Predictors of Fielding Performance in Professional Baseball Players

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The ultimate zone-rating extrapolation (UZR/150) rates fielding performance by runs saved or cost within a zone of responsibility in comparison with the league average (150 games) for a position. Spring-training anthropometric and performance measures have been previously related to hitting performance; however, their relationships with fielding performance measures are unknown. **Purpose:** To examine the relationship between anthropometric and performance measurements on fielding performance in professional baseball players.

**Methods:** Body mass, lean body mass (LBM), grip strength, 10-ya sprint, proagility, and vertical-jump mean (VJMP) and peak power (VJPP) were collected during spring training over the course of 5 seasons (2007–2011) for professional corner infielders (CI; n = 17, fielding opportunities = 420.7 ± 307.1), middle infielders (MI; n = 14, fielding opportunities = 497.3 ± 259.1), and outfielders (OF; n = 16, fielding opportunities = 227.9 ± 70.9). The relationships between these data and regular-season (100-opportunity minimum) fielding statistics were examined using Pearson correlation coefficients, while stepwise regression identified the single best predictor of UZR/150. **Results:** Significant correlations (P < .05) were observed between UZR/150 and body mass (r = .364), LBM (r = .396), VJPP (r = .397), and VJMP (r = .405). Of these variables, stepwise regression indicated VJMP (R = .405, SEE = 14.441, P = .005) as the single best predictor for all players, although the addition of proagility performance strengthened (R = .496, SEE = 13.865, P = .002) predictive ability by 8.3%. The best predictor for UZR/150 was body mass for CI (R = .519, SEE = 15.364, P = .033) and MI (R = .672, SEE = 12.331, P = .009), while proagility time was the best predictor for OF (R = .514, SEE = 8.850, P = .042). **Conclusions:** Spring-training measurements of VJMP and proagility time may predict the defensive run value of a player over the course of a professional baseball season.

**Keywords:** power, agility, ultimate zone rating, fielding percentage, range factor

Fielding performance, although statistically difficult to assess, is considered a significant factor in the outcome of a professional baseball game, accounting for approximately one-fifth of total wins during a major-league season. Over the course of an entire major-league baseball season (162 nine-inning games), a minimum of 4374 outs must be made. Two commonly accepted methods of measuring fielding performance are fielding percentage (FPCT) and range factor (RF), which are based on the percentage of outs per fielding opportunity and average outs made per inning played, respectively. However, these statistics are largely based on the number of defensive chances a team or specific player will face, which are not guaranteed. Several circumstantial variables such as defensive position, pitching performance, batter performance, defensive skill of one’s teammates, defensive strategy, player substitutions, injuries, and extra innings will all affect the number of fielding opportunities a baseball player will experience, as well as the requisite skill to successfully make the out. As a result, sabermetrics were developed to provide an objective statistical analysis of in-game activity for baseball. Several sabermetric statistics have been developed to equate players across position and quantify their value either in terms of runs or wins. Recently, the ultimate zone rating (UZR) sabermetric was developed to more accurately define fielding performance by calculating the number of runs a player saved (or cost) his team through fielding in comparison with his respective position’s league average for the season. This measure accounts for the trajectory, velocity, and the 2-dimensional location of the batted ball within a predefined zone of fielding responsibility while also correcting for situational factors such as the number of outs, the handedness of the batter, the ballpark being played in, base-runner configuration, the pitcher’s ground-ball-to-fly-ball ratio, and “ball-hogging” teammates. Although its major limitation is in the discretion used in creating the zones of responsibility, the UZR is believed to be a more comprehensive measure than FPCT or RF for describing the impact of an individual fielder.

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Before a competitive season, several anthropometric and performance measurements are collected to evaluate amateur and minor- and major-league professional baseball players. Significant associations between these measures and hitting performance have been demonstrated; however, whether these physical performance measures can predict fielding performance has not been established. It is believed that proficiency in 4 largely independent skills—sure-handedness (ability to avoid error), range, positioning, and throwing—define defensive capability. Although increased lower-body power, grip strength, and throwing distance have each been associated with increased throwing velocity, whether they translate to better fielding performance is not known. The need for a strong throw may depend on specific actions during a game. For instance, if the athlete is able to reach a ball in a difficult place on the field, his ability to throw out the runner may depend on his arm strength, but it was the initial ability to reach and field the ball that was key. For this task, speed and agility are valued assets in baseball players, particularly in centerfielders and middle infielders, as they appear to improve their range. Nevertheless, neither has been associated with greater FPCT, RF, or any other sabermetric statistic. Therefore, the purpose of this investigation was to identify the anthropometric and physiological variables that may predict fielding performance across defensive positions.

**Methods**

**Subjects**

Data from 22 professional baseball players from the Texas Rangers professional baseball organization during the 2007–2011 seasons were examined. To be considered for inclusion, all examined players totaled a minimum of 100 opportunities (ie, putouts, assists, and errors) per season to make a defensive play within their defensive category. In the event of a player qualifying for multiple defensive categories in the same season, comparisons were made for both categories in relation to spring-training data for that season. Consequently, data from 11 players occurred over multiple seasons (1 season, n = 11; 2 seasons, n = 3; 3 seasons, n = 4; 4 seasons, n = 2; 5 seasons, n = 2). Of the players tracked for multiple seasons, 1 player qualified for 2 different defensive categories within a season twice, while another’s defensive category changed between seasons. Three defensive categories of positions, based on similar positional demands, were used for analysis. The first group of players were corner infielders (first basemen and third basemen; CI; n = 17, innings = 617.5 ± 358, fielding opportunities = 420.7 ± 307.1). The second group of players were middle infielders (second basemen and shortstops; MI; n = 14, innings = 918.6 ± 474.3, fielding opportunities = 497.3 ± 259.1), and the final group included all 3 outfield positions (OF; n = 16, innings = 868.7 ± 220.8, fielding opportunities = 227.9 ± 70.9). Anthropometric and performance-data differences between the groups are presented in Table 1. For multipositional players, defensive statistics were combined when their positions fell within the same defensive category and separated when their positions fell across multiple defensive categorizations. Pitchers and catchers were excluded from the analysis due to the unique defensive demands of their positions and because they did not complete the same spring-training performance measures. All performance assessments were part of the athletes’ normal training-camp assessment routine. Players gave their informed consent as part of their sport requirements, which is consistent with our institution’s policies for use of human subjects in research.

**Design**

Deidentified data from professional baseball players who were tested as part of their team’s requirements for preseason training were analyzed. Field assessments included lower-body jump power, speed, agility, grip strength, and body composition. Correlations between these physical performance variables and fielding performance over the course of the associated regular season were made to identify their predictive ability. All testing sessions were supervised by certified strength and conditioning specialists.

**Performance Assessments**

The order of testing began with anthropometric measures (height, body mass, and body composition), followed by isometric-strength (handgrip dynamometer), vertical-jump, and anaerobic-power measures; speed (10-yd sprint); agility (proagility); and 300-yd shuttle. Test–retest reliabilities for all assessments have been previously reported to be r > .90. Isometric Handgrip Testing

Isometric grip strength was assessed with a Jamar handgrip dynamometer (Sammons Preston, Bolingbrook, IL, USA). All measurements were assessed with the player’s dominant and nondominant hands. Isometric handgrip assessments were performed as previously described. Briefly, players began seated with their back straight, arm resting on the arm rest, elbow at 90°, and were instructed to remain motionless while performing a maximal-effort attempt. The best score from 2 maximal-effort attempts was recorded in kilograms as maximal grip strength.
**Vertical-Jump and Anaerobic-Power Measures**

Countermovement vertical-jump height was measured using a Vertec jump trainer (Sports Imports, Columbus, OH, USA). Before testing, each athlete’s standing vertical-reach height was determined. Vertical-jump height was calculated by subtracting the standing reach height from the jump height. Each player performed 3 attempts, of which the highest vertical-jump height achieved was recorded. The Harman formula was used to estimate both vertical-jump peak power (VJPP) and vertical-jump mean power (VJMP) outputs.

**Speed and Agility Assessments**

All speed and agility assessments were timed by the same strength coach using standardized procedures. Speed was determined by a timed 10-yard (9-m) sprint. Sprint times were measured using an infrared testing device (Speed Trap II, Brower Timing Systems, Draper, UT, USA) and performed on an Astroturf field. Timing began on the player’s movement out of a 2-point (base-running) stance. The best of 3 attempts was recorded as the player’s fastest time.

Agility was determined by the proagility test. The protocol was conducted as previously described. Three lines with 5 yd (4.5 m) between consecutive lines were marked on the field. The player straddled the middle line and sprinted to one line (4.5 m away) and touched the line. He then changed direction and sprinted to the far opposite line (9 m away), touched the line with the same hand used to touch the first line, reversed direction, and returned to the starting point, sprinting through the finish line. Agility times were measured using a handheld stopwatch with the time beginning at the athlete’s initial movement and stopping as the athlete crossed the finish line. Each subject performed 3 maximal attempts, and the fastest time was recorded.

**Fielding Performance**

Fielding performance was determined from published statistics of regular-season Major League Baseball play. To objectively compare fielding performance, while accounting for situational variability among defensive positions (with the exception of catcher and pitcher), the UZR was used. This sabermetric statistic is determined by dividing the field of play into 64 zones of responsibility. Credits and debits are given for plays successfully made or not made within a player’s zone, with bonuses given to plays made outside of one’s responsibility. The final result is the season total number of runs saved (positive) or cost (negative) by the specific fielder. The year-to-year reliability of UZR has been reported to be $r = .444$. For players logging an entire season at a single position, this statistic is ideal in quantifying fielding performance. However, the current sample included players who logged multiple innings and fielding opportunities at several positions during their respective seasons. For these players, the UZR extrapolation was the most appropriate statistic to be used for comparison, as it multiplies the UZR by a factor of the average number of balls in play a fielder at that position would observe over 150 games. In addition, traditional measures of fielding performance were used for comparison. For these, the relationships between UZR/150 and FPCT, the total number of outs (assists + putouts) divided by the total number of defensive chances (putouts + assists + errors) and RF, the total number of outs (assists + putouts) per 9 innings played were examined.

**Statistical Analysis**

All data are reported as mean ± SD. Comparisons between defensive categorizations for spring-training performance data and regular-season defensive statistics were performed using 1-way analysis of variance (ANOVA). If a significant $F$ ratio was observed, then follow-up Tukey post hoc analyses were used to determine difference between groups. Pearson product–moment correlations were used to examine the relationships between performance data and defensive statistics (FPCT, RF, UZR, and UZR/150) for all players and by defensive category. The contribution of each variable was then evaluated using a stepwise-regression analysis. A criterion alpha level of $P \leq .05$ was used to determine statistical significance. Statistical software (PASW v. 20.0, SPSS Inc, Chicago, IL) was used for all analyses.

**Results**

Significant differences in anthropometric, performance, and defensive statistics were seen between defensive categories. Table 1 highlights the differences in fielding requirements among fielding positions for all players and for individual defensive categorizations.

The extrapolation of UZR over 150 (UZR/150) games produced different predictors of performance. Pearson correlation coefficients indicated significant relationships between UZR/150 and body mass, lean body mass (LBM), VJPP, and VJMP. Of these variables, stepwise regression indicated VJMP ($R = .405$, SEE = 14.441, $P = .005$) to be the single best predictor for all players, although the addition of proagility performance strengthened ($R = .496$, SEE = 13.865, $P = .002$) predictive ability by 8.3%. By itself, proagility was not significantly correlated, although a trend toward an inverse relationship ($r = -0.287, P = .051$) was observed. However, these relationships varied among defensive categories: Body mass, LBM, and VJMP remained significantly...
related to UZR/150 in CI, while body mass and LBM were the only significant variables for MI; a trend toward VJMP ($r = .507, P = .064$) was also observed. For both CI and MI, body mass was the single best predictor (CI, $R = .519, \text{SEE} = 15.364, P = .033$; MI, $R = .672, \text{SEE} = 12.331, P = .009$). A significant inverse relationship was observed between UZR/150 and proagility time for OF. Stepwise regression also revealed proagility time to be the single best predictor ($R = .514, \text{SEE} = 8.850, P = .042$) for UZR/150 in OF. Table 2 provides selected bivariate relationships between UZR/150 and the examined variables.

For all players, height appears to be the single most predictive variable for FPCT ($R = .296, \text{SEE} = 0.012, P = .043$), although inverse relationships with age ($R = .512, \text{SEE} = 0.016, P = .035$) and maximal grip strength ($R = .527, \text{SEE} = 0.242, P = .036$) were the best predictors for CI and OF, respectively. The predictive ability of any single variable for RF varied among defensive categories. For all players, percent body fat ($R = .313, \text{SEE} = 2.441, P = .032$) best predicted RF, while the addition of age ($R = .469, \text{SEE} = 2.296, P = .004$) strengthened predictive ability by 12.2%. However, neither was predictive of RF when players were categorized by defensive position. For CI, an inverse relationship with age appeared to best predict RF ($R = .544, \text{SEE} = 2.556, P = .024$), while no relationship was observed for MI. For OF, 10-yd sprint showed an inverse relationship with RF and was its best predictor ($R = .527, \text{SEE} = 0.242, P = .036$). In addition, a relationship between FPCT or RF and UZR/150 was not observed. Table 3 provides selected bivariate relationships between FPCT, RF, and the examined variables.

### Discussion

Fielding performance is considered to have a significant effect on the outcome of a professional baseball game. The results of this study suggest that fielding performance over an entire season of professional baseball may be predicted by anthropometric and physical-performance measurements typically obtained during spring training. Although variability existed between individual defensive positions, mean lower-body power, followed by agility, was the best predictor of defensive-player value for all positions, while the best predictor of traditional fielding measurements varied by position. Previous research has examined the relationship between these measurements and offensive statistics and the coach’s perception of fielding performance, but this study is the first to relate them to actual defensive statistics of performance in professional baseball players.

The results of the current study suggest that VJMP and proagility time are the best predictors of a fielder’s ability to routinely make outs of baseballs hit in play. Power is essential any time one needs to accelerate to a specific location, as a fielder does to catch or field a ball. It has also been reported to influence throwing velocity, which may determine whether a ball reaches its intended target in time to make an out. Furthermore, the ability to complete these tasks outside of the average zone of responsibility is rewarded in the UZR/150 scoring format. Our data indicate that those with greater VJMP are able to expand the range in which they make plays. Previous research in college baseball players did not find a significant relationship between measurements...
of power and fielding performance. However, the methods used to examine power (medicine-ball throw and standing broad jump) did not account for body mass or distinguish between peak and mean power, which are necessary to make comparisons between individuals of varying size. It is interesting that the researchers observed a significant difference between the highest- and lowest-rated fielders and their throwing ability, which has been reported to be related to lower-body power.

Proagility performance was the best predictor of “runs saved.” The current investigation measured power by converting countermovement vertical-jump performance with a previously published formula, providing an approximation of concentric power. Although concentr-
tric power is important for the acceleration aspect of the proagility test, deceleration ability is also important. Previously, it has been reported that the ability to change direction has a greater correlation to reactive strength, as measured by depth jump. Agility has previously been connected to fielding performance, and its necessity appears to be most apparent when fielding a ball that takes an odd bounce or when tracking a fly ball. However, it may also play a role in the ability to decelerate and set one’s feet to make an accurate throw. This seems to be most apparent in OF, who must routinely cover larger distances than infielders to track down fly balls, reverse direction, and make long, accurate throws. Consequently, proagility performance was the best predictor of fielding performance.

For infielders (both CI and MI), body mass was the single best predictor of UZR/150. However, only LBM, and not percent body fat, had a significant correlation (CI, r = .512, P = .036; MI, r = .650, P = .012). This is in agreement with previous research reporting greater LBM at the major-league level of professional baseball versus the minor leagues. VJMP was also significantly correlated (r = .502, P = .040) for CI. Although it did not significantly add to the regression equation, it may provide evidence to support power maintenance in first and third basemen to enable them to track down foul balls or move quickly to field line drives. Power was not significantly correlated to UZR/150 in MI, which may suggest a standard power requirement to play these positions. Little difference in power exists between professional baseball position players as they age; players who are able to maintain their power with age are the ones who are still playing. The same may be true for players at shortstop and second base.

The traditional measurements of fielding performance, FPCT and RF, did not produce consistent results for all players or across positions. This is likely related to the insensitivity of the 2 measurements. FPCT is a subjective measurement of sure-handedness that does not take into account the range covered by a fielder. It only accounts for the obvious mishandling of a ball in play, with no corresponding measure for rewarding players for a particularly well-handled fielding play. In fact, it does not appear to relate to team winning percentage. On the other hand, RF does not take errors into account; rather, it solely depends on the number of outs produced by the fielder. A variety of conditional factors influence these measures, including the number of innings played and fielding opportunities, the presence of base runners, the vicinity of a batted ball, and the skill of surrounding fielders. For these reasons the UZR system and other sabermetric measures were created.

Practical Applications

Considering the importance of individual and team fielding performance to the outcome of a professional baseball game and season, our data suggest that athletes and coaches should focus on developing and maintaining agility and power, which appear to be the best predictors of elite baseball fielding performance. Our results, therefore, suggest that spring-training measurements of LBM, vertical-jump power, and proagility run may be the best predictors of season-long value in runs a position player is defensively worth (UZR/150). Consequently, strength coaches and team managers may find this information useful in the early identification of the players who are most capable of contributing to team fielding performance or who need to improve agility and power.

Conclusions

Spring-training measurements of LBM, vertical-jump power, and agility may predict the number of runs saved (or cost) defensively by individual professional baseball players over an entire season (UZR/150). For CI and MI, body mass was the best predictor of UZR/150, while proagility time was the best predictor for OF. The predictors of traditional measures of fielding performance, FPCT and RF, vary by defensive category.

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References