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Static Stretching may have Immediate Positive Effects on Hip Kinematics and Ball Velocity in Baseball Pitching; a Prospective Pilot Case Series

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Abstract

Hip muscular tightness is thought to be associated with suboptimal pitching kinematics and shoulder injuries in baseball. Although hip stretching is generally recommended, its immediate effects on hip kinematics and ball velocity in baseball pitching is unknown. The purpose of this pilot study was to investigate the immediate effects of static stretching on hip kinematics and ball velocity. 10 young male participants (age, 19.7 ± 0.6 years; height, 170.5 ± 6.2 cm; weight, 64.0 ± 5.9 kg; body mass index, 22.1 ± 1.5) participated in this prospective case series. Hip kinematics and ball velocity were assessed before and after stretching interventions aimed for hip flexors and adductors. As a result, there was a significant increase in peak hip abduction range of motion (ROM) on the stride side (p<0.05), however not in peak hip abduction ROM or extension ROM on the trail side. Mean ball velocity improved significantly after stretching interventions (p<0.05). In conclusion, hip static stretching may be beneficial to improve hip dynamic ROM during baseball pitching and ball velocity in the short term. Further studies with more rigorous methodologies are required to test the hypotheses developed in this pilot study.

Keywords: *Baseball pitching, Static stretching, Hip kinematics, Ball velocity.*

Introduction

Shoulder pain is a common clinical condition in baseball players. One American study reported that shoulder pain was the most common complaint, accounting for 14.1-20.6% of all injuries in young collegiate baseball players [1]. According to one Japanese study recruiting 2,055 players in regional little leagues, 13.4% of the players complained shoulder pain during throwing [2]. Potential effects of disabled throwing shoulder on future careers of young baseball players can be detrimental.

In baseball, shoulder pain can be caused by various overuse injuries, such as rotator cuff tendinopathy, long head of biceps tendinopathy, subacromial bursitis and superior labrum anterior posterior (SLAP) lesion [3-5]. Since it is often difficult to make diagnoses by specifying the source of symptoms, 'disabled throwing shoulder' has been used as a general umbrella term [6-8].

Certain kinematic features have been suggested to contribute to disabled throwing shoulder. Potential risk factors include decreased hip range of motion (ROM) and early trunk rotation. One prospective cohort study identified hip muscular tightness as a potential contributing factor of shoulder pain [9]. As baseball pitching is a whole-body motion, which requires efficient kinetic chain from lower limbs through trunk to the throwing arm, it is reasonable to think that restricted hip mobility can lead to increased mechanical stress as a compensation, contributing to shoulder pain. Early trunk rotation in cocking phase tends to occur in less experienced baseball players, resulting in inefficient momentum transfer and increased mechanical stress on the shoulder joint [10, 11]. Although the mechanism of early trunk rotation is unclear, one potential theory is related to reduced dynamic hip mobility in cocking phase. In cocking phase, hip abduction on both sides and hip extension on the trail side (the same side as the throwing arm) are necessary for pitchers to enable smooth translational movements towards the catcher. Hip muscular tightness may prevent this translation and result in early trunk rotation, compromising the timing of the force transfer from lower limbs through trunk to the throwing arm. Furthermore, decreased stride length may be disadvantageous to achieve higher ball velocity because it is more difficult to utilise potential energy generated by sloped pitching mound.

Stretching hip muscles to improve its ROM is generally recommended for efficient throwing kinetic chain and shoulder injury prevention [5]. To the best of the authors' knowledge, however, no study has ever investigated the effects of hip stretching on hip kinematics and ball velocity in baseball pitching.

The purpose of this pilot study was to examine immediate effects of static stretching on hip kinematics and ball velocity in baseball pitching. It was hypothesised that stretching interventions would immediately improve hip dynamic ROM and ball velocity.

Methods

Study Design

This study was a prospective case series. A trial protocol was registered in University Hospital Medical Information Clinical Trials Registry (registration number: UMIN000031280) before conducting experiments. An experimental session consisted of a warm-up, active hip stretching, and pre- and post-intervention assessments of hip kinematics and ball velocity in pitching with maximal efforts (Figure 1). Due to the nature of active stretching interventions, blinding participants was not possible because they also served as intervention providers in this research.

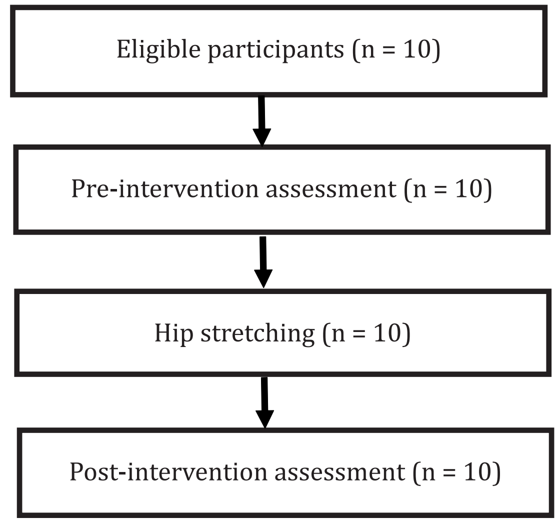

Fig 1. *Flowchart of the study*

Participants

10 healthy male participants (age, 19.7 ± 0.6 years; height, 170.3 ± 6.2 cm; weight, 64.0 ± 5.9 kg; body mass index, 22.1 ± 1.5) were recruited from undergraduate physiotherapy students at Tokyo University of Technology. Most players (n = 9) were right-handed, except for one left-handed player. Their main field positions were infielders (n = 4), outfielders (n = 4), a pitcher (n = 1) and a catcher (n = 1). Inclusion criteria were: (1) healthy men aged over 18 years, (2) regular participation in baseball at recreational levels, (3) no history of shoulder surgery, (4) no shoulder or elbow pain during throwing with maximum effort. Before participation, all participants were informed of the aims and risks of the study and gave written informed consent. An ethical approval was achieved from an ethical committee at Tokyo University of Technology before the commencement of the experiments (registration number: E17HS-012).

Experimental Procedures

A six-camera Vicon motion-analysis system and Vicon Nexus software version 1.7.1 (Vicon, UK) were used to evaluate and process kinematic data of hip joint during pitching motions. A camera frequency was set at 200 Hz. In testing sessions, a total of 35 reflective markers (1.4-cm diameter) were attached at bony landmarks of the whole body, based on the Plug-In-Gait model (Vicon, UK) (Figure 2). The raw data of marker positions were digitally filtered with a fourth order low-pass Butterworth filter with 6 Hz cut-off frequency. Participants were instructed to wear only non-reflective firm-fitting elastic short pants. Motion data were collected for a total of 10 fastball pitches. Mean values of maximum hip abduction ROM on both sides and hip extension ROM on the trail side were calculated.

Fig 2. *Assessment of the pitching task using VICON and radar gun*

Prior to the experiments, anthropometric measurements were conducted. After all markers were positioned on the given bony landmarks, all participants performed 10 pitching to familiarise themselves with the task. They were instructed to increase their efforts incrementally to maximum until 10th pitching. It also served the purpose of a warm-up. The actual experimental setting is shown in Figure 2. A schematic illustration of the experimental setting is presented in Figure 3. Participants used a hard rubber baseball (Nagase Kenko, Japan). The height of the wooden artificial mound was 0.3 m above the floor. In pre- and post-intervention assessments, they were instructed to pitch a fastball as quickly as possible towards the radar gun (Bushnell, USA) behind the pitching net (GP, Japan), 10 times with 30-second intervals. One assessor manually held the radar gun 1.2m above the floor, 6.2m away from the marker line on the mound. This radar gun has an accuracy of +/- 1.6 km/h. The marker line on the wooden mound were set with white adhesive tape (Nitto, Japan) with certain distances (Figure 3). Participants put their left feet on the line and threw a ball after the assessor's verbal cue "ready, go". Kinematic data were extracted throughout the entire pitching phases, from set position to contact of the leg on the dominant side after the follow-through phase. When the ball velocity was ± 20 km/h of the average, the data were excluded as outliers due to measurement errors and the remaining data were included for analyses.

Following the warm-up, participants rested on a chair for three minutes. After the participants performed the pitching task as the baseline assessments, they conducted active static stretching. Two types of static stretching were performed by participants actively in a standing position (Figure 4). One stretch was aimed for hip adductors on both sides to improve abduction ROM. The other stretch was for hip flexors on the trail side to improve extension ROM. Participants were instructed to hold the end position statically for 20 seconds, and repeat three times with a 10-second rest between stretches. After stretching, pitching motions and ball velocity were assessed in the same manner as the baseline measurements.

Participants were instructed to refrain from alcohol intake and not to participate in any exercises for 48 hours before experiments. All testing sessions were conducted in the same laboratory room at Tokyo University of Technology. A care was taken to ensure that all participants received consistent verbal instructions, visual cues, stretching interventions and assessment procedures to minimise confounding factors.

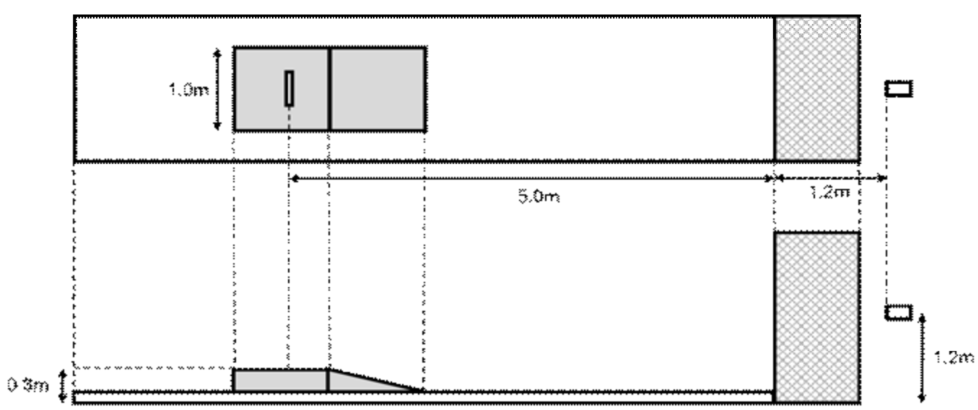

Fig 3. *Schematic illustration of the setting*

Top view (up) and side view (down). Participants set their left foot on the mark line on the mound (painted in grey) in the set position, and threw a ball towards the radar gun behind the pitching net (painted in mesh pattern).

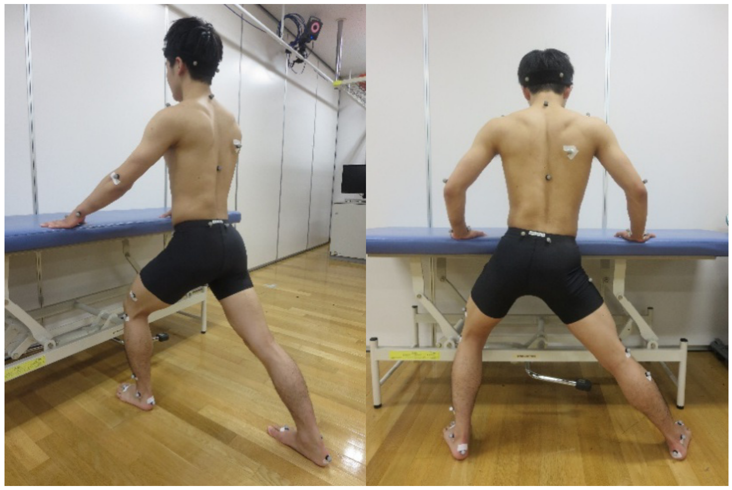

Fig 4. *Two types of hip stretching; stretching for hip flexors (left) and stretching for hip adductors (right).*

Statistical Analysis

The results are described as mean ± standard deviation (SD) values. A paired t-test was used to assess differences between pre- and post-intervention data with regards to kinematic parameters and ball velocity. All statistical tests were conducted with SPSS (IBM, USA). Hedges' g and 95% confidence intervals (CI) were calculated to determine within-group effect sizes. Effect size was categorised as large (≥0.8), moderate (≥0.5) or small (≥0.2) [12].

Results

All participants completed the experimental sessions without injuries or pain. The average fastball velocity was 98.5 ± 13.4 km/h in the baseline measurements. Results are summarised in Table 1. As a result of statistical tests, there was a significant increase in peak hip abduction ROM on the stride side (p<0.05), however not in peak hip abduction ROM or extension ROM on the trail side (Table 1). Mean ball velocity increased significantly after stretching interventions (p<0.05). Within group effect sizes were small for both hip abduction ROM on the stride side (Hedges' g = 0.24, 95%CI: -2.50 to 2.99) and ball velocity (Hedges' g = 0.19, 95%CI: -5.28 to 5.65).

Table 1. *A comparison of peak angle and ball velocity. Values for performance were described as median.*

Outcome measure	Participants (n = 10)		p	Effect size (95% CI)
	pre	post		
Hip EXT [°]	23.7 ± 6.8	23.1 ± 6.8	0.26	-0.08 (-3.08 to 2.91)
Hip ABD TR[°]	43.1 ± 8.9	42.0 ± 9.1	0.10	-0.11 (-4.07 to 3.84)
Hip ABD ST [°]	53.1 ± 6.4	54.7 ± 6.1	0.03*	0.24 (-2.50 to 2.99)
Ball velocity [km/h]	98.5 ± 13.4	100.9 ±11.4	0.03*	0.19 (-5.28 to 5.65)

*Hip EXT = maximum hip extension ROM on the trail side, Hip ABD TR = maximum hip abduction ROM on the trail side, Hip ABD ST = maximum hip abduction ROM on stride side, * = p<0.05.*

Discussion

This prospective pilot case series aimed to examine the immediate effects of static hip stretching on peak hip extension and abduction ROM and ball velocity in baseball pitching. To the best of the authors' knowledge, this is the first study to attempt to clarify the immediate effects of hip stretching interventions in baseball pitching. Our hypothesis was that stretching hip flexors and adductors would be effective to improve hip dynamic mobility, resulting in higher ball velocity. As a result of statistical analyses, there were significant improvements in maximum hip abduction ROM on stride side and ball velocity. These findings were in line with our hypothesis.

The wooden mound used in this research had a slope (Figure 2 and 3). When baseball pitchers' dynamic hip mobility improves, stride length is expected to increase during throwing. This will result in greater difference in height between the two feet, and greater potential energy, which will be converted to kinetic energy from lower limbs through trunk to the throwing arm in the whole-body kinetic chain. Thus, significantly increased hip abduction ROM on stride side identified in this study might have increased stride length during pitching, leading to greater kinetic energy and higher ball velocity.

Based on the findings in this research, hip stretching interventions may be used to acquire better kinetic chain and higher ball velocity for pitchers immediately before or during games. However, longer stride length may potentially induce earlier physical exertion and fatigue [13]. Thus, overall effects must be carefully assessed and monitored individually.

Several methodological limitations are to be recognised to appraise the findings critically. Firstly, this study may be limited by its own research design. Case series is generally regarded as the lowest level of evidence [14]. Although it is useful as a first step in clinical investigations, it is rarely definitive for hypothesis testing [15]. Secondly, small sample in this pilot study might have compromised statistical accuracy. Third weakness lies in the fact that we did not restrict participants to pitchers. This might have led to heterogeneous samples. Since pitchers and position players may have different physical characteristics and pitching biomechanics, it may be difficult to broadly apply the findings to pitchers, the most relevant players [16]. Lastly, despite statistically significant changes in peak hip abduction ROM on the stride side and ball velocity, within-group effect sizes were consistently small and the ranges of 95%CI were wide. This implies that these statistical estimates may not be precise [17]. Considering these potential flaws, findings in this study should be interpreted with caution, and further studies with more rigorous methodologies are required to test the hypotheses developed in this pilot study.

Conclusion

Static stretching for hip flexors and adductors may be effective to improve hip dynamic mobility and ball velocity in baseball pitching in the short term. Stretching interventions used in this study may be applied to baseball pitchers immediately before or during games to achieve better pitching biomechanics and higher ball velocity. However, overall effects must be carefully assessed and monitored individually. Further studies with more rigorous methodologies are required to test the hypotheses developed in this pilot study.

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