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Competition-Level Differences on the Lower Quarter Y-Balance Test in Baseball Players

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Context: Decreased performance in dynamic balance has previously been associated with a history of ulnar collateral ligament injury in baseball players. Previous research on dynamic balance in soccer players has shown that test performance depends on competition level. However, dynamic balance has yet to be examined in baseball players.

Objective: To understand normative values and determine differences in dynamic balance, as measured by the Lower Quarter Y-Balance Test, across competition levels in baseball players.

Design: Cross-sectional study.

Setting: Preseason physical examinations.

Patients or Other Participants: Dynamic balance was measured in 88 high school (HS), 78 collegiate (COL), and 90 professional (PRO) baseball players.

Main Outcome Measure(s): All participants completed the Lower Quarter Y-Balance Test using the standard protocol. In unilateral stance, they reached with 1 foot in the anterior, posteromedial, and posterolateral directions. We calculated 1-way analyses of variance to compare performance, composite score, and reach asymmetry for each direction as well as the sum of the asymmetry values ($P < .05$). Composite score was calculated by averaging the maximum normalized reach scores. Reach asymmetry was determined by calculating bilateral differences in reach ability.

Results: In comparison with the HS and COL groups, the PRO players exhibited greater posteromedial ($P < .01$; effect size index $[ESI]_{HS} = 1.06$, $ESI_{COL} = 0.95$) and posterolateral reach ($P < .01$; $ESI_{HS} = 0.82$, $ESI_{COL} = 0.84$) as well as a greater composite score ($P < .01$; $ESI_{HS} = 0.60$, $ESI_{COL} = 0.87$). In contrast, HS baseball players exhibited increased anterior reach ($P < .01$; $ESI_{COL} = 0.60$, $ESI_{PRO} = 0.39$) compared with the COL and PRO cohorts. No significant differences in reach asymmetry were observed among groups.

Conclusions: Lower extremity dynamic balance performance differed based on the baseball players' competition level. These baseline data may be helpful in identifying low-performing athletes who might benefit from neuromuscular interventions.

Key Words: dynamic balance, professional athletes, collegiate athletes, high school athletes

Key Points

- Professional baseball players displayed better overall dynamic balance than collegiate and high school baseball players.
- Anterior reach was greatest in the high school players.
- The collegiate and high school groups did not differ in posteromedial, posterolateral, or composite reach.

Concerns about injury rates at all levels of baseball are increasing. In the past decade, the injury rates of high school (HS), collegiate (COL), and professional (PRO) baseball players were 4.0, 5.8, and 3.61 per 1000 athlete-exposures, respectively[1–3]; noncontact upper extremity injuries accounted for the highest proportion.[1,3] Early screening may be helpful in identifying athletes at risk for injury or facilitating injury rehabilitation.[4,5] One factor that may be associated with upper extremity injuries, specifically ulnar collateral ligament (UCL) injuries, is lower extremity dynamic balance. In response, assessment of dynamic balance as a screening tool to identify and facilitate interventions that improve dynamic balance has generated clinical interest.[4–6]

Dynamic balance is defined as an individual's ability to maintain total body stability of the center of mass during movement.[6] One instrument used to examine dynamic balance is the Lower Quarter Y-Balance Test (YBT-LQ). The YBT-LQ is derived from the Star Excursion Balance Test and uses 3 reach directions: anterior, posteromedial, and posterolateral.[6] Traditionally, dynamic balance on this measure has been correlated with lower extremity musculoskeletal injury.[4,5,7–10] One factor that is correlated with lower quarter injury and reach ability on the YBT-LQ is competition level.[6] Specifically, dynamic balance in soccer players, as measured by the YBT-LQ, is positively correlated with competition level except for anterior reach.[6] In addition, previous researchers[4,7,10] suggested that a lower overall score, or a greater amount of asymmetry, is

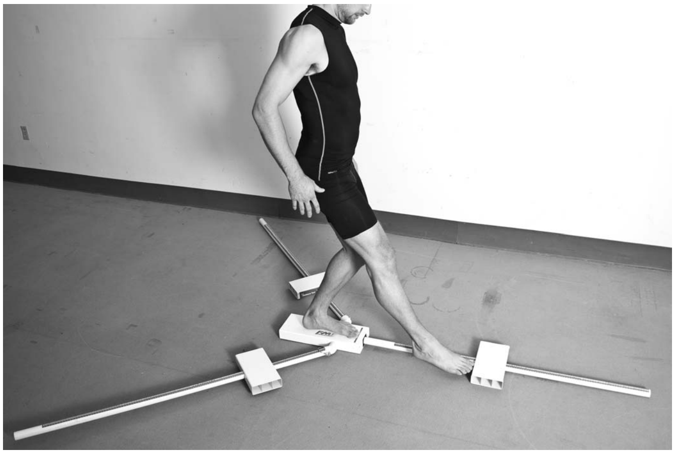

Figure 1. Lower Quarter Y-Balance Test anterior reach.

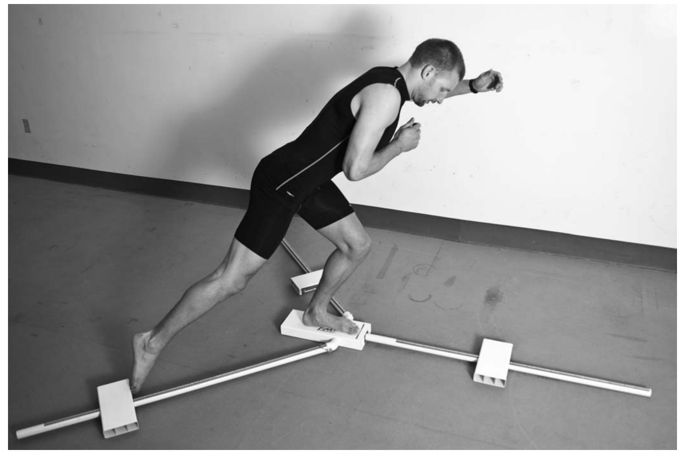

Figure 2. Lower Quarter Y-Balance Test posteromedial reach.

associated with an increased risk of injury in certain populations. Although a number of studies on the YBT-LQ have been conducted, few authors have focused on baseball players.

Recent investigations correlating dynamic balance and upper extremity injury have highlighted the relevance of the kinetic chain in throwing mechanics. It has been proposed that the baseball throwing motion begins in the lower extremity, with the forces transferred through the trunk and into the upper extremity.[4] Diminished core, hip, and lower extremity neuromuscular control may affect the ability to transfer these forces, causing undue upper extremity stress[5,11–13] and fostering subsequent UCL injury.[5] Garrison et al[5] noted that baseball players with a UCL injury displayed poorer dynamic balance than did healthy baseball players. In a follow-up study by Hannon et al,[14] baseball players with UCL injuries who received lower extremity dynamic balance and neuromuscular control interventions after surgery exhibited improved performance on the YBT-LQ at 3 months. These findings would suggest that dynamic balance is a modifiable factor in pitchers and may be a relevant modifiable impairment in treating or preventing UCL injuries (or both).

Understanding competition-level specific dynamic balance normative standards is valuable in interpreting athletes' physical readiness to participate in or return to sport. These normative data may be helpful in identifying low-performing athletes who may benefit from neuromuscular interventions. The purpose of our study was to compare performance on the YBT-LQ among 3 baseball competition levels: HS, COL, and PRO. We expected that players at the higher levels of competition (COL and PRO) would exhibit higher scores on the YBT-LQ. The a priori hypothesis was established based on prior research in soccer players and the expected increased strength and proprioceptive requirements at higher competition levels that would be associated with increased levels of performance.[6]

METHODS

During preseason physicals, the YBT-LQ was administered using a previously established testing protocol.[6,10] Participants were currently competing at the HS (varsity level, n = 88), COL (National Collegiate Athletic Association Division I, n = 78), or PRO (Major League Baseball, n = 90) level and were pain free and active in baseball-related activities.[6] Volunteers were excluded if they reported a current injury, had pain while performing the YBT-LQ, or currently had a concussion or inner ear infection. After the preseason screening, we gathered the data used in this study through a retrospective chart review. The institutional review board at the local academic institution approved a retrospective review and analysis of these data.

Test administrators who were trained in conducting the YBT-LQ collected all data. Recruits performed the test barefoot. Before the trial, a test administrator instructed the participant to maintain the following criteria during performance: (1) push the reach indicator as far as possible while maintaining balance and return to the starting position without resting the foot on the ground, (2) do not use momentum (ie, a kick) to move the reach indicator, and (3) do not step on top of the reach indicator while pushing it. Each participant stood with 1 foot stationary and with the long axis of the foot in line with the anterior-reach pole on a centralized platform. To standardize the protocol, the right limb was chosen first as the stance leg. While maintaining unilateral stance, the person used the most distal portion of the opposite foot to reach in the anterior (Figure 1), posteromedial (Figure 2), and posterolateral (Figure 3) directions; all reach directions are referenced to the stance limb.[10] The *stance limb* was defined as the leg that coincided with the participant's throwing arm. The *lead leg* was defined as the limb contralateral to the throwing extremity.[5] Each recruit completed 6 practice trials followed by 3 consecutive reaches in each direction for the data-collection trials.[6] A trial was discarded and deemed a failed attempt if the participant touched the foot to the ground, used the indicator for stability, or did not return to standing under control.[6,10,15] The rest period between trials was approximately 20 seconds, which was enough time for the test administrator to record the data and return the indicator to its starting position. Performance on the test was normalized to the person's limb length. Limb length was measured from the inferior anterior-superior iliac spine to the inferior medial malleolus while the participant was supine. The maximum reach performed for all reach directions (anterior, posteromedial, and posterolateral)

Figure 3. Lower Quarter Y-Balance Test posterolateral reach.

during a successful trial was used to create other metrics for statistical analysis.[10]

The primary variables of interest for this study were the averaged normalized reach distance for the lead and stance limbs in each of the 3 reach directions, composite score, and reach asymmetry. The composite score was calculated by averaging the maximum normalized reaches across all 3 directions and then multiplying by 100. Reach asymmetry was derived by taking the absolute value of the difference in the maximum reach distance between the right and left sides. Because we found no differences between the stance and lead limbs, we combined these values and then averaged them to minimize the potential for type I error. Reducing the number of statistical tests decreased the likelihood of finding a statistical difference due to chance alone. As a result, the normalized reach distance, composite score, and reach asymmetry were then compared across competition levels. The asymmetry composite score was also examined among age groups to provide an estimate of overall reach asymmetry.[6]

We calculated a series of 1-way analyses of variance to identify differences among the competition levels (HS, COL, PRO). Statistical significance was set at $P < .05$. If the results were significant, a Tukey honestly significant difference post hoc test was then conducted to determine where specific differences existed among competition levels. We used SPSS (version 22; IBM Corp, Armonk, NY). Effect size indices (ESIs) were also calculated to provide a better understanding of the clinical relevance of the differences that were not due to sample size.

RESULTS

Based on the study sample, we expected and confirmed that significant incremental increases in age and weight existed across the 3 groups (Table). Height and limb length were less in the HS group, but no difference was found between the COL and PRO groups ($P < .01$).

Dynamic balance performance differed across the groups, yet the relationships were inconsistent (Figure 4). The HS baseball players exhibited greater dynamic balance in the anterior-reach direction compared with the COL (ESI = 0.60) and PRO (ESI = 0.39) players ($P < .01$). In contrast, PRO baseball players demonstrated greater dynamic balance in comparison with the HS and COL groups for the posteromedial ($ESI_{HS} = 1.06$, $ESI_{COL} = 0.95$) and posterolateral ($ESI_{HS} = 0.82$, $ESI_{COL} = 0.84$) reach directions and for composite score ($ESI_{HS} = 0.60$, $ESI_{COL} = 0.87$; $P < .01$). For the posteromedial, posterolateral, and composite score results, no differences were observed between the HS and COL groups.

Asymmetry in dynamic balance was similar among groups in all reach directions (Figure 5). The largest differences in asymmetry were observed between the HS and PRO groups in the posterolateral reach (ESI = 0.32, $P = .08$) and composite score (ESI = 0.33, $P = .07$).

DISCUSSION

The purpose of our study was to examine the differences in dynamic lower extremity balance across multiple baseball competition levels using the YBT-LQ. The results support our hypothesis: the PRO baseball players had greater overall dynamic balance than the HS and COL groups. Unexpectedly, the HS group displayed greater dynamic balance in the anterior-reach direction compared with the COL and PRO players.

No statistically significant differences for reach direction or composite score were observed between the lead and stance limbs. This is in line with our hypothesis based on previous research by Garrison et al,[5] who found that baseball players with a prior UCL injury exhibited symmetric dynamic balance between the lead and stance limbs.[5] Some of the proportional lower extremity dynamic balance may be explained by prior authors[16–18] who observed symmetric kinematics of the hip during the throwing motion. Other variances within throwing may be due to factors beyond the fundamental movement competency of the single-leg–squat pattern.[19] These findings suggest that asymmetric performance within a skill may not be associated with a more foundational movement strategy. Although the baseball throwing motion is an asymmetric activity,[19] dynamic balance symmetry between limbs should be expected as a typical finding.

The PRO group exhibited better dynamic balance in the posteromedial reach, posterolateral reach, and composite reach on the YBT-LQ than the COL and HS groups did. Furthermore, when we normalized the variance of the

Table. Anthropometric Characteristics of High School, Collegiate, and Professional Baseball Players

Characteristic	Competition Level, Mean ± SD		
	High School (n = 88)	Collegiate (n = 78)	Professional (n = 90)
Age, y	15.6 ± 1.2[a]	19.5 ± 1.0[a]	23.2 ± 3.0[a]
Height, m	1.76 ± 0.08[a]	1.84 ± 0.06	1.86 ± 0.05
Limb length, cm	90.8 ± 5.9[a]	96.4 ± 5.2	97.5 ± 4.5
Weight, kg	70.9 ± 12.1	87.1 ± 9.0	92.5 ± 11.5

[a] Different from the other 2 groups ($P < .05$).

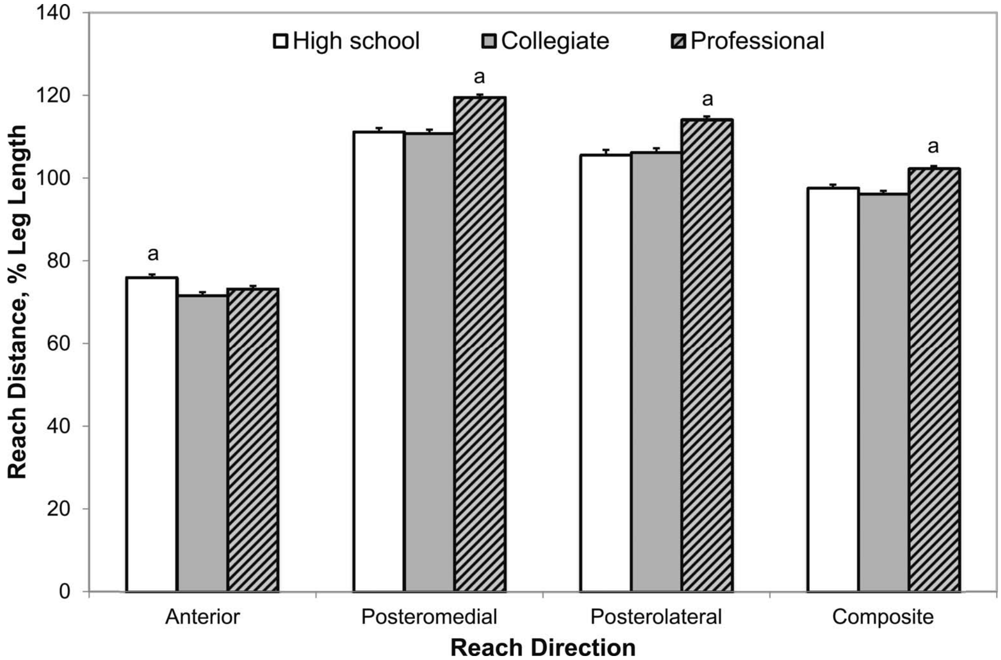

Figure 4. Differences in normalized reach distances on the Lower Quarter Y-Balance Test for the high school, collegiate, and professional baseball players. [a] Indicates a difference from the other 2 groups ($P < .05$).

measure, PRO baseball players displayed a large difference compared with HS and COL players for both posterior-reach directions and the COL group's composite score. The PRO players also exhibited a moderate outcome distinction associated with HS composite scores. The greater composite reach of PRO baseball players is comparable with the results of previous studies[6,20–23] demonstrating that higher-level athletes had improved balance as measured by reach distance. However, the COL group did not display improved dynamic balance compared with the HS group in the posteromedial, posterolateral, or composite reach scores. This finding is in contrast to the findings of Butler et al[6] that soccer players at higher competition levels had greater dynamic balance. Greater differences in dynamic balance between HS and COL soccer athletes compared with baseball athletes might reflect the physical demands of the sport, among other factors. It is interesting that the PRO and COL groups had decreased normalized variance in the anterior reach compared with the HS cohort. This is consistent with previous anterior-reach differences between PRO and soccer players at lower competition levels.[6] In a study by Chimera et al,[24] injury history did not play a role

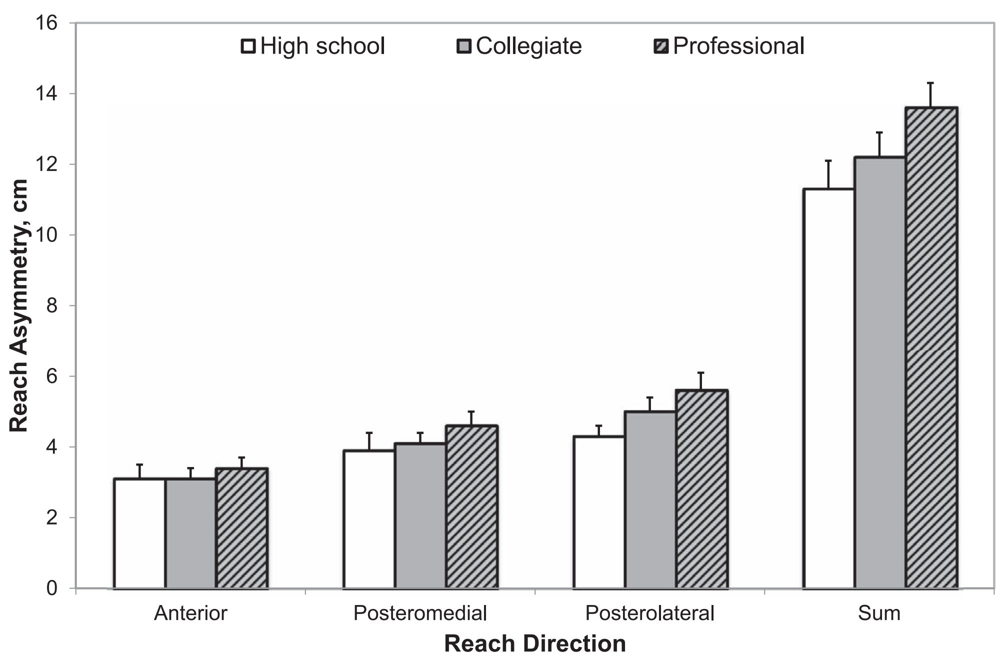

Figure 5. Differences in reach symmetry on the Lower Quarter Y-Balance Test for the high school, collegiate, and professional baseball players.

in National Collegiate Athletic Association Division I athletes' YBT-LQ composite score; however, previous injuries did affect anterior-reach performance. Anterior reach has been shown to require the greatest closed chain dorsiflexion.[22] Reduced reach ability was investigated by Gribble et al,[22] who suggested that diminished proximal control decreases distal joint mobility. Specifically, decreased proximal neuromuscular control of the core, hip, and thigh would decrease closed chain dorsiflexion and thereby alter anterior-reach kinematics.[22,25] As a result, the greater closed chain dorsiflexion demands of the anterior reach compared with the posterolateral and posteromedial reaches may bring to light altered proximal neuromuscular control. Although injury history may play a role in the different anterior-reach distances noted in baseball players, total playing volume may also affect dynamic balance strategies as observed in 3 studies.[6,21,26] Regardless of the mechanism of development, the goal should be to normalize specific deficits in the anterior-reach direction based on normative values.[8]

No asymmetric differences were observed between the stance and lead limbs. Furthermore, all groups displayed similar asymmetry between the right and left limbs across reach directions. Specifically, all groups were below the 4-cm asymmetric cutoff score for anterior reach as defined by Plisky et al.[4] Prior authors[4,6,8] have reported an increased injury risk when the asymmetric anterior-reach difference between the right and left limbs was greater than 4 cm. Smith et al[8] noted that anterior-reach asymmetry greater than 4 cm was the only significant injury predictor in Division I athletes. Previous investigators[4,27,28] have suggested that athletes with substantial side-to-side differences in lower extremity dynamic balance may have a less stable base of support. Further research is necessary to understand if altered neuromuscular control is observed specifically in baseball players. However, the currently available literature indicates that asymmetries should not be based on sport or competition level.[4,8]

As with any research, several limitations existed in our study. The primary limitations were the limited groups from whom the data were collected and the lack of differentiation in outcomes by position played. Participants from a small cohort of locations were studied for this initial project. We have no reason to believe these players were not representative of the population as a whole, but future investigators should determine if these findings are maintained in a larger cohort from a wider range of locations across the same competition levels. Further examination of possible correlations of dynamic balance performance with positions (eg, pitchers versus nonpitchers) and baseball injuries is warranted. Because this study was retrospective in nature, participants' previous histories may have influenced their dynamic balance. Specifically, we lacked information about their injury exposures and balance-training experience. Differences in cohort injury histories may explain some of the disparities in dynamic balance.[6] Finally, we based our procedure on the standardized YBT-LQ protocol of Plisky et al,[15] which involves standing first on the right foot and reaching in the anterior direction. The absence of randomization could have created an order effect, thereby altering the data; as a result, this may be a limitation of the Plisky et al[15] protocol.

In summary, PRO baseball players exhibited greater overall dynamic balance than COL and HS baseball players. Consistent with previous research,[6] HS players displayed the greatest anterior-reach distance. It is notable that the COL and HS groups did not display differences in posteromedial, posterolateral, or composite reach. Looking into the nuances of YBT-LQ scores, future authors may want to focus on anterior and posteromedial reach in baseball players due to the similarity of these reach directions with the throwing motion. Our findings suggest that dynamic balance varies among baseball competition levels. By identifying normative values according to competition level in baseball players, health care professionals may be able to efficiently recognize players who might benefit from dynamic balance training.

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