Age and Level of Performance in Major League Baseball

Ray Over

The relationship between age and the level of performance of major league baseball players was assessed through quasi-experimental designs. Whereas cross-sectional comparisons revealed no differences in batting and fielding statistics between younger and older players, longitudinal analysis showed significant decrements in batting performance as players aged from 30 to 35 years. A decline in performance with age was found even among elite players. Age decrements in achievement need to be studied not only in the context of molar measures such as batting statistics but also at a microanalytic level through reference to component skills. This paper outlines a methodology that can be used in assessing the nature and basis of age decrements in skilled athletic performance.

Key Words: aging, athletic achievement, cross-sectional comparisons, developmental processes, longitudinal analysis

One method of identifying relationships between age and athletic achievement has been to determine the age at which peak performance occurs. In adopting this approach, Lehman (1953) established for a number of sports the ages at which athletes are most likely to top averages, break records, or win championships. He concluded that the highest standards of performance are reached between the ages of 31 and 36 in sports such as billiards and rifle shooting, which require psychomotor precision but not physical strength, whereas skills peak before age 30 in sports such as baseball, boxing, football, ice hockey, and tennis, which require explosive outbursts of speed and energy.

Schulz and Curnow (1988) demonstrated through a similar mode of analysis that despite substantial improvement over the last 100 years in absolute levels of performance (e.g., world records in timed athletic events), the age at which performance peaks has remained stable. Men have continued to demonstrate maximal performance at around ages 19 for swimming; 23 for short-distance running; 24 for jumping, medium-distance running, and tennis; 27 for long-distance running; 28 for baseball; and 31 for golf. Gender differences are evident,

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with women generally demonstrating peak performance at a consistently younger age than men (e.g., ages 17 for swimming and 22 for short-distance running).

Cross-sectional analysis comparing the performance levels of athletes at different ages, as well as longitudinal studies of changes in performance as an individual ages, offer further methods for identifying relationships between age and achievement. The popularity of veteran and masters athlete competitions at regional, national, and international levels, wherein adults at all levels across the life span compete with age peers, has provided measures of peak performance for a range of ages and for a number of sports. Several investigators (Ericsson, 1990; Hartley & Hartley, 1984; Spirduso, in press; Stones & Kozma, 1982) have used these data to plot age trends for performance in competitive sports such as running, throwing, jumping, swimming, cycling, rowing, and weight lifting. For example, the long-jump record for men exceeds 25 ft prior to age 30, but is about 20 ft at age 50, 15 ft at age 70, and 10 ft at age 85.

As noted by Spirduso (in press), increased participation in masters athlete competition, together with greater commitment to practice and greater motivation to achieve, seems likely to result in new records being set by future cohorts of the elderly. An interesting finding from cross-sectional and longitudinal studies is that age trends in performance level differ between sports (Stones & Kozma, 1986). At peak performance for example, there is proportionally less difference between younger and older runners in the time taken to complete a sprint compared to a distance event. World records across ages indicate that the best achieving male athlete over 85 years of age has completed the 100-meter dash at about 60% of the speed of the fastest young athlete, whereas the value drops to below 50% for running 800 m and to 35% for 10 km (see Spirduso, in press).

Although Lehman (1953) did not offer an account of why skilled athletic performance declines with age, others have pointed to possible physiological bases. Stones and Kozma (1986), for example, have argued that elderly athletes show less impaired performance in activities of a brief duration. Age differences in peak performance are hence less for sports relying on the anaerobic system than for those relying on the aerobic system. In addition to physiological processes, however, the relationship between age and athletic achievement probably reflects psychological factors such as achievement orientation and competitiveness, aspects of lifestyle such as commitment to fitness and practice, and secular influences such as societal age norms affecting participation (Ericsson, 1990; Spirduso, in press).

The present study is concerned with the relationship between age and achievement in major league baseball. Figure 1, which reports frequency distributions established on the basis of Lehman's mode of analysis, identifies the ages of the players with the highest batting average in the American and National Leagues in each season between 1920 and 1980. Entries in the fifth edition of The Baseball Encyclopedia (Reichler, 1982) were used for this purpose. Ages were also established for players who had hit the most home runs in a season, as well as for players who had stolen the most bases. Figure 1 demonstrates an inverted-U relationship between age and achievement. The distributions peak at ages 27-28 for batting average, 27-30 for home runs, and 29-30 for stolen bases.

Upon finding that the modal age of baseball players who hit the most home runs in a season is 28, Lehman (1953) concluded that the ability of major league baseball players to hit home runs increases with age up to 28 years and thereafter
declines. However, it is questionable whether developmental trends can be inferred from the modal age of peak performance. Since age constituted the dependent variable in Lehman's data analysis, and performance levels were not compared between players in different age ranges, the methodology used by Lehman (and by Schulz & Curnow, 1988) provides only indirect information about developmental trends.

When interpreting the modal age for hitting the most home runs in a season, we must also recognize that most players become established in the major leagues in their mid-20s and have retired by their mid-30s. The age distribution of currently active players peaks at around 28 years. Hence the modal age for hitting the most home runs in a season might be 28, not because performance rises to a peak at this age and then declines, but because there are more players at age 28 than at other ages. Performance at the level of the individual may remain relatively stable season by season, with the modal age for most home runs per season probably reflecting the age distribution of players.

Focusing on the age at which peak achievement occurs does not provide specific information about the relative levels of performance of younger and older players, or about the manner in which the performance of individuals changes across seasons. A more direct approach to studying relationships between age and skilled athletic performance is to use conventional developmental designs, such as longitudinal and cross-sectional methodologies, which include age in analysis as an independent or predictor variable.
The quasi-experimental designs used in the present study examine relationships between age and performance in major league baseball with chronological age as the independent variable and performance measures as the dependent variable. As Bateman, Karwan, and Kazee (1983) have noted, baseball statistics offer objective, quantifiable, and unobtrusive measures of achievement in contexts that are reasonably comparable across individuals and relatively stable over time. Further, individual performance can be assessed using a number of measures that are to a substantial extent independent of contributions from other members of the team (Jones, 1974).

— Studies —

1. Cross-sectional Comparisons

The objective in cross-sectional analysis is to compare the achievements of younger and older players in the same season; the data therefore provide information about age differences in level of performance. There are relatively few players in major league baseball under 20 or over 35 years of age; the contrasts that follow are thus between players within four age ranges: 20–23, 24–27, 28–31, and 32–35 years of age. Four-year spans were used because shorter intervals would have yielded too few cases per age group for players at the extremes of the age range.

Since peak performance levels have not remained stable over the history of baseball, cohort (season) was included in the design as a further independent variable. This step meant that cross-sectional trends (age differences in performance) can be compared between the 1920, 1950, and 1980 seasons. Including cohort as an independent variable thus allows the generality of age trends to be identified; for example, the interactive influence of cohort and age of players should be nonsignificant if age trends have remained stable over time.

METHOD

The analysis was based on players who had participated in 50 or more games in the American or National Leagues in the season of interest. Since the concern is primarily with batting performance, pitchers were not included in the sample. Nor were catchers, since some may have held a team place for reasons other than batting performance, or players who participated in 50 or more games but had transferred between teams during the season. Entries in the fifth edition of *The Baseball Encyclopedia* (Reichler, 1982) yielded information on the players in the sample. Age was taken as the difference in years between the season in which the player was included in the sample and his year of birth.

Five measures were studied as dependent variables in order to ensure that the sample covered several aspects of performance. These measures were batting average (hits divided by times at bat), home run average (home runs divided by times at bat), slugging average (mean number of bases scored per time at bat), stolen base average (stolen bases divided by times on base), and fielding average (proportion of fielding opportunities executed without error). Since all five measures are expressed as ratios, each is independent of the number of games that individuals had played in the season.
Table 1  Mean Performance Levels of Major League Baseball Players as a Function of Age (cross-sectional comparisons) and Season

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<td>.425</td>
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<td></td>
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<td>20–23</td>
<td>20</td>
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<td>.021</td>
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<td></td>
<td>32–35</td>
<td>50</td>
<td>.271</td>
<td>.026</td>
<td>.403</td>
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RESULTS AND DISCUSSION

Table 1 shows mean achievement levels on the five performance measures for players ages 20–23, 24–27, 28–31, and 32–35 years in the 1920, 1950, and 1980 seasons. Multivariate analysis of variance indicated that means on the measures varied across seasons, $F(12, 1070) = 22.41, p < .01$. Univariate tests followed by Newman-Keuls multiple comparisons indicated that the mean batting average was lower in the 1980 season than in the 1920 or 1950 seasons; the home run rate was lowest in 1920; the slugging average was highest in 1950; in 1950 there was a lower stolen base average than in 1920 or 1980; and the fielding error rate was higher in 1920 than in the other two seasons.

Differences across generations of players are not unexpected, given the changes that have occurred in baseball over time. Playing conditions and rules have regularly been modified, equipment has changed, and style and tactics in the game have varied (Reichler, 1982). However, since the interaction between season (cohort) and age group was not significant, $F(36, 3234) = 0.85, p > .05$, the generational differences noted above do not provide information about developmental processes.

Although there was overall a significant main effect of age on level of performance, $F(18, 1608) = 18.88, p < .02$, univariate tests followed by Newman-Keuls multiple comparisons showed that the age differences were limited to stolen bases (players 32–35 years of age had significantly lower rates) and fielding average (players 20–23 years of age had significantly lower averages than players either 28–31 or 32–35 years of age). The age variation in fielding average can be discounted since fielding position was not allowed for in the analysis. The differences in means for batting average, home run rate, or slugging average
between players in the four age groups (20–23, 24–27, 28–31, 32–35 years) were not significant, \( p > .05 \).

The main finding from cross-sectional analysis is that younger and older baseball players in the major leagues have similar batting averages, home run rates, and slugging averages. Although such a finding seems inconsistent with the inverted-U relationship between age and achievement generated using Lehman’s method of analysis, caution is called for in interpreting the cross-sectional data. Baseball is a highly competitive sport, and a player must continue to perform at an acceptable standard to retain his place on a major league team. The career span of major league players averages only about eight seasons.

The young players in any given season are possibly a diverse group in terms of ability, with a number not talented enough to hold their place on a major league team over time, while the older players are a select group in the sense of having performed consistently well over time. Instead of achievement remaining stable with age, selective attrition might result in the survival of only the older players who are performing at a high standard. The nonsignificant age differences that were found through cross-sectional analysis might thus reflect selective attrition over time rather than individuals maintaining a stable level of batting performance over the age range covered by the analysis. In addressing this issue, it is useful to establish the extent to which the level of individual performance changes over seasons.

2. Longitudinal Comparisons

METHOD

Longitudinal trends were identified by comparing the performance of the same individuals at different ages. Entries in the fifth edition of *The Baseball Encyclopedia* (Reichler, 1982) were searched for baseball players other than pitchers or catchers who had played 50 or more games in the major leagues at 25, 30, and 35 years of age. The comparison is thus between early-career, mid-career, and late-career performance levels for the same player.

The analysis was restricted to players active within the period 1920 to 1982, the interval covered by cross-sectional comparisons in Study 1. Thus the sample included only players who had turned 25 in or after 1920, and 35 in or before 1982. The 71 players meeting the above criteria included 24 who had by 1982 been inducted into the Baseball Hall of Fame. Longitudinal comparisons were undertaken with five performance measures—batting average, home run average, slugging average, stolen base average, and fielding average—as the dependent variables. The independent variables were age (25 vs. 30 vs. 35) and a player’s status (i.e., whether he had been elected to the Hall of Fame).

RESULTS AND DISCUSSION

The mean performance levels of the two groups of players at 25, 30, and 35 years of age are reported in Table 2. As might be expected, there was a significant difference in level of performance between the players in the sample who had by 1982 been inducted into the Hall of Fame and the players who had not been so honored, \( F(6, 65) = 17.87, p < .01 \). Univariate tests showed that the Hall of
Table 2  Mean Performance Levels of Hall-of-Fame and Other Players at 25, 30, and 35 Years of Age (longitudinal data)

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<td>Hall-of-Fame</td>
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<td>.039</td>
<td>.536</td>
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<tr>
<td>players</td>
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<td>.313</td>
<td>.039</td>
<td>.510</td>
<td>.043</td>
<td>.973</td>
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<tr>
<td>(n = 24)</td>
<td>35</td>
<td>.290</td>
<td>.032</td>
<td>.453</td>
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<td>.975</td>
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<tr>
<td>Other players</td>
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<td>.021</td>
<td>.401</td>
<td>.062</td>
<td>.969</td>
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<tr>
<td>(n = 47)</td>
<td>30</td>
<td>.277</td>
<td>.021</td>
<td>.403</td>
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<tr>
<td></td>
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<td>.261</td>
<td>.017</td>
<td>.366</td>
<td>.042</td>
<td>.974</td>
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</table>

Fame players had a higher mean batting average, $F(1, 70) = 63.57, p < .01$, a higher mean home run average, $F(1, 70) = 11.42, p < .01$, and a higher mean slugging average, $F(1, 70) = 17.16, p < .01$; but they did not differ significantly from the players who had not been elected to the Hall of Fame in terms of mean stolen base average or mean fielding average.

There was a significant change in level of performance as the players in the sample aged, $F(12, 256) = 6.86, p < .01$. Univariate comparisons showed that with age there were significant reductions in mean batting average, home run average, slugging average, and stolen base average, but not in fielding average. Multiple comparisons between means showed no significant deterioration on any of the five performance measures between 25 and 30 years of age. However, there were significant declines in mean batting average, mean slugging average, and mean stolen base rate (but not mean home run rate or mean fielding average) between 30 and 35 years of age. Since the interactive effect between a player’s status and chronological age was not significant, $F(12, 256) = 1.11, p > .05$, the age differences in performance applied equally to the players who had been inducted into the Hall of Fame and those who had not.

Cross-sectional comparisons and longitudinal analyses did not reveal similar age trends. Whereas there was no difference in level of performance between younger and older players active in the same season (cross-sectional comparison), level of performance—at least in the case of batting average, slugging average, and stolen base rate—declined between ages 30 and 35 (longitudinal analysis).

Such a decline is consistent with the claim by Lehman (1953) that performance in baseball has peaked by age 30. However, longitudinal analysis did not reveal improvement between ages 25 and age 30, as might be expected from the inverted-U relationship between age and performance generated using Lehman’s methodology. Further, the decrement between ages 30 and 35 (see Table 2) is less than expected if distributions of the type plotted in Figure 1 reflect a developmental function.

The longitudinal data reported in Table 2 probably underestimate the degree to which performance deteriorates with age. The sample included only players who participated in 50 or more games at ages 25, 30, and 35. If players are displaced from major league baseball when they no longer meet quite stringent...
performance standards, the longitudinal analysis covered only those who maintained a high level of performance over an extended career. The analysis did not include players who were active at either or both ages 25 and 30, but not at age 35. These players may have been displaced from major league baseball through age related deterioration in performance.

3. Correlates of Career Span

Entries in *The Baseball Encyclopedia* (Reichler, 1982) indicate marked differences in career span among major league baseball players. Whereas some players participate in almost every game over a number of seasons, others play only a few games over their entire career. Established players typically win a regular place in their mid-20s, but few remain active beyond their mid-30s. The age distribution of baseball players active at any given time follows an inverted-U distribution; this circumstance suggests that few older players can perform at the standard needed to continue in the major leagues. Identifying correlates of career span offers a further perspective for studying relationships between age and performance.

METHOD

The analysis was based on the first 200 entries in the fifth edition of *The Baseball Encyclopedia* listing a player (other than pitcher or catcher) who had batted 50 times or more in each of at least two seasons, the first which was later than 1919 and the last of which was earlier than 1980. The following measures were obtained for each player: (a) career span (number of years between the first season and the last season in which the player had batted 50 times or more), (b) number of games over career, (c) games in final season, (d) batting average over career, (e) batting average in final season, (f) home run average over career, (g) home run average in final season, and (h) age in final season.

RESULTS AND DISCUSSION

The 200 men in the sample had averaged 737 games (SD 625) over 8.4 seasons (SD 4.5), and their mean age in the last season in which they had batted 50 times or more was 31.9 years (SD 4.0). Although the players had a mean batting average of .252 (SD .29) over their entire career, their mean batting average in the final season was only .190 (SD .102). Mean home run average dropped from a career value of .018 (SD .014) to a final season value of .009 (SD .015). Slugging average and stolen base average also were lower in the final season than over the total career, but there was no drop in fielding average.

The above statistics suggest that players must exceed a threshold standard of performance to remain in major league baseball. Although some players are forced out through injury and others voluntarily retire, probably in most cases a career in the major leagues ends through a player failing to meet performance standards.

Although baseball is a team sport, an individual player's level of achievement is highly visible. The major statistics in baseball, such as hit rate, home runs, slugging, and stolen bases, all relate to the effectiveness of individual
performance. Players can be compared on the basis of their records, and in selecting a team’s line-up or deciding which players to recruit, trade, or retain, a team’s management has access to highly detailed records bearing on each player’s performance. If runs win games, players who are most likely to maximize the runs gained by their own team and minimize the runs conceded to the opposition will be those most in favor. Even though some players have extended careers, there is no certainty of tenure on a major league team. A player retains his place only by performing better than potential replacements might.

Analysis of data for the 200 players in the sample showed a correlation of .43 between career length (i.e., number of seasons) and career-long batting average, and a correlation of .49 between career-total of games and career-long batting average. Although these values suggest that players retain their place on a major league team on the basis of performance level, a substantial proportion of variance in career duration is associated with variables other than career-long performance level (e.g., batting average).

As indicated above, players demonstrate a drop in performance in their final season in major league baseball. Batting average in the final season is relatively unrelated to career-long batting average (correlation of .10), career span (−.08), number of games played over the career (−.02), and age in the final season (.10). Termination of a career in major league baseball thus seems more a matter of current level of performance rather than a player’s age or level of performance over his career.

— Discussion —

Baseball players operate in a highly competitive labor market. At least in the 1950s, only 1 in every 300 or so who signed a contract to play professional baseball reached the major leagues (La Place, 1954). Further, among those who play major league baseball, many participate for several seasons without establishing a place on a team. Even though the financial rewards for the successful player are substantial, there is no certainty of tenure. Although the likelihood of a player continuing to command a regular place on a major league team is related to age (there are relatively few players beyond their mid-30s), the factor that seems to trigger displacement is not a player’s age but his current level of performance. Possibly a player at any age is vulnerable if his recent batting average is below, say, .250.

Players who never were highly talented, as indexed by career-long performance statistics, are displaced from the major leagues at an earlier age than those who become legendary figures in baseball. The truly gifted player begins his major league career at a relatively early age and initially performs well above this threshold. As he ages, the gap between his level of performance and the standard needed to retain a place on a major league team decreases. Even though players later inducted into the Hall of Fame were still, at age 35 with a mean batting average of .290, outperforming the majority of younger players, they nevertheless had a substantially lower batting average at age 35 than at ages 25 or 30 (see Table 2).

Notwithstanding the fact that some players retire from major league baseball in their mid-30s or even older while performing at or near their peak level
of achievement, the careers of most great players are marked by a decline in performance. Players active beyond 1920 and inducted into the Hall of Fame had a mean batting average of .259 in their final season of 50 or more games, in contrast to a lifetime average of .309 and a mean of .329 at age 25. Some of these players had truly undistinguished final seasons.

Although demonstrating that some players over 30 perform to the same standard as players under 30, the present results indicate that individual players generally demonstrate a decline in level of performance between ages 30 and 35. The consequence is that most players are displaced from major league baseball by their late 30s. These claims are generally consistent with data on peak performance in baseball reported by Lehman (1953) and by Schulz and Curnow (1988). Lehman offered no account of the basis for age specificity in skilled athletic performance; his objective was simply to undertake statistical analyses in order to identify the age ranges within which athletes are most likely to achieve at the highest standards.

Schulz and Curnow (1988) instead considered age grading in performance within the perspective of component psychomotor and physical proficiency skills. Relying on a taxonomy developed by Fleishman and Quaintance (1984), Schulz and Curnow argued that performance in sports relying on reaction time, speed of limb movement, flexibility, explosive strength, and gross body coordination is maximal by the mid-20s, whereas prowess demanding control precision, rate control, arm-hand steadiness, aiming, and stamina peaks in the late 20s or early 30s. The relationship between age and achievement is thus seen to be dependent on whether the component skills underlying performance are at their peak, have yet to develop fully, or are in decline.

Although descriptive data relating molar measures of performance (such as batting average and home run rate) to age provide a useful starting point, the basis for age specificity can be identified only by direct examination of the component skills underlying molar performance. The methodology known as "molar equivalence/molecular decomposition" can be used for this purpose. Charness (1981) employed this method in comparing younger and older chess players of comparable standard (molar equivalence) over a number of skills that correlate with skill at chess (molecular decomposition). Older players demonstrated poorer memory for the position of pieces on the board but had greater strategic knowledge.

Employing a similar methodology, Salthouse (1984) compared younger and older women who were similar in typing speed across measures that can be thought of as component skills. Whereas perceptual-motor efficiency was impaired with age, the older typists showed greater eye-hand span (indexed by anticipation of impending characters and planning further ahead). The implication from such findings is that younger and older persons who perform equally well at a molar level may do so for different reasons. Possibly molar performance remains stable with age because age related deterioration in some constituents is accompanied by compensatory gains in other components (see Backman & Dixon, 1992, for a discussion of literature relating to this issue).

Applying the above strategy in the study of age specificity in baseball begins with identifying the molecular constituents of a molar skill such as batting average. The biomechanics of hitting a baseball with force and accuracy require the execution of a finely graded sequence of skilled movements. Performance
in baseball is unrelated to general measures such as reaction time, movement time, and visual acuity (Nielsen & McGown, 1985; Winograd, 1942); it is more likely that measures which can be used as molecular constituents in data analysis are more domain specific and task relevant.

Any analysis of how and why molar performance changes with age must extend beyond perceptual and motor skills. Decision making when batting (Newell, 1974) is a relevant factor. Cognitive and motivational correlates of molar performance also need to be assessed, as should the possibility that age stereotyping in performance evaluation by the player himself as well as by others induces a self-fulfilling prophecy. A player’s attitudes relating to retirement from sport (Baillie, 1993) may also be important. Since self-efficacy and attribution can regulate performance, the social context of failure should be considered (Ball, 1976).

Age related decline in performance may also reflect tactics employed by opposing teams. Detailed statistics are kept in baseball, and a player’s weaknesses as well as his strengths soon become widely known. Deterioration in molar performance with age may at least in part reflect increasing exploitation of weaknesses in technique by the opposition.

Charness (1981) and Salthouse (1984) used cross-sectional analysis in searching for differences in molecular constituents between younger and older persons who were comparable in molar performance. In employing this same approach, younger and older baseball players with a similar current batting average can be compared over a range of component measures. The relationship between molar performance and molecular skills can also be studied through longitudinal analysis. The objective is to identify the extent to which component skills and molar performance change as players age. Whether loss in certain skills with age is compensated for by enhancement of other skills is again of interest. Combining cross-sectional and longitudinal methodologies is more likely to reveal skills that will determine not only which players will remain in and which players will drop out of major league baseball as they age, but also why few baseball players can command a regular place on a major league team beyond their mid-30s.

References


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