The Performance Demand of Softball Pitching: A Comprehensive Muscle Fatigue Study

Jeffrey S. Corben[1], Sara A. Cerrone[1], Julie E. Soviero[1], Susan Y. Kwiecien[2], Stephen J. Nicholas[2], Malachy P. McHugh, FACSM[2]

[1]Central Physical Therapy, Garden City, NY.; [2]Nicholas Institute of Sports Medicine and Athletic Trauma, Lenox Hill Hospital, New York, NY.

ABSTRACT

PURPOSE: Postgame muscle fatigue patterns have been described for baseball pitchers (Mullaney et al 2005) but little is known about fatigue patterns in softball pitchers. The purpose of this study was to examine muscle fatigue after fast-pitch softball performances to provide an assessment of performance demand.

METHODS: Bilateral strength measurements (hand-held dynamometer) were made on 19 female softball pitchers (age 15.2±1.2 yr) prior to and after pitching a game (99±21 pitches, 5±1 innings). 20 tests were performed on the dominant (dom) and nondominant (ndom) sides: forearm (grip, wrist flexion/extension, pronation/supination, elbow flexion/extension), shoulder (flexion, abduction/adduction, external/internal rotation, empty can test), scapula (middle/lower trapezius, rhomboid) and hip (hip flexion/extension, abduction/adduction). Fatigue (% strength loss) was categorized based on bilateral vs. unilateral presentation using paired t-tests: Bilateral Symmetric (significant on dom and ndom, and not different between sides), Bilateral Asymmetric (significant on dom and ndom, but significantly greater on dom), Unilateral Asymmetric (significant on dom only, and significantly greater than ndom), or Unilateral Equivocal (significant on dom only but not different from ndom).

RESULTS: Bilateral Symmetric fatigue was evident for all hip (dom 19.3% ndom 15.2%) and scapula tests (dom 19.2% ndom 19.3%). In general, shoulder tests exhibited Bilateral Asymmetric fatigue (dom 16.9% ndom 11.6%). Forearm tests were more variable, with Bilateral Symmetric fatigue in the elbow flexors (dom 22.5% ndom 19.2%), and wrist flexors (dom 21.6% ndom 19.0%), Bilateral Asymmetric fatigue in the supinators (dom 21.8% ndom 15.5%), Unilateral Asymmetric fatigue in the elbow extensors (dom 22.1% ndom 11.3%) and Unilateral Equivocal fatigue in the pronators (dom 18.8% ndom 15.2%) and grip (dom 11.4% ndom 6.6%).

CONCLUSIONS: Previously baseball pitching was characterized by dom shoulder fatigue, with minimal scapula or hip fatigue (Mullaney et al 2005). By contrast, softball pitching resulted in profound bilateral fatigue in the hip and scapular muscles with more selective fatigue in the shoulder and arm muscles. These findings emphasize the importance of strength in the proximal musculature to provide a stable platform for the arm to propel the ball.

(email mchugh@nismat.org)

INTRODUCTION

The fast-pitch softball pitching motion has been described in terms of six phases: (1) a downward shoulder movement to a six o'clock position (wind-up phase), (2) an upward movement from six o'clock to three o'clock (preparatory), (3) an upward movement from three o'clock to twelve o'clock (acceleration), (4) a downward movement from twelve o'clock to nine o'clock (power), (5) movement from nine o'clock to ball release, and (6) movement from ball release to completion of the follow through motion (deceleration).

There has been limited research on the softball pitching motion with respect to the physical demands of the action and injury risk. Consequently, no guidelines exist with regard to pitch count limits and required days of rest between pitching outings for softball pitchers. Softball pitching is regarded as a much less stressful motion than baseball pitching. Therefore, the purpose of this study was to examine the performance demand for softball pitching by documenting the upper and lower extremity fatigue patterns associated with a real game fast-pitch softball performance.

METHODS

Experimental Protocol

Bilateral strength measurements (hand-held dynamometer: Lafayette Manual Muscle Tester, Lafayette, IN) were made on 19 female softball pitchers (age 15.2±1.2 yr) prior to and after pitching a game (99±21 pitches, 5±1 innings).

Strength Tests

Forearm Tests: grip, wrist flexion/extension, pronation/supination, elbow flexion/extension
Shoulder Tests: flexion, abduction/adduction, external/internal rotation, empty can test
Scapular Tests: middle/lower trapezius, rhomboid
Hip Tests: flexion, abduction, adduction, extension

All strength tests were performed as break tests. On the day prior to a pitching performance, strength was assessed. The starting side (dominant vs non-dominant) was randomly selected. The average of 2 repetitions in each strength test was recorded. During the pitching performance, pitch counts and velocity of pitches were recorded. Within seven minutes of completion of the pitching performance, the range of motion and strength measurements were repeated in the same order as pregame testing.

METHODS cont.

Statistical Analysis

Dominance effects (dominant vs non-dominant) at baseline (pregame testing) were tested using paired t tests. Fatigue was quantified as the percent change in strength from pregame to postgame for all tests. One sample t-tests were used to assess if pre- to post- game strength loss was significant on the dominant and non-dominant sides.

Paired t-tests were used to assess if strength loss was greater on the dominant vs. non-dominant side. Fatigue (% strength loss) was categorized based on bilateral vs. unilateral presentation:

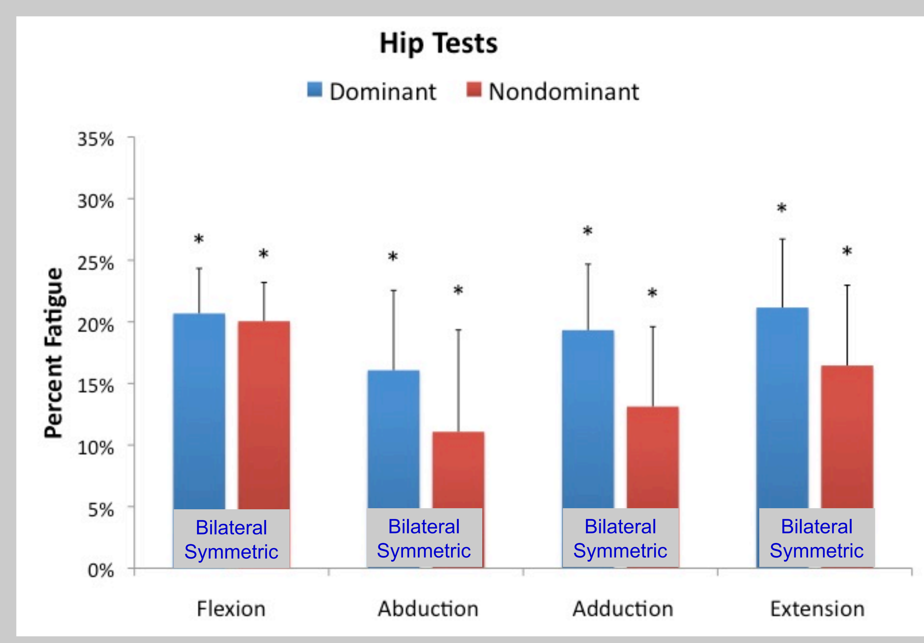
Classification of Fatigue:

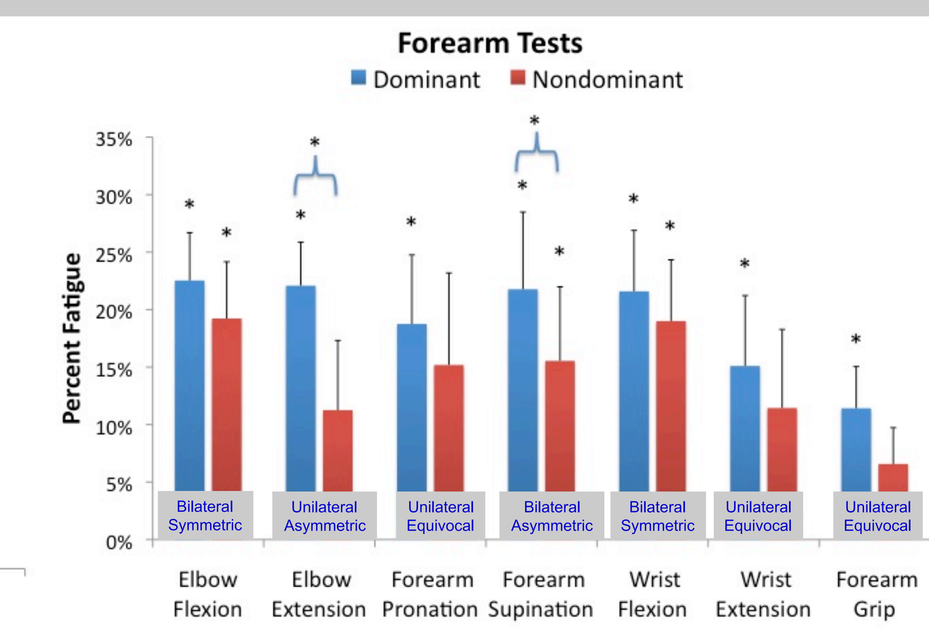
Bilateral Symmetric – significant on dominant and non-dominant sides but not different between sides;
Bilateral Asymmetric – significant on dominant and non-dominant sides and significantly greater on dominant side;
Unilateral Asymmetric – significant on dominant side only and significantly greater than non-dominant side;
Unilateral Equivocal – significant on dominant side only but not different than non-dominant side.

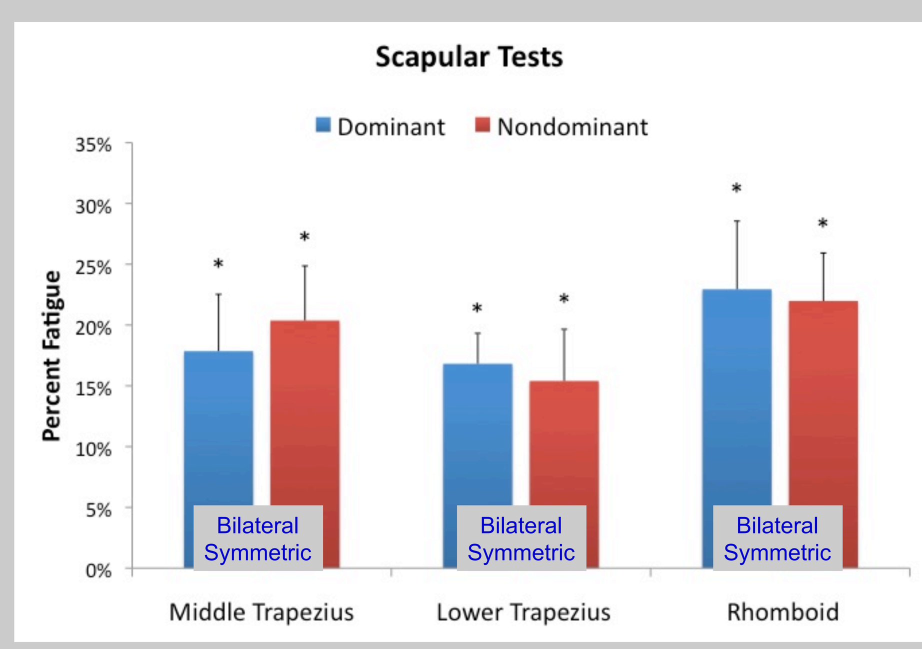
Differences in fatigue between the 4 different joints were assessed by Side (dominant vs. non-dominant) by Joint (forearm, shoulder, scapula, hip) repeated measures analysis of variance with fatigue values averaged across tests for each joint, and Bonferroni corrections for between joint pairwise comparisons.

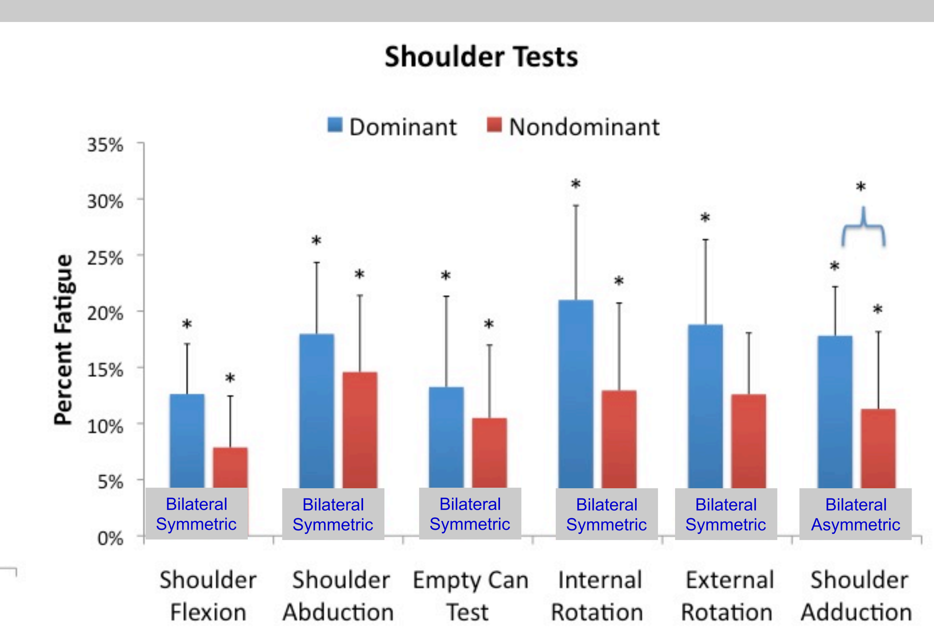
RESULTS

Fatigue was unrelated to the number of pitches thrown, the number of innings completed, or the loss of velocity from first to final inning. Similarly, fatigue was not correlated with the age of the pitcher. Percent fatigue for all muscle groups shown below (* above bar = significant fatigue; * above ⌐¬ = fatigue greater on dominant side.



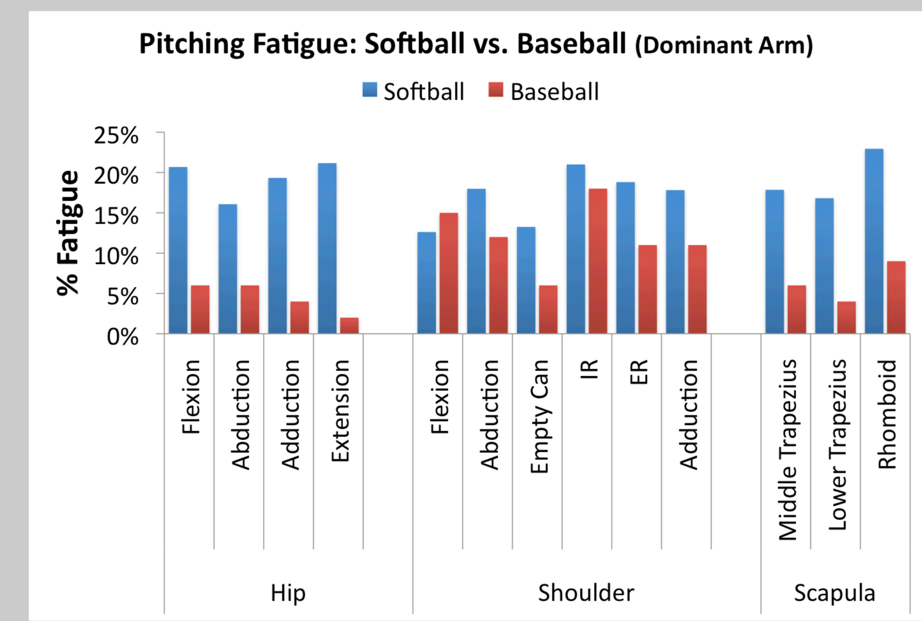


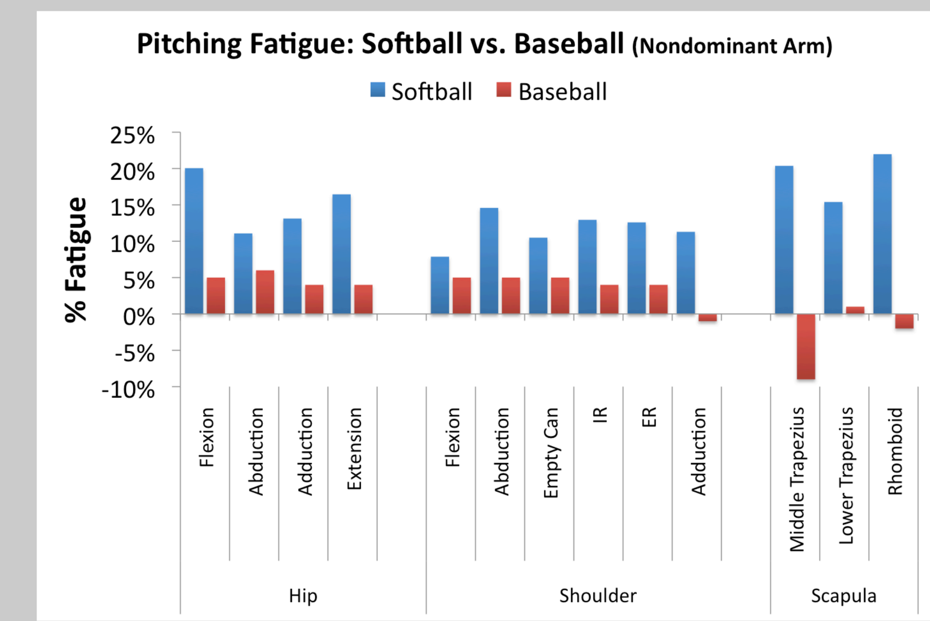




DISCUSSION

Following a fast-pitch softball pitching performance, fatigue was evident through the entire kinetic chain. Fatigue was present in all upper and lower extremity muscles, primarily unilateral in shoulder but bilateral in the proximal musculature (scapula and hip). By contrast Mullaney, et al (2005) showed that fatigue in college baseball pitchers occurred primarily in the dominant shoulder, with minimal scapluar fatigue and no lower extremity fatigue. Thus fast-pitch softball pitching appears to involve a greater performance demand than baseball pitching (see graphs below). However, Mullaney et al (2005) studied college baseball pitchers while high school softball pitchers were studied here. Therefore, age is a confounding variable in comparing these studies.





In 1992 Loosli et al challenged the view that windmill pitch put the throwing arm at minimal risk for injury compared with the overhand pitching technique by documenting that windmill pitchers reported a significant number of time-loss injuries. Barrentine et al (1998) demonstrated distraction stresses of 70% to 98% body weight at the elbow and shoulder joints of collegiate level windmill pitchers. At the youth softball level, Werner et al (2001) estimated stresses of 46% to 94% body weight at the elbow and shoulder joints. The windmill pitching motion has been shown to have significantly higher biceps brachii muscle activation than the baseball pitching motion (Rojas et al 2009), with peak activation shortly before ball release (Oliver et al 2011), when the muscle is in a lengthened position. Marked elbow flexor fatigue was evident in the present study (22%).

Conclusion

Fast-pitch softball pitching results in marked muscle fatigue throughout the kinetic chain. Bilateral strength training for the hip and scapular muscles is as important as training the shoulder muscles in adolescent fast-pitch softball pitchers.

Future research is required to establish is specific strength measures are associated with increased risk of injury in softball pitchers. Considering the significant performance demand of softball pitching, limits may need to be placed on the number of pitches per game, and the number rest days between games for adolescent pitchers.

References

1. Mullaney, Michael J., et al. "Upper and lower extremity muscle fatigue after a baseball pitching performance." *The American journal of sports medicine* 33.1 (2005): 108-113.
2. Barrentine SW, Fleisig GS, Whiteside JA, et al. Biomechanics of windmill softball pitching with implications about injury mechanisms at the shoulder and elbow. J. Orthop. Sports Phys. Ther. 1998; 28:405.
3. Werner SL, Gill TJ, Murray TA, et al. Relationships between throwing mechanics and shoulder distraction in professional baseball pitchers. Am. J. Sports Med. 2001; 29:354.
4. Oliver GD, Plummer HA, Keeley DW. Muscle activation patterns of the upper and lower extremity during the windmill softball pitch. J. Strength Cond. Res. 2011; 25:1653.
5. Rojas IL, Provencher MT, Bhatia S, et al. Biceps activity during windmill softball pitching. Am. J. Sports Med. 2009; 37:558.

Scan to download poster →