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The Effects of a Posture Shirt on Throwing Velocity, Throwing Accuracy and Blood Flow in Professional Baseball Pitchers: a Pilot Study

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Abstract

Background: Studies have attempted to quantify the effects of popular tight-fitting, elastic "compression garments" to athletic performance. Preliminary research suggests that benefits of such garments are sport-specific rather than global improvements in performance. The elite baseball pitcher represents a niche athlete that could potentially see benefits from specialized garments.

Hypothesis/Purpose: This research serves as a pilot study to determine the effects of a form-fitting upper body posture garment on pitching performance and throwing arm blood flow in a group of elite pitchers.

Study Design: Crossover study.

Methods: Six professional baseball players participated in a four-day crossover study. Each subject pitched four simulated innings of 45 pitches, two while wearing an experimental posture shirt (PS) and two wearing a control shirt. Pitch velocity and accuracy were measured, and Doppler duplex ultrasound blood flow studies were performed following periods of exertion. Statistical analysis was done using Cumulative effect sizes (Cohen's D), longitudinal mixed effects modeling and generalized estimating equations.

Results: There were no statistically significant trends in pitch velocity attributable to the PS either within-subject or in aggregate. In aggregate, there was an increase in velocity of 1.47 miles per hour attributable to the PS ($p=.079$) and a trend of diminishing effects of the PS across a 45-pitch session, with an average decrease in effect of 0.45 miles per hour per pitch ($p=.089$). An important negative in this study is that the PS did not significantly affect accuracy ($p=.147$), implying that velocity gains are not undermined by accuracy losses. The PS significantly affected many measurements of vascular physiology. Most notably, throwing arm brachial artery diameter and flow velocity both increased with the PS by approximately 3.3% ($p<.001$ and $p=.02$, respectively), suggesting improved bloodflow to the pitching arm.

Conclusion: This pilot study demonstrates that the use of a form-fitting posture shirt significantly affects bloodflow characteristics of the pitching arm of elite pitchers. While pitch velocity and accuracy were both improved with the posture shirt, no differences in measures of pitching performance were statistically significant.

Clinical Relevance: The results of this study suggest that the posture shirt may have a positive effect on pitching performance and throwing arm vascular physiology.

Key Terms: compression garment, posture shirt, baseball, pitching, velocity and accuracy

What is known about the subject: This study is the first to evaluate the effects of a posture garment on a study population of elite baseball pitchers.

Introduction

Athletes in a wide array of sports choose to wear tight, form-fitting "compression" garments. With mixed results, many studies have attempted to pin down the athletic, psychophysical or injury-preventing effects of compression garments.[12,35,13]

Studies conducted in the context performance orthotic mouthguards suggest that stabilization of upper body posture can influence three all-important attributes: strength, balance and stamina. [8,45] These attributes are central to the skill of pitching in the sport of baseball. Upper body posture may affect baseball pitching performance.

Studies have shown that throwing athletes, including baseball pitchers, develop sport-specific musculoskeletal and neurovascular adaptations in response to the repeated physical stresses of their sport.[36,39] Elite adult baseball pitchers are susceptible to specific throwing-arm vascular problems,[15] such as axillary artery compression [42] thoracic outlet syndrome and effort thrombosis.[37,3,4,44] In baseball pitchers, performance is measured by pitch velocity and pitch accuracy. Arm fatigue influences both of these measures: velocity and accuracy are expected to decrease with fatigue from increasing pitch counts during an outing. It has been hypothesized that a posture-enhancing garment might correct for postural maladaptations in pitchers and improve pitching performance.

The purpose of this pilot study was to evaluate the effects of a posture shirt (PS) on pitching velocity, pitching accuracy and throwing arm blood flow in the number of elite baseball pitchers.

Materials and Methods

Under an IRB protocol, six professional baseball pitchers were evaluated during the baseball preseason. The pitchers were approached at a training clinic held at the University of Southern California, made aware of the nature of the study and given written informed consent forms. Six pitchers (average age = 23.5, range = 22-26) agreed to participate.

The study was a crossover study designed to assess the subject's pitching velocity, pitching accuracy and throwing arm vascular physiology when wearing the PS compared to a control shirt. The PS, designed by Evidence Based Apparel (Santa Ana, CA), is a stretchy garment made of Polyester, Nylon and Lycra, much like similar "compression shirts," except it has strips of non-stretch material sewn into it that form a more rigid skeleton within the shirt. The control shirt was a relaxed fitting t-shirt.

Pitchers each completed four days of pitching. On the first and third days, pitchers wore relaxed-fit t-shirts (control shirt). On the second and fourth days, pitchers wore the PS.

Each test day began with a 45-minute aerobic warmup, followed by a standard protocol designed to simulate the three innings of a typical baseball game. During innings, pitchers threw eight unmeasured warm-up pitches and fifteen maximum-effort fastballs for which velocity and accuracy were measured. The pitchers threw from the mound toward a marked strike-zone on the backstop behind home plate. Velocity was measured from behind the backstop using a handheld radar gun. Accuracy, scored in real-time as “strike” or “ball,” was defined by the lower right corner of the marked traditional strike zone for right handed pitchers and the lower left corner for left handed pitchers.

Immediately after the aerobic warm-up and each inning, the pitchers rested for 10-minute breaks, during which throwing arm brachial and radial blood pressures and throwing arm brachial and radial artery duplex ultrasound studies,[11,14] measuring arterial diameter and blood flow velocity, were done. These standard measurements were taken by a certified vascular ultrasound technician in a repeatable fashion within one minute after activity. Each arm site was marked by ink for reproducibility of ultrasound probe placement. In addition to measurements at these time points, pitchers also underwent baseline measurements each day before the aerobic warmup and final measurements 20 minutes after the third inning ended. The baseline and final measurements included nonthrowing arm blood pressure and duplex ultrasound measurements in addition to the same throwing arm measurements described above. The ultrasound machine employed in this study was a MODELGE Logiq E9, (Fairfield, Connecticut) with linear-array transducer set at 15MHz. Statistical analysis was done using Cumulative effect sizes (Cohen’s D), longitudinal mixed effects modeling and generalized estimating equations for pitch velocity, pitch accuracy and vascular physiology measurements.

Results

There were six participants in this study. However, since one participant only had one session with the shirt, and none without, he was excluded from analyses. Of the remaining five participants, four of the participants completed all four sessions (2 with the control shirt, and 2 with the form-fitting shirt). One participant completed the 2 control session, but only 1 with the form-fitting shirt.

Pitch velocity: Cumulative effect sizes (Cohen's D) were computed for each participant comparing aggregate data with and without the PS. This statistic provides a measure of the magnitude of a treatment effect, the effect size. Individually, two pitchers showed increased velocity with the posture shirt. Two pitchers showed decreased velocity with the PS. One pitcher showed no change (figure 1).

Longitudinal mixed effects modeling was used to assess (a) whether there was a velocity improvement in the PS versus control shirt, and (b) whether this difference changed across 45 pitches within a session, and (c) whether there was a velocity difference when the pitches were stratified by innings. Three models were run. The first modeled the velocity across pitches 1 through 45, unadjusted for the shirt. The second model included a main effect for shirt, but did not examine whether there was an effect of the shirt across pitches. The final model examined the effect of the shirt across pitches. The models were examined for fit, examining improvement in -2lnL from the unadjusted model, as well as the p-value for each variable in the model (table 1).

When the pitchers were taken as a group, there was an increase of 1.47 MPH in average velocity attributable to the PS ($p = .079$)(figure 2). This effect diminished by an average of 0.05 MPH per pitch across the 45 pitches ($p=.089$). When stratified by innings, the differences in velocity between PS and control shirt were not statistically significant.

Pitch Accuracy: Figure 3 depicts session accuracy for each of the six pitchers with and without the PS. To assess the effect of the PS on pitch accuracy, generalized estimating equations were used to assess (a) whether there was improvement in the posture shirt versus control shirt, and (b) whether this difference changed across 45 pitches within a session. The outcome was binary logistic (accurate/not). First, univariate models were performed with pitch and shirt, then a combined model that took into account both the pitch number and the shirt variable was run to determine if there were differences in accuracy across the 45 pitches. P-values and % improvement in accuracy with the shirt are reported in Table 2.

Although not statistically significant, there was a trend for the PS improving overall accuracy by 23.5% in the main effect model ($p=.147$). When the interaction of shirt by pitch was included in this model, the accuracy improvement decreased to 21.8% ($p=.939$). The main effect of pitch was a consistent velocity improvement across innings with the PS that was highest in inning 3, showing a 27.8% accuracy improvement compared to control shirt ($p=.265$)

There was no significant effect in the trend of accuracy across the 45 pitches within a session; accuracy was consistent from the first to last pitch within a session for both the PS and the control shirt.

Vascular Physiology: There were multiple statistically significant effects attributable to the PS, as reported in table 3. In the throwing arm, average brachial artery diameter increased by 3.3% with the PS ($p<.001$) and average brachial flow velocity increased by 3.2% with the PS ($p=.020$). These data support the conclusion that the PS increased volume flow through the throwing arm brachial artery.

Throwing arm radial artery flow velocity increased by 6.3% and the throwing arm radial artery diameter decreased by 7.7% ($p<.001$), resulting in a decreased estimated volume flow through the throwing arm radial artery with the PS compared to control shirt. Throwing arm Wrist-Brachial Index (WBI), the ratio of radial to brachial systolic blood pressure, increased by 3.0% with the PS ($p=.019$).

Discussion

These results demonstrate that the posture shirt increased average pitch velocity within a group of elite baseball pitchers. In this study, the effect of the posture shirt on velocity was greatest in the first inning and steadily decreased as the pitchers pitched more. Pitchers tended to show improvements in throwing accuracy with the posture shirt, but this effect was not statistically significant ($p=.147$)

Research in a related area, the effect of custom-fitted orthotic mouthguards on temporomandibular joint stability and athletic performance, suggests that interventions to affect posture in the hopes of improving sport performance are most effective for subjects with pre-existing postural dysfunction.[19] Studies have shown that in all overhead throwing athletes [39] and baseball players[30] found that the dominant-side scapula was more internally rotated and anteriorly tilted than non-dominant-side scapula.

Further studies could attempt to quantify aspects of pitcher posture to determine which pitchers are most likely to benefit from posture enhancing shirts, since the results of this study indicate that only some pitchers show increased velocity with the posture shirt while other pitchers show decreased velocity or no change. This study helps to define some of the physiologic changes that occur during pitching.

This data demonstrated a measured change in performance with this small number of throwing athletes. Clinical difficulties are commonly seen with baseball pitchers. Further measurements and testing are warranted to better define the effects and best use of the posture shirt on the throwing athlete.

Vascular physiology was effected by the PS with an increase in brachial artery velocity and diameter. The opposite physiologic response was true for the radial artery where the PS resulted in a significant decrease in radial artery diameter and an increase in peak systolic velocity, with an overall decrease in volume flow. The improved hemodynamics at the brachial artery level suggests that PS impacted proximal arterial bloodflow. The throwing motion of professional pitchers has resulted in a number of arterial injuries of the subclavian and axillary artery with arterial thrombosis and/or distal embolization. It is presumed that the traumatic arterial injury to the subclavian artery is due to the boney and muscular structures at the thoracic outlet that "pinch" the subclavian artery with shoulder abduction. Concerning the axillary artery, effacement of the artery by the humeral head is thought to result in axillary as well as branch vessel arterial injury in throwing athletes. It is possible that stabilization of posture with the PS lessens arterial trauma particularly at the thoracic outlet where posture is known to impact the degree of outlet compression of vascular and neural structures.

The contrary findings at the radial artery may suggest that the improved proximal bloodflow through the brachial artery with the PS results in improved nutrient blood flow to the hand. The improved nutrient flow reduces tissue acidosis of the distal limb/hand thereby reducing the associated radial artery dilatation. The significant increase in the wrist/brachial index found with the PS is supportive of this hypothesis.

These positive changes in vascular physiology with the PS provide interesting possibilities. Although, no significant difference was seen in accuracy and pitch velocity with the PS, it would be interesting to determine whether the positive physiologic changes might become important with an increased pitch count, such as 90-100 pitches commonly seen in major league baseball. Certainly the fact that statistical significance between PS and the control shirt was obtained in a relatively small sample size suggests vascular physiology of the pitching motion is profoundly altered with PS. The question to be determined is whether this has any practical value in the effectiveness and stamina of a major league pitcher.

Conclusion:

This pilot study demonstrates that the use of a form-fitting posture shirt significantly affects bloodflow characteristics of the pitching arm of elite pitchers. While pitch velocity and accuracy were both initially improved with the posture shirt, no differences in measures of throwing performance were statistically significant after the simulated 45 pitch 3 inning pitching session.

Legends

Figures

<u>Figure 1: Individual Pitching Velocity</u>

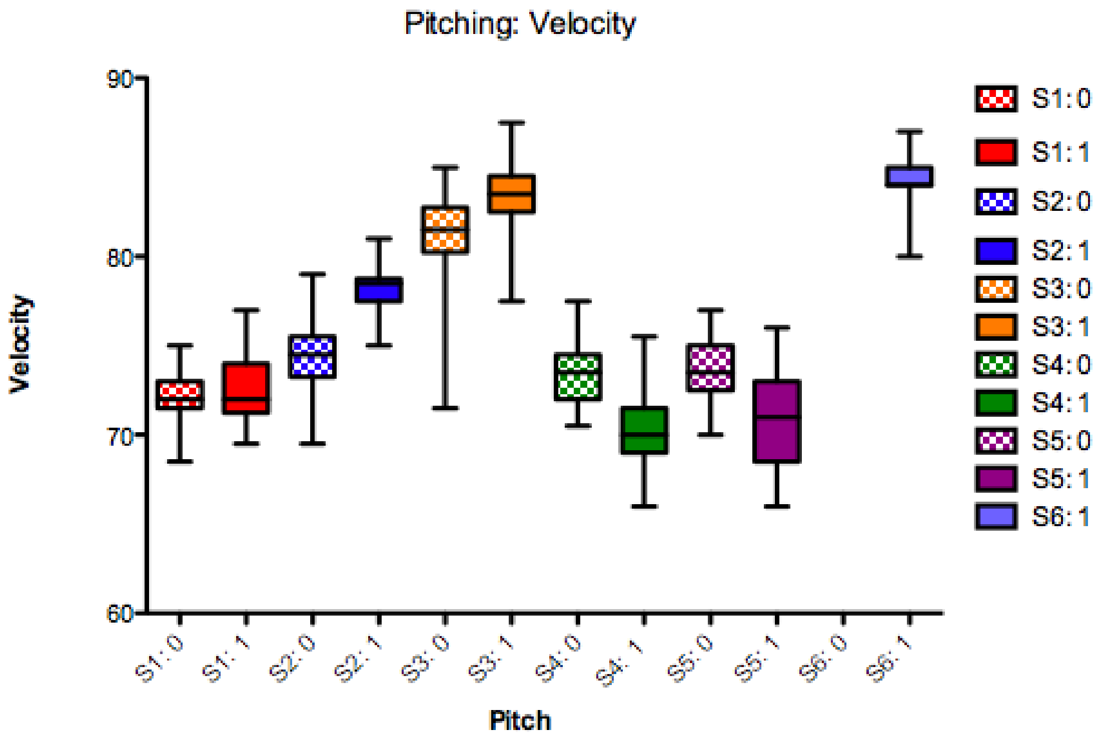

Figure 2: Group Average Pitching Velocity Across 45-pitches

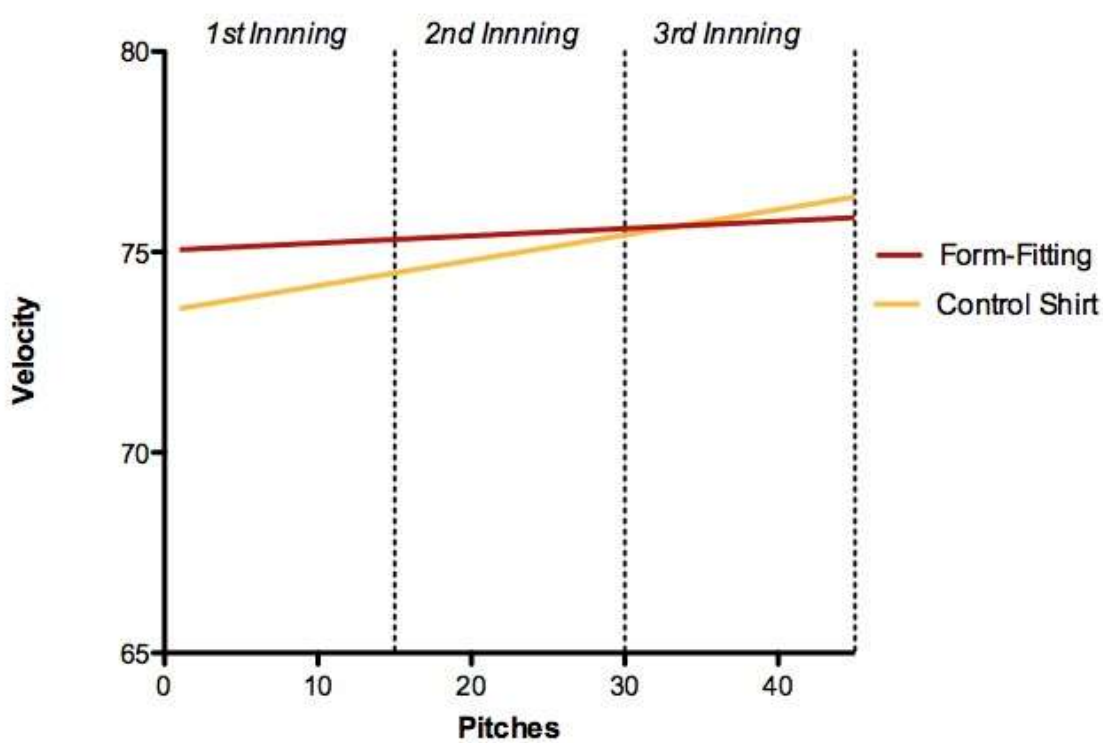

Figure 3: Pitching Accuracy

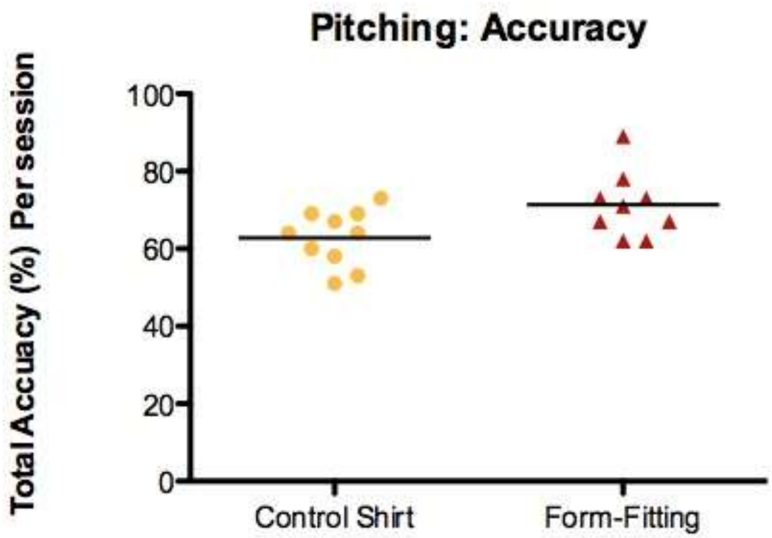

Table 1: Group Pitching Velocity - Effect of shirt on velocity across pitches

			Shirt		Shirt x Pitch	
Model	Estimate (MPH)	p-value	Estimate (MPH)	p-value	Estimate (MPH)	p-value
All Innings	*Pitch (1-45)*					
Main effect of Shirt	.042	.002	.432	.450	---	---
Shirt x Pitch	.063	.001	1.470	.079	-.045	.089
Inning 1	*Pitch (1-15)*					
Main effect of Shirt	.124	.056	.969	.325	---	---
Shirt x Pitch	.130	.147	1.061	.439	-.011	.930
Inning 2	*Pitch (16-30)*					
Main effect of Shirt	.064	.353	.723	.224	---	---
Shirt x Pitch	.099	.294	2.450	.446	-.075	.584
Inning 3	*Pitch (31-45)*					
Main effect of Shirt	.007	.924	-.333	.597	---	---
Shirt x Pitch	.025	.803	1.114	.842	-.038	.794

Table 2: Group Pitching Accuracy

	Pitch (1-45)	Shirt	Shirt x Pitch	% improvement in accuracy with shirt
Model	p-value	p-value	p-value	
All Innings				
Main effect of Shirt	.372	.147	---	23.5%
Shirt x Pitch	.484	.361	.939	21.8%
Inning 1				
Main effect of Shirt	<.001	.389	---	21.5%
Shirt x Pitch	.009	.230	.436	66.8%
Inning 2				
Main effect of Shirt	.081	.306	---	21.8%

Shirt x Pitch	.001	.958	.512	-2.1%
Inning 3				
Main effect of Shirt	.690	.265	---	27.8%
Shirt x Pitch	.681	.955	.966	14.6%

Table 3: Vascular Physiology

	Shirt	Estimated Marginal Means	
		Control	Shirt
TBrachDiam (mm)	<.001	4.641	4.800
TBrachVel (cm/s)	.020	89.045	92.000
TBrachBP (mmHg)	<.001	139.986	130.000
TRadDiam (mm)	<.001	2.600	2.400
TRadVel (cm/s)	.008	67.758	72.300
TRadBP (mmHg)	NC		
Wrist Brachial Index	.019	.939	.968
NBrachDiam (mm)	.936	4.538	4.492
NBrachVel (cm/s)	.100	85.044	78.611
NBrachBP (mmHg)	<.001	130.0	140.0
NRadDiam (mm)	.251	2.494	2.400
NRadVel (cm/s)	<.001	63.600	51.100
NRadBP (mmHg)	.532	130.810	130.000
P02	.999	63.0	61.0
PC02	<.001	39.0	37.0
TBrach volume flow (mL/s)	.025	361.802	279.551
TRad volume flow (mL/s)	.302	1429.267	1480.217

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