[Physical Therapy]

Youth Baseball Pitching Stride Length: Normal Values and Correlation With Field Testing

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Background: Pitching biomechanical analysis has been recommended as an important component of performance, injury prevention, and rehabilitation. Normal values for youth pitching stride length have not been established, leading to application of normative values found among professional pitchers to youth pitchers.

Hypotheses: The average youth pitching stride length will be significantly less than that of college and professional pitchers. There will be a positive correlation between stride length, lower extremity power, balance, and pitching experience.

Study Design: Prospective cohort study.

Level of Evidence: Level 3.

Methods: Ninety-two youth baseball pitchers (aged 9-14 years) met the inclusion/exclusion criteria and completed the study. Stride length was recorded using a Dartfish video system over 3 maximal effort pitches. Both intra- and interrater reliability was calculated for the assessment of stride length. Double-leg vertical jump, single-leg stance time, leg length, weight, age, and pitching experience were also recorded.

Results: Mean (SD) stride length was 66.0% (7.1%) of height. Stride length was correlated ($P < 0.01$) with vertical jump (0.38), pitching experience (0.36), and single-leg balance (0.28), with excellent intra- and interrater reliability (0.985 or higher). No significant correlations between stride length and body weight, leg length, or age existed.

Conclusions: There was a significant difference between youth pitching stride length and the current published norms for older and more elite throwers. There was a positive correlation between stride length and lower extremity power, pitching experience, and single-leg balance.

Clinical Relevance: Two-dimensional analysis of stride length allows for the assessment of pitching biomechanics in a practical manner. These values can be used for return to pitching parameters after an injury and designing injury prevention and performance programs.

Keywords: youth baseball; pitchers; throwing mechanics

The stride phase starts when the lead leg reaches peak height and ends when it makes contact with the pitching mound.[19,23] Pitch stride is important in order to position the lower extremity and trunk in optimal alignment for performance of the kinetic chain.[2,13,18] The lower extremities and trunk are major force generators in the pitching motion.[2] Research has shown that a 20% decrease in kinetic energy transfer from the hip and trunk to the upper extremity results in a 34% increase in rotational velocity demand at the shoulder.[19] This highlights the need for efficiency of the kinetic

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Figure 1. Height was measured with subject in supine position. The Dartfish software program was used to determine stride length as percentage of body height. The figure is not actual video footage from the study, but provides an example of how stride length was recorded.

chain. This is especially of interest in youth pitchers to reduce stress to the upper extremity[1] as up to 50% of youth pitchers report having shoulder or elbow pain.[16] Factors such as velocity, pitching volume, pitch type, and poor mechanics (including stride) are risk factors for upper extremity injuries in youth.[16,25]

Youth baseball players often begin pitching between the ages of 8 and 11 years. For these children, developing proper pitching mechanics is likely to facilitate throwing accuracy and reduce their risk for injury. While coaches for beginning pitchers have historically focused most of their attention on arm positioning and movement,[24] it is becoming much more common for coaches to also devote attention to the position and movement of the lower body. Lower extremity balance is associated with ulnar collateral ligament pathology in mature pitchers.[8] Many of the published studies on pitching mechanics have focused on professional, collegiate, and high school pitchers. These studies have consistently reported a pitcher's stride length to be ~85% of body height.[5,7,23] Although there are many studies reporting on mechanics in more advanced throwers, only 1 published study focused on stride length distance in youth pitchers.[6] As more coaches and parents become aware of the importance of following pitch counts and proper rest, there is a growing trend and need for more children on a team to pitch. It is the youth population, as opposed to high school, college, and professional pitchers, that makes up the overwhelming majority of participating athletes. Lower extremity power and dynamic balance have both been linked to pitching velocity and ulnar collateral ligament injuries, respectively.[4,8,15]

The purposes of this study were (1) to establish normative values for stride length in youth pitchers as a percentage of body height via 2-dimensional video assessment and (2) to determine if a correlation exists between stride length and variables such as pitching experience, lower extremity balance, or lower extremity power. We hypothesize that (1) 2-dimensional video assessment of youth pitching stride length will be significantly less than the published 3-dimensional values of older pitchers and (2) pitching stride length will be positively correlated with lower extremity balance, pitching experience, and lower extremity power in healthy youth pitchers.

METHODS

Research Design

This was a prospective cohort study.

Subjects

This study was approved by the University of Wisconsin Institutional Review Board. A convenience sample was drawn from both tournament teams and Little League baseball teams in the Madison, Wisconsin, area. Subjects were recruited through coaches and in person at preseason skills assessments. A total of 92 male youth baseball players between the ages of 9 and 14 years participated in this study. Inclusion criteria consisted of being between the ages of 9 and 14 years and having pitched at least 1 season in organized games. Subjects were excluded if (1) they were currently being treated or evaluated for a musculoskeletal injury by a medical professional or (2) they were unable to throw at self-perceived maximal effort. Prior to participation, subjects and guardians provided written informed consent. Testing procedures were explained, but subjects were not told the purpose of this study.

Test Protocol

Weight and Leg Length

Weight and leg length were recorded for all participants prior to testing. Leg length was assessed using a standard soft tape measure and recorded in centimeters.[9]

Stride Length

Stride length was assessed using a Dartfish recording system (Dartfish USA). The Dartfish recording system was placed in line with the athlete and perpendicular to the athlete's power line. The power line is defined as a visible line on the mound from the center of the pitching rubber directed to the central point of home plate (Figure 1). The camera was consistently placed 3 m from the side of the mound. This distance was chosen so that stride length and the marker demonstrating the pitcher's height were both visible in the same frame. Prior to testing, each subject's height was measured by having the subject lie supine. A 5-cm piece of white tape was placed on the pitching mound at the distance of the subject's height as measured from the front of the pitching rubber. The tape was affixed parallel to the pitching rubber directly on the power line. The distance between the pitching rubber and home plate was set equal to the regulation pitching distance for the subject's league (12-16 m for

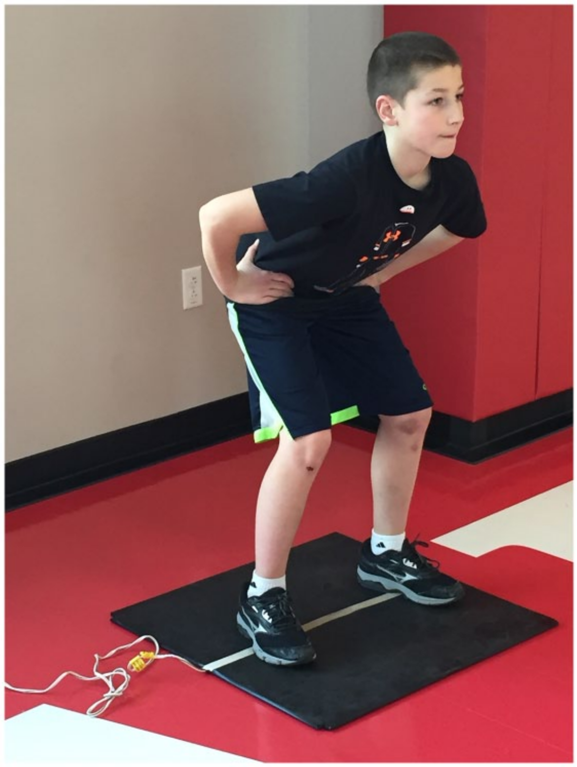

Figure 2. Vertical jump test. The examiner instructs the participant to jump for maximal height and land with both feet returning to the mat, keeping hands on hips. Each participant is given 3 practice trials. The test is repeated a total of 3 times after the practice trials. The examiner records the highest jump for each participant.

youth). Pitchers completed a throwing warm-up and then 3 warm-up pitches off the mound prior to the test pitches. The pitcher was then instructed to throw a fastball (as if throwing in a game) from the wind-up. Stride length was recorded as a percentage of the athlete's body height, measuring from the front of the pitching rubber to the back of the heel on the landing foot. This percentage was calculated during play-back from the Dartfish video. Data were collected on 3 trials. The average of the 3 stride lengths was also recorded. Intra- and interrater reliability of stride length was assessed on 41 subjects. Two researchers calculated stride length using Dartfish software and were blinded to subject appearance during data collection. Each researcher recorded stride length (as a percentage of body height) for each of the 3 pitches in sequential order and a second time in randomized order. Researchers were blinded to their previous stride length measurements in the first attempt and at least 48 hours passed between first and second calculations. Excellent reliability was found with both intrarater (intraclass correlation coefficient [ICC] = 0.997-1000) and interrater reliability (0.989-0.997). The standard error of the measurement of stride length was 1.03% of body height.

Vertical Jump

Vertical jump height was used as a relative measure of power and assessed using a Just Jump System (JJS) (Figure 2).[17] Jump height was used as a relative measure of power and measured consistently across all subjects.[11,12,14,15]

Static Balance

Single-leg balance was measured through single-leg stance time and was performed on the athlete's dominant leg (Figure 3).[3] A stopwatch was used to time single-leg stance duration. Leg dominance was determined through assessment of the subject's pitching motion with the throwing-side leg being considered the dominant leg. The balance point was achieved with the subject standing on the dominant leg, placing the nondominant leg in the air at 90° of hip and knee flexion, placing hands on hips, and closing the eyes. Each subject was instructed to hold this position for as long as possible. Once eyes were closed, the stopwatch was started. The trial was terminated when subject (1) lowered lead leg more than 20°, (2) touched the contralateral leg to the stance leg, (3) moved the stance leg foot on the ground, (4) opened the eyes, or (5) removed 1 or both hands from the hips. A maximum time of 30 seconds (twice the established norm) also terminated the trial. Each subject was tested for 3 trials with eyes closed in the balance point position.[21,22] The best of the 3 trials was recorded.

Statistics

Reliability of measurement of stride length as a percentage of body height was assessed with ICC. Intrarater reliability used ICC(3,1) and interrater reliability specifically used ICC(2,1), as described by Shrout and Fleiss.[20] ICCs <0.8 are considered to show excellent reliability.[10] With excellent reliability seen in stride length, we averaged the stride lengths plus or minus standard deviation for each athlete for comparative analysis. Correlations between stride length and other athlete characteristics (Table 1) were assessed with Pearson's correlation coefficients and 95% CI. Comparing stride length between age groups and experience groups was done with 2-sample *t* tests.

RESULTS

Subjects

Ninety-two male subjects with an average age of 10.4 (1.3) years met the inclusion and exclusion criteria and completed the testing procedures as outlined in the study (Table 1).

Stride Length Normal Values

The average (SD) stride length for the population was found to be 66.0% (7.1%) of body height. There was a significant difference between the groups of pitchers based on experience (Table 2).

Stride Length Correlations

The average stride length was found to have a statistically significant correlation with 3 variables for the subjects:

Figure 3. Single-leg balance test. The examiner instructs the participant to assume a balance point on the dominant leg (same side as throwing arm). The balance point is achieved with the subject placing the nondominant leg in the air at 90° of hip and knee flexion, placing hands on hips, and closing both eyes. Each participant is instructed to hold this position for as long as possible (up to 30 seconds). The test is repeated a total of 3 times. The best of the 3 trials is recorded to the nearest second using a stopwatch.

Table 1. Subject descriptive characteristics

	Mean (SD)
Stride length, as percentage of body height	66.0% (7.1%)
Age, y	10.4 (1.3)
Weight, kg	41.5 (10.2)
Leg length, cm	79.4 (7.6)
Pitching experience, y	1.7 (1.2)
Single-leg balance, s	10.2 (5.9)
Vertical jump, cm	38.4 (5.6)

Table 2. Stride length normal values comparison

	Stride Length, Mean (SD)	*P*
Pitching experience, y		
0-1	63.3 (7.2)	
2+	68.6 (6.1)	<0.001
Age, y		
9-10 (n = 57)	65.1 (6.7)	
>10 (n = 35)	67.5 (7.6)	0.136

Table 3. Stride length correlations

	Pearson Correlation (95% CI)	*P*
Vertical jump	0.38 (0.19, 0.54)	<0.001
Years pitching	0.36 (0.17, 0.53)	<0.001
Single-leg balance	0.28 (0.08, 0.46)	0.007
Leg length	0.17 (–0.04, 0.36)	0.109
Age	0.16 (–0.05, 0.35)	0.128
Weight	–0.06 (–0.26, 0.15)	0.574

double-leg vertical jump, pitching experience, and single-leg balance. The correlations with double-leg vertical jump and pitching experience were moderately correlated, while single-leg balance was weakly correlated. The other variables showed no statistically significant correlation with stride length (Table 3).

Reliability of 2-Dimensional Stride Length Assessment

The 2-dimensional stride length assessment procedures had excellent both intra- and interrater reliability. All the individual pitches and averages for stride length exceeded 0.988 for ICC values.

DISCUSSION

This study illustrates significant differences between established normative data for older, experienced higher level pitchers and youth pitchers with limited experience. This difference is related to several factors, including pitching experience, lower extremity power, and balance. Fleisig et al[6] concluded no difference in stride length between youth, high school, college, and professional pitchers. However, the youth pitchers in that particular study ranged from 10 to 15 years old and consisted of only 23 of the 231 total subjects tested. Also, pitching experience was not described and the age range was quite large considering the small youth sample size.

Pitching is a very technical skill that requires a mixture of strength, balance, flexibility, and timing to maximize the body's potential to throw hard and accurately. By using normative youth pitching stride length as a baseline for evaluating youth pitchers, clinicians and coaches can educate youth pitchers whose stride length falls outside the expected norm and make sure adequate balance and strength are established before encouraging longer strides. These normative values can be used when developing performance-based programs for pitchers.

The excellent reliability of the 2-dimensional video assessment provides clinicians a practical, inexpensive, and reliable method to evaluate the stride length of youth pitchers.

There are limitations to this study. The groupings by age were based on a convenience sample and not a sample size determined from a power analysis. Also, this study measured stride length from the back of the heel. Standard 3-dimensional methods for measuring stride length measure from the middle of the ankle joint. The difference in methods of measurement naturally causes stride length to be slightly shorter for the 2-dimensional method. Finally, the subjects in this study were all male youth pitchers.

CONCLUSION

There is a significant difference in youth pitching stride length, measured using 2-dimensional assessment methods, compared with the current published normative values for older, more elite throwers. The 2-dimensional method is a reliable method for accurately recording stride length. There is a positive correlation between stride length and pitching experience, lower extremity power, and single-leg balance. Each of these factors can be influenced by proper training and education.

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