# LONGITUDINAL CHANGES IN SHOULDER ROM AND STRENGTH IN ASSOCIATION WITH BALL-THROWING SPEED IN ELITE YOUTH BASEBALL PITCHERS

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The purpose of this prospective study was to examine the longitudinal changes in shoulder ER ROM and relative IR strength in elite youth baseball pitchers over one year and to determine their associations with changes in ball speed for throwing fastballs. One hundred and five Dutch elite youth baseball pitchers were measured three times over a period of one year. Statistical analyses of the data revealed that changes in ER ROM and relative IR strength were not significantly associated with changes in ball-throwing speed.

**KEY WORDS:** baseball, pitching, performance, screening, prospective study

**INTRODUCTION:** To achieve high ball speeds when pitching fastballs in baseball anthropometric characteristics of pitchers are important. Adult pitchers generally demonstrate more external rotation (ER) range of motion (ROM) in the dominant shoulder compared to the non-dominant shoulder and the ER ROM in pitchers is usually larger than in non-pitchers (Sauers et al., 2014). Moreover, previously ball-throwing speed was found to be positively correlated with maximum shoulder ER ROM (Fortenbaugh et al., 2009). In addition, internal rotation (IR) strength appears to be related to higher ball-throwing speeds and differences between the dominant and non-dominant shoulder have been found in baseball pitchers (Escamilla et al., 2002; Noguchi et al., 2013). Thus, shoulder ER ROM and IR strength appear to be important determining factors of the throwing technique to achieve high ball speeds in adult pitchers.
Bigliani et al. (1997) suggested that ER ROM may play a role in the selection of baseball pitchers. Young baseball players that achieve a high ball-throwing speed may be the players that already have or quickly develop a greater shoulder ER ROM in their dominant arm. A similar selection effect might also hold for strength. Although not reported in the scientific literature – as far as we know – maturation and development in strength might be associated with the development of ball-throwing speed in youth baseball players.
Therefore, the purpose of this study was to explore the changes in shoulder ER ROM and relative IR strength in elite youth pitchers occurring over the course of a competitive baseball season and to determine whether these changes are associated with changes in ball-throwing speed.

**METHODS:** One hundred and five male adolescent elite baseball pitchers, in the age of 12 to 18 years and all members of the six Dutch baseball talent academies or the national AAA team, participated in this study. The present study is part of a larger prospective study developed and initiated in cooperation with the Dutch baseball federation. Participants were measured at the start and end of the competitive baseball season in March and October 2014 (T0 and T1) and in March 2015 (T2).
As part of a large screening protocol, both shoulder ER ROM (in degrees (deg)) and IR strength, afterwards normalized to body height, (in Newton per meter (N/m)) were assessed three times for the dominant shoulder using a digital inclinometer and hand-held dynamometer respectively. For both the ROM and strength measurements, participants were lying in supine position on a standard treatment table with the shoulder in 90 degrees of abduction and the elbow flexed at 90 degrees. For ROM measurements the examiner rotated the upper arm passively into ER until a firm capsular endfeel was noted or the participant reported discomfort. For IR strength measurements participants were asked to perform maximal voluntary effort in a pure rotational direction against resistance of the examiner.

Different examiners performed the ROM and strength measurements at T0, T1 and T2. No reliability study for the current data was performed, but all measurement procedures were previously found to be reliable for clinical use (Cools et al., 2014).
After the ROM and strength assessments, participants were instructed to perform their preferred warm-up routine for pitching (e.g. static and dynamic stretching, throwing exercises, and pitching specific exercises). When a participant reported to be ready to pitch, a few trial pitches were thrown from a pitch mound. Subsequently, the participants threw 10 fastballs of which the speed was measured in miles per hour (mph) with a radar gun. Off-speed pitches and breaking balls were marked as such and left out of data analysis.
Descriptive statistics were used to explore the changes in shoulder ER ROM, relative IR strength and ball-throwing speed over the three measurement periods (T0, T1 and T2) for pitchers under and over 15 years of age separately. Linear regression analyses were performed to explore whether changes in shoulder ER ROM and relative IR strength were associated with changes in ball-throwing speed.

**Table 1. Participant characteristics.**

| | < 15 years | | ≥ 15 years | |
|---|---|---|---|---|
| | Mean ± SD | N | Mean ± SD | N |
| Age at first measurement (years) | 13.65 ± 0.85 | 59 | 16.46 ± 0.91 | 46 |
| Body height (m) | 1.71 ± 0.11 | 58 | 1.85 ± 0.07 | 46 |
| Body weight (kg) | 59.91 ± 12.91 | 58 | 77.17 ± 12.95 | 46 |
| Average ball-throwing speed (mph) | 61.52 ± 5.52 | 52 | 71.24 ± 5.12 | 45 |
| ER ROM (deg) | 121.84 ± 16.42 | 54 | 112.16 ± 10.78 | 45 |
| Relative IR strength (N/m) | 66.55 ± 20.05 | 54 | 82.41 ± 23.27 | 46 |

SD = standard deviation; N = number of cases

**RESULTS:** Table 1 describes the characteristics of the pitchers at their first screening (T0) for the groups under and over 15 years separately. The mean changes in shoulder ER ROM, relative IR strength and ball-throwing speed are presented in Table 2 (age <15 years) and Table 3 (age ≥15 years). The largest change in ball-throwing speed from T0 to T2 (8 mph) occurred in the younger aged pitchers, whereby ER ROM and relative IR strength also increased in this group. In the group of pitchers over 15 years, ball-throwing speed increased from T0 tot T2 (with almost 5 mph), as well as ER ROM, whilst relative IR strength remained almost unchanged.

**Table 2. Change in measured variables from T0 to T1, T1 to T2 and T0 to T2 in the under 15 years age group.**

| | < 15 years | | | | | |
|---|---|---|---|---|---|---|
| | T0 – T1 | | T1 – T2 | | T0 – T2 | |
| | Mean ± SD | N | Mean ± SD | N | Mean ± SD | N |
| Ball-throwing speed (mph) | 4.49 ± 2.63 | 32 | 3.49 ± 3.45 | 31 | 8.00 ± 3.51 | 28 |
| ER ROM (deg) | 0.33 ± 16.93 | 37 | 5.15 ± 20.19 | 33 | 4.60 ± 15.65 | 31 |
| Relative IR strength (N/m) | 6.55 ± 21.54 | 36 | 3.94 ± 14.60 | 33 | 10.18 ± 22.96 | 30 |

**Table 3. Change in measured variables from T0 to T1, T1 to T2 and T0 to T2 in the 15 years and older age group**

| | ≥ 15 years | | | | | |
|---|---|---|---|---|---|---|
| | T0 – T1 | | T1 – T2 | | T0 – T2 | |
| | Mean ± SD | N | Mean ± SD | N | Mean ± SD | N |
| Ball-throwing speed (mph) | 2.88 ± 3.74 | 29 | 1.28 ± 5.26 | 23 | 4.86 ± 3.46 | 28 |
| ER ROM (deg) | -1.68 ± 16.43 | 36 | 20.75 ± 21.61 | 27 | 20.27 ± 20.21 | 28 |
| Relative IR strength (N/m) | 9.27 ± 27.12 | 34 | -6.12 ± 20.61 | 25 | 0.22 ± 24.28 | 28 |

Figure 1 shows the changes in ER ROM from T0 to T2 and the changes in IR strength from T0 to T2 against the changes in ball speed over the same period of time, for pitchers under and over 15 years of age separately. Ignoring the two age groups, linear regression analysis showed that the change in ER ROM was not significantly associated with ball-throwing speed (regression coefficient 0.010 mph/degree, 95% CI [-0.044, 0.063]). Neither was there a significant association between relative IR strength and ball-throwing speed (regression coefficient 0.011 mph/(N/m)), 95% CI [-0.031, 0.053]).

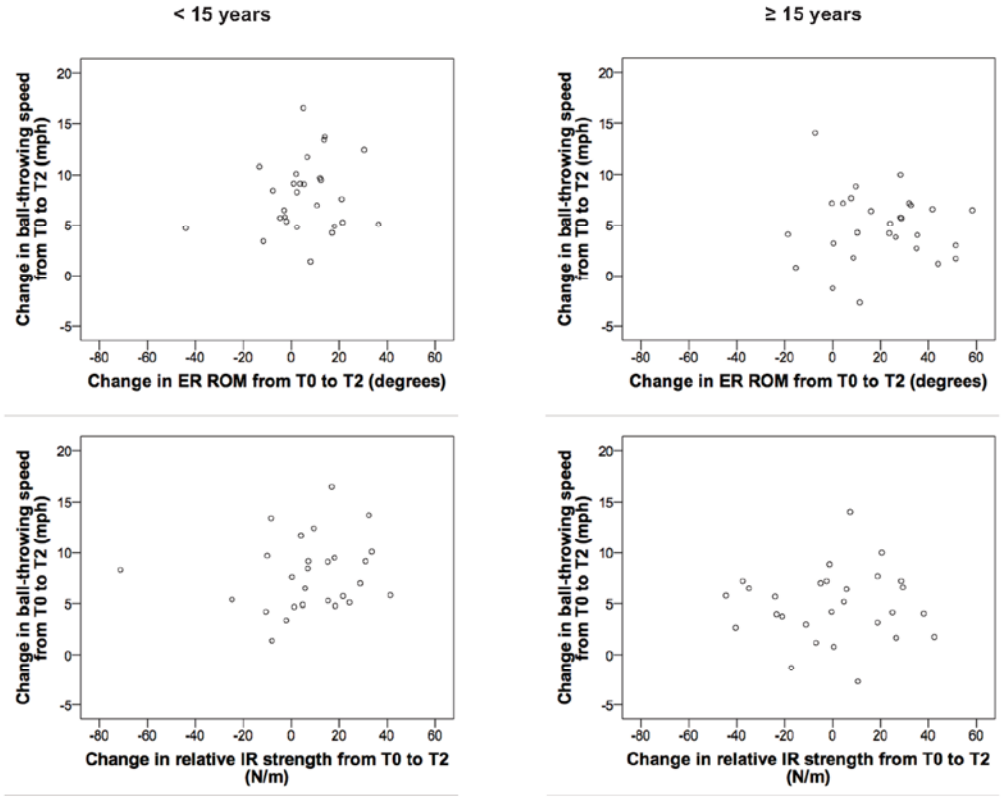


**Figure 1. Changes in shoulder ER ROM and relative IR strength plotted against the changes in ball-throwing speed from T0 to T2.**

**DISCUSSION:** The purpose of the present study was to describe the changes in shoulder ER ROM and relative IR strength in elite youth baseball pitchers occurring over the course of a competitive baseball season and to examine their associations with ball-throwing speed. Generally, changes were more positively pronounced in the group of pitchers under the age of 15 years compared to pitchers over 15 years, except for ER ROM. In addition, the older pitchers showed higher values of IR strength and ball-throwing speed, but not for ER ROM. Although other studies – with adult pitchers – did report significant associations, in the present study, changes in ER ROM and IR strength over one year were not significantly associated with changes in ball-throwing speed.

An explanation for not finding significant associations may be that besides ROM and strength of the shoulder there are other factors that determine ball-throwing speed more strongly in youth baseball pitchers. It is suggested that the kinetic chain plays an important role in the throwing movement (Seroyer et al., 2010). For example, an increase in knee extension of the stance leg alters ball-throwing speed (Dun et al., 2007) and also the relative timing of rotation of the pelvis and trunk might affect ball-throwing speed (Stodden et al., 2001). As such, it might be that a development of the throwing technique as a whole, combined with the maturation of the young pitchers themselves, causes the anthropometric characteristics studied not to be associated with ball-throwing speed.

Another explanation for not finding significant associations between changes in anthropometric characteristics and changes in ball-throwing speeds might be that the changes observed are not functional adaptations related to increasing ball-throwing speeds. Bigliani et al. (1997) suggested that a greater shoulder ER is a physiological adaptation because of repetitive micro trauma occurring as a result of the exposure to repetitive pitching, leading to lengthening of the anterior capsule and shortening of the posterior capsule. In addition, these changes may result in the failure of proper throwing mechanics over the course of a competitive season (Laudner et al., 2010) and in (shoulder) injuries.
The methodology used in this study shows some limitations. Despite a standardized protocol and several practice sessions to decrease inter- and intraobserver variability, it might be possible that the use of several assessors performing the measurements may have lead to increased variability in the outcome variables, despite of using the average of three repeated measurements for each of the variables under study.

**CONCLUSION:** Changes in maximal shoulder ER ROM and relative IR strength are not significantly associated with changes in ball-throwing speed over the course of one year in elite youth baseball pitchers. A better understanding of the anthropometric and kinematic variables that determine ball-throwing speed could provide pitching coaches with key factors to focus on in training and pitcher development.

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