of the 4 consecutive measurements and pain intensity as the averaged median scores of the 4 consecutive measurements, all with corresponding 95% CIs.

Table 4. Median Kerlan-Jobe Orthopaedic Clinic (KJOC) Scores of the Throwing Side at the Time of Administration[a]

KJOC Scores (0 = Worst, 100 = Best)	Shoulder Symptoms Only	Elbow Symptoms Only	Both Shoulder and Elbow Symptoms
No. of reported scores	55	44	16
All	80.0 (75.3, 84.7)	92.2 (89.2, 95.3)	88.2 (84.4, 92.2)
Current level of play			
Playing without any arm trouble	90.0 (86.5, 93.5)	94.5 (92.2, 96.8)	88.8 (81.1, 96.4)
Playing but with arm trouble	71.5 (56.9, 86.1)	67.2 (63.9, 70.6)	73.7 (66.4, 80.9)
Not playing due to arm trouble	82.0 (80.0, 84.0)	NA	71.0 (65.1, 76.9)

Abbreviation: NA, not available.
[a] Data are expressed as averaged median scores of the 4 consecutive measurements with corresponding 95% CIs.

measurements, the lowest median total score at the time of administration was reported when throwing-side symptoms in the past 6 months were reported at both regions compared with when only throwing-elbow or -shoulder symptoms were reported (Figure 1).

The WOSI questionnaire was completed at least once at 1 of the 4 measurements by 18 of the 125 players (14.4%) to evaluate the reported throwing-shoulder symptoms they experienced in the past 6 months. No single player completed the WOSI questionnaire at all 4 or 3 measurements. Only 2 players (16.6%) completed 2 measurements, and 15 (71.4%) completed the questionnaire once. The throwing-shoulder symptoms that required medical attention or resulted in being unable to complete current or future training sessions or competition in the past 6 months scored on average a median total of 421 (95% CI = 200, 642) out of 2100 (worst score possible) per measurement on the questionnaire (Table 5). Per measurement, on average, the highest median total score was scored on the domain physical symptoms and pain (139 [95% CI = 30, 247]), followed by emotional well-being (103 [95% CI = 46, 160]); sport, recreation, and work (93 [95% CI = 69, 117]); and lifestyle and social functioning (23 [95% CI = 6, 39]). The median total score over the 4 follow-up measurements shows a visually observed downward trend, which starts with an initial median total score of 722 (IQR = 322) at the first measurement (March 2015), followed by 456 (IQR = 202) at the second measurement (October 2015), 204 (IQR = 190) at the third (March 2016), and finally a median score of 303 (IQR = 100; October 2016; Figure 2). This observed trend also appears to be visible in the domains of physical symptoms and pain; emotional well-being; and sport, recreation, and work.

DISCUSSION

In this study, we examined the epidemiology and self-reported shoulder and elbow functional status of Dutch high school baseball pitchers over 2 competitive seasons. Baseball pitchers reported mostly shoulder and elbow symptoms on the throwing side and lower back symptoms.

Injury definitions determine epidemiologic prevalences. Symptom-based definitions have the highest prevalence.[9] When less-inclusive definitions like requiring medical attention or time loss due to a shoulder or elbow injury are used, the prevalence is lowest.[9] Our cohort had different shoulder and elbow prevalences than previous epidemiologic studies on baseball pitchers.[6,7,23] Two studies had significantly higher

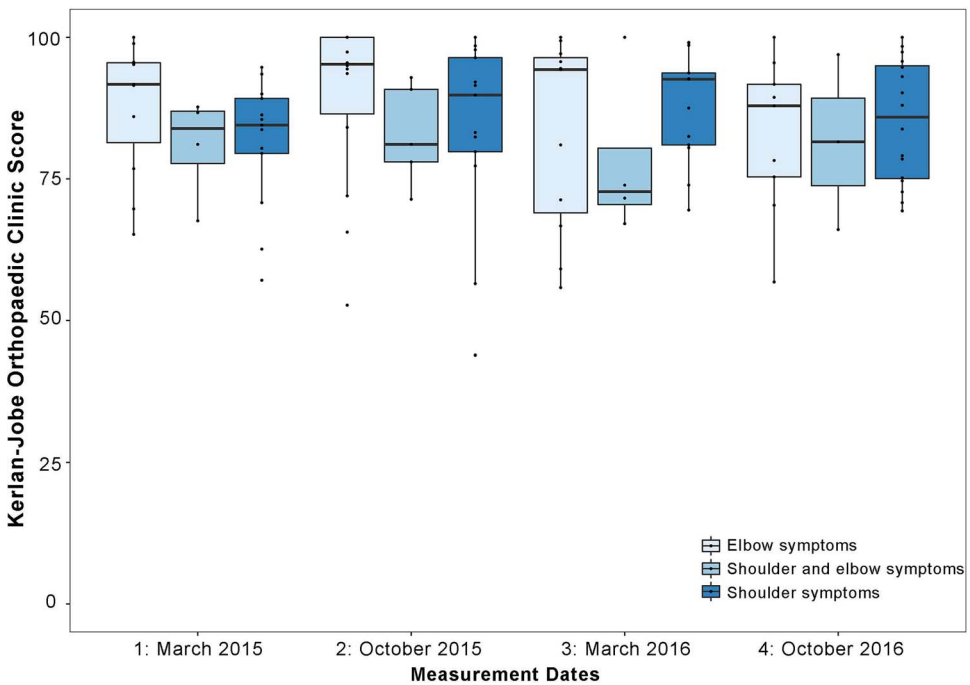

Figure 1. Distribution of the Kerlan-Jobe Orthopaedic Clinic scores (0–100, worst to best upper extremity function and performance) of the throwing side at the time of administration of the 4 consecutive measurements, presented with individual reported scores represented by the black dots on each occasion.

Table 5. Median Western Ontario Shoulder Instability Index (WOSI) Scores of the Throwing Side at the Time of Administration[a]

WOSI Scores	Population Reporting Shoulder Symptoms
No. of reported scores	21
Total score	421.2 (200.1, 642.4)
Domains	
Physical symptoms and pain	138.8 (30.1, 247.4)
Sport, recreation, and work	93.0 (69.2, 116.8)
Lifestyle and social functioning	22.5 (6.0, 39.0)
Emotional well-being	102.5 (45.5, 159.5)

[a] Data are expressed as averaged median scores of the 4 consecutive measurements with corresponding 95% CIs.

prevalences of elbow (57%) and shoulder (40%) injuries than our study.[6,23] These epidemiologic studies defined shoulder and elbow injuries by medical attention and time loss. These prevalences account for pitchers' shoulder and elbow loads. Dutch and US baseball pitchers have different shoulder and elbow loads, which may explain the reported prevalence differences. Baseball pitchers must rest and limit their pitches to reduce shoulder and elbow loads. Authors of a recent study found that nearly half of US states did not have pitch-count rules for high school baseball pitchers based on competition level or age.[24] High school athletes in the US typically had a maximum pitch count of 100 to 135 and required rest ranging from 0 to 5 days, depending on the number of balls pitched.[24] No Dutch baseball pitch count studies have examined compliance. The Royal Dutch Baseball and Softball Association allows high school pitchers in the Netherlands to throw 50 to 90 pitches, depending on age and competition level.[25] It is likely that US baseball pitchers report more injuries than Dutch pitchers due to higher cumulative shoulder and elbow loads. The differences in shoulder and elbow injury prevalence among baseball pitchers may thus be due to injury definitions and the different loads pitchers in different countries are exposed to.

The KJOC and WOSI questionnaires assessed our baseball pitchers' shoulder and elbow symptoms. The KJOC was originally designed to evaluate overhead athletes' upper extremity function.[15] Nearly all baseball pitchers had KJOC scores below 90, indicating poor shoulder or elbow function. In 2 studies, asymptomatic professional baseball pitchers had mean KJOC scores above 93 points, indicating good shoulder and elbow function.[26,27] Our baseball pitchers' shoulder and elbow symptoms affect their baseball pitching. The WOSI questionnaire, unlike the KJOC, was originally designed to assess the quality of life of symptomatic shoulder-instability patients.[17] Our baseball pitchers who reported shoulder symptoms in the past 6 months scored 421 on the questionnaire, indicating a good shoulder-related quality of life. Baseball pitchers who had an isolated superior labral anterior-posterior tear repair scored 421 points for their healthy shoulder,[28] similar to our pitchers who had shoulder symptoms in the past 6 months. The KJOC questionnaire assesses upper extremity function better than the WOSI questionnaire, as this questionnaire specifically addresses the unique demands of overhand athletes like baseball pitchers. Thus, using this questionnaire to monitor the functional status of these high school baseball pitchers would help develop preventive strategies to optimize performance and reduce injury risk.

Methodologic Strengths and Limitations

Interpreting our study's results requires methodologic considerations. First, as with any questionnaire, the ones used in this study are subject to recall bias, especially because our baseball pitchers were asked to report symptoms from the past 6 months. Baseball pitchers may have answered 1 of the multiple-choice questions just to answer because they could not remember their symptoms from the past 6 months. Authors of a previous study found that respondents could accurately recall their functioning using the shortened version of the

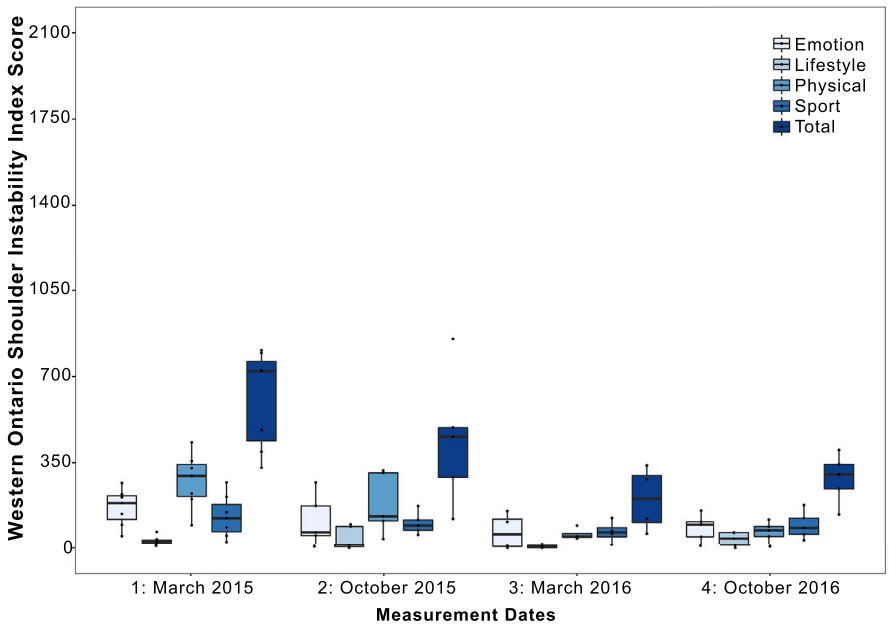

Figure 2. Distribution of the Western Ontario Shoulder Instability Index scores (0–2100, best to worst shoulder-related quality of life) of the throwing side at the time of administration of the 4 consecutive measurements presented with the individual reported scores represented by the black dots on each occasion.

DASH questionnaire for up to 2 years, suggesting that recall bias is unlikely to affect our reported prevalences.[29]

Second, our outcomes may have been affected by the open cohort design. Baseball pitchers might have dropped out of the study for various reasons. These include pitchers who had become too old for the Dutch National U-18 team, pitchers who had been excluded from their respective selection team among 1 of the 6 Dutch baseball talent academies due to declining performance, or pitchers who had either compulsorily or voluntarily decided to leave their selection team for personal reasons. Additionally, pitchers might have dropped out due to severe symptoms that prevented them from practicing and playing, whereas others joined without symptoms. Selective dropout of pitchers may have led to underestimation of the prevalence and severity of symptoms reported in our study. The reasons for pitchers not participating in consecutive measurements are unclear, making it difficult to determine whether the subsequent dropouts affected our outcomes.

Clinical Implications

Given baseball's inherent risks, our high school pitchers' low rate of musculoskeletal symptoms is encouraging. Despite these low prevalence rates, our symptom registrations showed that about a third of our baseball pitchers participate in practices and matches with shoulder and elbow symptoms and reduced function. These findings suggest the need for an early focus on shoulder and elbow injury prevention. Monitoring symptoms instead of injuries may help identify early signs of injury and prevent them from worsening and causing more serious injuries.[30] This prevents baseball pitchers from missing practices and games, which can hurt their performance and career. By recognizing symptoms early, baseball pitchers can reduce shoulder and elbow symptoms and avoid long-term injuries.

CONCLUSIONS

According to our findings, reported shoulder and elbow symptoms on the throwing side and lower back symptoms dominated the musculoskeletal symptoms reported by baseball pitchers. One-third of our baseball pitchers reported shoulder and elbow symptoms and decreased functional status. Future efforts should be directed toward developing preventive strategies based on early symptom detection to prevent symptom progression and, ultimately, the development of severe injuries.

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