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# Comparison of Steady State Exercise and Interval Training on Pitching Performance in Collegiate Baseball Players: A Pilot Study

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ABSTRACT

***International Journal of Exercise Science 12(6): 726-734, 2019.*** Traditionally, a baseball pitcher's in-season conditioning between starts has consisted of steady state exercise. Little to no research exists on the effects of interval training on pitching performance. The purpose of this study was to examine the difference between steady state exercise (SSE) and interval training (IT) on exercise and pitching performance in collegiate baseball pitchers following an 11-week program. A total of 13 collegiate baseball pitchers were randomly assigned to either the SSE or IT group and tested pre- and post-season on a one-mile run, 30-m sprint, pitching velocity, walks plus hits per innings pitched (WHIP), fatigue index, and a muscle soreness/readiness scale. Pitchers in the SSE group had better one-mile run times post-season than the interval training group ($p=0.007$), but no difference on 30-m sprint performance ($p=0.15$). No differences were observed for pitching velocity ($p=0.25$), WHIP ($p=0.75$), fatigue index ($p=0.79$), or muscle soreness ($p=0.52$). There appears to be no additive benefit on interval training, as opposed to traditional steady state exercise on pitching performance.

KEY WORDS: Training, exercise, performance

## INTRODUCTION

Steady state exercise has been the traditional approach to in-season conditioning for baseball pitchers. Pitchers routinely use off-days, while in-season, to condition by running to improve cardiovascular endurance and relieve lactic acid build up in their dominant, throwing arm (17). This aerobic approach has been debated for years, despite little to no evidence related to sport performance. Collegiate baseball pitchers may throw upwards of 150 pitches per game, including warm-up throws and in-game throws, per start (14), which requires aerobic measures of endurance to go deep into a start and anaerobic measures of strength and power (5). Pitching involves intermittent high-intensity contractions of relatively short durations, which may further suggest that pitching is mostly an anaerobic activity (13). Due to the large volume of pitches that a baseball pitcher may throw in a single game, as well as over the course of a collegiate or professional season, physiological breakdown may occur (8).

The main goal of in-season conditioning programs are to build and maintain strength, endurance, and performance kinematics on and off the playing field, while also keeping the athlete healthy and decreasing soreness post-performance (16). While most of the attention regarding sports performance has involved interventions regarding blood flow restriction (9,12) and therapeutic recovery for performance and recovery (10,20), little is known about sport-specific metrics. Early investigation into pitching performance and recovery measures assessed blood lactate levels following a pitched game, yielding no differences in lactate levels between pre-pitching (0.76 mmol/L) and post-pitching (0.94 mmol/L) blood lactate levels of collegiate pitchers throwing 7-innings of a simulated game (14). This potentially indicates that blood lactate levels may not be the only causes of soreness (14), but potentially the method of training and conditioning. Additionally, these pitchers worked at 45% maximal oxygen uptake during pitching performances but returned to baseline after 6 minutes of rest between innings, reiterating the consideration for anaerobic aspects to training. Professional baseball starting pitchers yielded an 84% heart rate max while pitching, suggesting that pitching in professional baseball is predominately an anaerobic task (5). This warrants the prescription of high-intensity exercises when developing conditioning programs for starting pitchers. While there are no clear guidelines to the conditioning approach that is best for in-season training, Coleman and colleagues (4) have suggested that pitcher's in-season training consist of three sessions between starts, with 2 days of lower extremity focus and 1 day of upper extremity focus. Others have suggested a 5-day split for pitchers with 3 days of repeated sprint training (17), 2 days of sprint training and 1 days of 75% effort aerobic running (8).

Other speculation has been made into the integration of interval training, due to the similar in-game approach of work to rest intervals (3). Interval training has been reported to increase mean and peak power output and maximal oxygen uptake ($VO_2$ max) in men and women after a 2-week intervention (2), while also increasing muscle deoxyhemoglobin concentration in recreationally active individuals as compared to endurance training groups. To better understand how these anaerobic substrates relate to sport performance (ex. vertical jump), previous literature examined effects of interval training on muscular power in baseball players (15). Individuals in the sprint training group had improved lower extremity power as compared to the endurance training group over the course of a competitive season.

High-intensity interval training has been revealed to improve performance in other sports. Following a 4-week training program, hockey players in an interval training group had greater values of peak power, mean power, faster sprint times, and faster endurance than a continuous exercise group (11). Female soccer athletes in a sprint-interval intervention displayed greater power and lower fatigue index (1). This may warrant the need for exploration into the effects of interval training on pitching performance, as little is known about sport-specific performance measures. Therefore, the purpose of this study was to conduct a pilot study examining the difference between steady state exercise (SSE) and interval training (IT) on exercise and pitching performance in collegiate baseball pitchers following an 11-week program. It was hypothesized that the interval training group would perform better on exercise and pitching measures than the steady state exercise group following the training program.

## METHODS

*Participants*

The current study consisted of 13 National Collegiate Athletic Association (NCAA) baseball pitchers (20.23±1.01 years), from one university in the Mid-Atlantic region. Participants were eligible for the study if they were current student-athletes at the designated institution and had pitched a minimum of 3 innings over the course of the season. Participants were excluded if they had sustained any injuries related to sport (i.e., overuse, muscle strains, etc.) that would affect performance one month prior to the start of the season or during the season. Any athletes that underwent surgical reconstruction (i.e., Tommy John Surgery) were excluded as well. Participant's academic class was comprised of 4 freshmen, 3 sophomores, 5 juniors, and 1 senior. All participants were randomly assigned to either the steady state exercise (SSE) or interval training (IT) group. Informed consent was obtained by the student-athletes prior to the start of the season.

One-mile run: Cardiovascular endurance was measured through a 1-mile run pre- and post-season. Pitchers followed the same dynamic warm-up each time and were instructed to follow normal eating and hydration habits prior to running. The mile run was performed at the same time of day and on same indoor track (1/8-mile track) pre- and post-testing. To prevent running in groups, no more than 5 participants ran at same time and began at staggered time intervals.

30-m sprint: Anaerobic sprint performance was measured using a 30-meter sprint. All sprints were performed at the same time of day on the same indoor track. Participants were instructed to perform the sprint from a standing, upright starting position. A total of 12 trials were performed with the fastest time being recorded as the 30-m sprint time. There was a 90-second rest window between trials. Electronic timing systems (Brower Timing System, Draper, Utah, USA) were used to record sprint times.

Pitching velocity: Pitching velocity was measured during a bullpen session at beginning and end of the season. During pre-season testing, pitchers threw from a replica mound indoors to hitters in a competitive environment. At the end of the season, velocity was re-collected during a live game or during a competitive bullpen session if that pitcher did not participate in a game towards the end of the season. A radar gun (Stalker Sport, Richardson, Texas, USA) measured the average miles per hour (mph) of first 10 fastball pitches. During a live session, other pitches such as a curveball and changeup were not recorded for velocity. Pitchers were instructed to follow their typical pre-game warm-up routine for both test sessions.

Walks plus Hits per Innings Pitched (WHIP): WHIP is a sabermetric, baseball measurement of the number of baserunners that a pitcher allows per inning pitched, reflecting a pitcher's propensity for allowing batters to reach base either by being walked or getting a hit. WHIP is controlled directly by the pitcher, unlike wins or earned run average (ERA), which require assistance from teammates to improve in these statistics. A lower WHIP indicates better pitching performance. WHIP is calculated as the number of walks and hits, divided by the number of innings pitched. WHIP was examined at mid-season and not pre-season since all pitchers needed to participate in multiple games to accurately measure performance.

Fatigue index: Fatigue index was measured to examine the rate at which power declines in an individual athlete over the course of the training program. Fatigue index was measured using previous methodology through the 12, 30-m sprint, pre- and post-season (7). Fatigue index was calculated as the slowest sprint time (minimal power) subtracted from the fastest sprint time (maximal power), then dividing the sum by 12 (trials).

Muscle soreness/readiness scale: Participants completed a comparative muscle soreness and readiness scale, mid and post-season prior to the start of a game. The scale was completed at mid-season, due to the assumption that participants would not have soreness to report prior to the season. Participants rate their symptoms of soreness on a scale of 0 (none) to 10 (severe), with varying degrees of soreness and types of pain in between (19).

*Protocol*

Institutional Review Board approval was granted prior to the start of the season. Participants were randomized into either the SSE or IT group. The IT group followed an 11-week conditioning program from Tonnessen et al. (18). The training consisted of varying repetitions and sets of 40-meter sprints (ex. 3 x 4 x 40m), with between a minute and a half to 2 minutes of repetition recovery and 10 minutes of set recovery, at 95-100% of the athlete's maximal intensity. The SSE group jogged at the participant's desired pace around the indoor track until the IT group completed their training, which took approximately 20-30 minutes. Both groups trained two days a week on the same days, 48 hours apart, due to in-season competition and travel. Resistance training for both groups remained the same throughout the study and were completed on separate days from the training program. Participants completed pre-season baseline measures or mid-season depending on pitching performance and post-season measures. The time points of the study for collected variables are displayed in Table 1.

**Table 1.** Variables collected at pre, mid, and post-season

| Time Point | Collected variables |
|---|---|
| Pre-season | 1-mile run<br>30-m sprint<br>Pitching velocity<br>Fatigue index |
| Mid-season | WHIP<br>Muscle soreness/readiness scale |
| Post-season | 1-mile run<br>30-m spring<br>Pitching velocity<br>Fatigue index<br>WHIP<br>Muscle soreness/readiness scale |

*Statistical Analysis*
General descriptive (i.e., means, standard deviation, frequencies) and inferential statistics were used to summarize all demographic data, independent variables, and outcome variables. One-way analysis of variance (ANOVA) was performed to analyze differences between dependent variables within groups. Differences between groups were analyzed with a 2x2 (training [SSE or IT] x time [pre/mid and post]) mixed ANOVA. Additionally, Cronbach α was calculated to assess consistency of pitching velocity between the 10 trials at pre-season and post-season. All statistical tests were conducted with an alpha level of ≤.05 and analyzed using SPSS version 25.0 software.

**RESULTS**
A total of 13 student-athlete baseball pitchers participated in the study, with 7 assigned to the SSE group and 6 assigned to the IT group (Table 2). No differences were observed for all demographic variables between the SSE group and IT group ($p > 0.05$).

**Table 2**. Participant Demographics by Group

| Group | Height (in.) | Weight (lbs.) | Age (yr.) | Body Fat (%) |
|---|---|---|---|---|
| SSE (N=7) | 71.8 (±2.67) | 190 (±19.29) | 20 | 14.35% (±7.21) |
| IT (N=6) | 71.6 (±1.36) | 189.5 (±21.34) | 20 | 14.28% (±6.06) |

IT= Interval training; SSE= Steady state exercise

Overall, the pilot sample improved on mean 1-mile run time from pre (6:24±28s) to post-season (6:17±28s), 30-m sprint from pre (4.30±0.1s) to post-season (4.26±0.1s), pitching velocity from pre (83.6±2.2mph) to post-season (82.1±3.3mph), and WHIP from mid-season (1.94±1.1) to post-season (1.80±0.4). Pitching velocity trials yielded a Cronbach α of 0.94 (95% CI: 0.88, 0.98), displaying high consistency at pre-season. As anticipated, fatigue index increased from 2.73±1.3% at pre-season to 3.95±3.0% at post-season. Additionally, muscle soreness/readiness scores increased from 0.38±0.7 to 2.0±1.5 between mid and post-season. Muscle soreness scores at pre-season ranged from 0-2, with 10 participants reporting 0, 1 reporting 1, and 2 reporting 2. Post-season scores for the sample ranged from 0-5, with 2 participants reporting 0, 4 reporting 1, 2 reporting 2, 3 reporting 3, 1 reporting 4, and 1 reporting 5. No group differences were observed on pre and mid-season baseline measurements, indicating that groups were equal at the start of the season on all measures (Table 3).

**Table 3**. Pre and mid-season baseline measures of performance by group

| Performance measure | Mean (SD) | 95% CI | p |
|---|---|---|---|
| 1-mile run (M:S) | | | |
| *SSE* | 6:28 (31.3) | 359.4, 417.4 | 0.64 |
| *IT* | 6:21 (26.1) | 353.1, 408.1 | |
| 30-m sprint (s) | | | |
| *SSE* | 4.36 (0.1) | 4.24, 4.48 | 0.80 |
| *IT* | 4.24 (0.7) | 4.16, 4.32 | |
| Pitching velocity (mph) | | | |
| *SSE* | 83.7 (2.5) | 81.3, 86.0 | 0.86 |
| *IT* | 83.4 (2.0) | 81.3, 85.6 | |
| WHIP | | | |
| *SSE* | 1.97 (1.5) | 0.51, 3.43 | 0.92 |

| | | | |
|---|---|---|---|
| *IT* | 1.90 (0.5) | 1.35, 2.46 | |
| Fatigue index (%) | | | |
| *SSE* | 2.32 (0.7) | 1.67, 2.97 | 0.25 |
| *IT* | 3.20 (1.8) | 1.30, 5.10 | |
| Soreness | | | |
| *SSE* | 0.14 (0.3) | -0.21, 0.49 | 0.53 |
| *IT* | 0.67 (1.0) | -0.42, 1.75 | |

When examining group differences post-season, while controlling for change from pre/mid-season, the SSE group had a faster 1-mile run time than the IT group ($p = 0.007$) (Table 4). No group differences were observed on 30-m sprint ($p = 0.15$), nor any pitching performance measures, specifically pitching velocity ($p = 0.25$), WHIP ($P = 0.75$), fatigue index ($p = 0.79$), and muscle soreness/readiness scores ($p = 0.52$) (Table 4). Post-season pitching velocity trials yielded a Cronbach $\alpha$ of 0.97 (95% CI: 0.95, 0.99), representing higher consistency than at pre-season.

**Table 4**. Post-season group differences on performance

| Performance measure | Mean (SD) | 95% CI | p |
|---|---|---|---|
| 1-mile run (M:S) | | | |
| *SSE* | 6:07 (19.4) | 349.1, 385.1 | 0.007* |
| *IT* | 6:28 (33.8) | 353.1, 424.1 | |
| 30-m sprint (s) | | | |
| *SSE* | 4.27 (0.1) | 4.11, 4.43 | 0.15 |
| *IT* | 4.25 (0.1) | 4.14, 4.35 | |
| Pitching velocity (mph) | | | |
| *SSE* | 83.0 (2.8) | 80.4, 85.7 | 0.25 |
| *IT* | 81.1 (3.7) | 77.1, 85.0 | |
| WHIP | | | |
| *SSE* | 1.73 (0.39) | 1.37, 2.09 | 0.75 |
| *IT* | 1.88 (0.54) | 1.31, 2.45 | |
| Fatigue index (%) | | | |
| *SSE* | 3.77 (3.2) | 0.72, 6.82 | 0.79 |
| *IT* | 4.16 (3.0) | 0.92, 7.41 | |
| Soreness | | | |
| *SSE* | 2.0 (1.1) | 0.93, 3.07 | 0.52 |
| *IT* | 2.0 (2.0) | -0.10, 4.10 | |

* denotes significance at the .05 level

## DISCUSSION

This is believed to be the first study to examine sport-specific performance measures related to aerobic and anaerobic fitness, velocity, WHIP, and soreness in collegiate baseball pitchers between steady state exercise and interval training groups. Overall, there were no significant differences between the steady state exercise group and the interval training group on pitching specific performance measures, including velocity, WHIP, and muscle soreness scales. However, while no differences were reported between groups on 30-meter sprint time or fatigue index, the steady state exercise group had a faster one-mile endurance run time. It was expected that the one mile run times would differ between groups, as the steady state exercise was running for endurance, as opposed to sprint training in the interval group. In a study by Potteiger (14), the mean $VO_2$ only reached a high of 20.6 ml/kg/min during a live pitching session, which may help explain how minimally important aerobic capacity may be for a pitcher. This provides insight as to our results, as it can be speculated that the 15-25 minutes of SSE was enough of a training stimulus to elicit changes in one-mile run time.

Fatigue is another measure for pitchers, in which we did not find any differences between groups. These results contrast Arazi et al. (1), who reported that reported a lower fatigue index in a sprint-based interval training group, compared to a heart-rate based group. The less fatigue that a pitcher has, the longer they can sustain a high level of performance. Coaches often look for a decrease in velocity to indicate fatigue in a starting pitcher. As velocity was not measured in game, or synonymous to pitching mechanics, fatigue index via lower extremity sprint may not have any application to pitching. The season length for the current sample was 40 games, over a 3-month time span, which may explain the lack of differences in fatigue as this time span was shorter than most professional seasons.

As this is believed to be the first study to examine pitching performance measures between SSE and IT groups, limited evidence is available to confirm or contradict the findings. However, a study investigating interval training on hockey performance reported improvements in peak power and mean power, along with faster sprint and endurance time than a continuous endurance group (11). The current study implemented an 11-week program as compared to a 4-week intervention of Naimo et al. (11), so there is potential that the pitchers in the current study plateaued from a longer intervention and training program. However, while the findings contradict the current study, hockey athletes may not be similar to pitchers in terms of their demand for aerobic and anaerobic fitness.

The main findings of this study contradict Rhea et al. (15) who reported a decrease in lower body power output in collegiate baseball pitchers who performed steady state exercise during the season. Power output was not specifically measured in this study, but performing SSE did not significantly impact pitching velocity. According to Szymanski et al. (16), relief pitchers tend to throw 30-60 pitches and starters around 100 pitches per game. Pitchers who throw fewer pitches per inning, such as relief pitchers, tend to throw harder than a starter. The mixture of relievers and starters in both groups may explain not finding a significant difference, as we did not control for sub-category of pitchers, whether a starter, reliever, or closer. This may influence results as higher aerobic capacity may be more influential for starting pitchers rather than relievers (6). Additionally, this study did not record any psychological reported outcomes data, although muscle soreness and readiness was subjectively reported. Previous research on in-game heart rate response of pitching revealed that inning-dependent psychological factors, such as home field advantage, stress, motivation, or arousal level may contribute to changes in physiological intensity (5).

This study was not without limitations. First, this was conducted as a pilot study, incorporating a small sample size. Despite all student-athlete baseball pitchers from the institution participating in the current study, a larger sample is needed with even distribution among groups. Research exploring different sport populations, such as softball, volleyball, etc. may be of additive benefit. Further research should also aim to address higher volume and intensity training programs. Other measures for the current study's variables should be incorporated (i.e., 12-minute run for aerobic capacity, power as measured by vertical jump or broad jump, etc.). A laboratory muscle endurance test for the upper extremity or biomechanical data may help to determine fatigue more efficiently in future studies.

The current study provides preliminary data for sport science clinicians, such as strength and conditioning professionals, in regard to the effects of steady state exercise compared to interval training on pitching performance in collegiate baseball pitchers. While steady state exercise has been the norm for baseball pitchers, there appears to be no benefit of using interval training in-season for conditioning. No differences were noted between steady state exercise and interval training on both aerobic and anaerobic exercise performance, as tested by a one-mile run and 30-m sprint, along with pitching performance, as measured by velocity, WHIP, fatigue index, and muscle soreness.

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