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ORIGINAL ARTICLE

Effects of season period, team quality, and playing time on basketball players' game-related statistics

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Abstract

The aim of this study was to identify within-season differences in basketball players' game-related statistics according to team quality and playing time. The sample comprised 5309 records from 198 players in the Spanish professional basketball league (2007–2008). Factor analysis with principal components was applied to the game-related statistics gathered from the official box-scores, which limited the analysis to five factors (free-throws, 2-point field-goals, 3-point field-goals, passes, and errors) and two variables (defensive and offensive rebounds). A two-step cluster analysis classified the teams as stronger (69 ± 8 winning percentage), intermediate (43 ± 5 winning percentage), and weaker teams (32 ± 5 winning percentage); individual players were classified based on playing time as important players (28 ± 4 min) or less important players (16 ± 4 min). Seasonal variation was analysed monthly in eight periods. A mixed linear model was applied to identify the effects of team quality and playing time within the months of the season on the previously identified factors and game-related statistics. No significant effect of season period was observed. A team quality effect was identified, with stronger teams being superior in terms of 2-point field-goals and passes. The weaker teams were the worst at defensive rebounding (stronger teams: 0.17 ± 0.05; intermediate teams: 0.17 ± 0.06; weaker teams: 0.15 ± 0.03; $P = 0.001$). While playing time was significant in almost all variables, errors were the most important factor when contrasting important and less important players, with fewer errors being made by important players. The trends identified can help coaches and players to create performance profiles according to team quality and playing time. However, these performance profiles appear to be independent of season period.

Keywords: *Team ball sports, principal components analysis, mixed linear models, elite athletes, annual variance*

Introduction

Maintaining high performance during the season is a complex but key target for all team ball sports. Approaches used to investigate the demands placed on players during competition include match and time–motion analyses (Carling, Bloomfield, Nelsen, & Reilly, 2008; Drust, Atkinson, & Reilly, 2007). Basketball match analysis research has shown that winning teams outperform losing teams in shooting field-goals and securing defensive rebounds (Sampaio & Janeira, 2003; Trninić, Dizdar, & Dežman, 2002). These results suggest that the performance of a winning team is aided by increased opportunities to attempt field-goals and by the quality of player decision making and field-goal proficiency within a well-defined strategic and tactical environment. Recently, Ibañez and colleagues (Ibañez, Sampaio, Feu, Lorenzo, & Gomez, 2008) analysed 870 regular season games played between 2000 and 2006 and suggested that, unlike match winners, season-winning teams have enhanced passing and defensive skills. The defensive skills studied were ball steals and blocked field-goals, tasks that depend greatly on players' assertiveness and fitness (Dezman, Trninic, & Dizdar, 2001; Sampaio, Ibanez, Lorenzo, & Gomez, 2006a).

Research on seasonal variation in game-related statistics is limited and related only to fitness variables. Mohr and colleagues (Mohr, Krustrup, & Bangsbo, 2003) reported large seasonal changes in the fitness and physical performance of soccer players during matches, with significant improvements being

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observed during the season. In contrast, Clark and colleagues (Clark, Edwards, Morton, & Butterly, 2008) identified performance changes in physiological variables in mid-season, but a noticeable decline in some indicators towards the end of the competitive season. More specifically, the results available suggest that aerobic performance increases after the training preparation period and may remain relatively constant throughout the rest of the training season (Clark et al., 2008; Metaxas, Sendelides, Koutlianos, & Mandroukas, 2006). Also, researchers have reported within-season similarities in maximal heart rate and maximal oxygen consumption, but differences in speed and heart rate at the anaerobic threshold (Casajús, 2001; Clark et al., 2008).

Although unlike the three substitutions allowed in soccer, the rules of basketball allow for unlimited player substitutions and better control of players' fatigue, seasonal changes are still unknown. Research on this topic is limited to the study of Drinkwater and colleagues (Drinkwater, Hopkins, McKenna, Hunt, & Pyne, 2005), who used mixed modelling of fitness variables to estimate mean changes within and between basketball competitive seasons. Drinkwater et al. assessed aerobic fitness (20-m shuttle run) and power (vertical jump and 20-m sprint), and then categorized the data by the phase of the year (early phase = January–April, middle phase = May–August, late phase = September–December). The resulting effect sizes showed that fitness changes were mostly trivial or small and the authors concluded that there is generally little overall change in mean fitness within and between seasons. Despite these results, it is possible that changes in fitness will have some effect on game technical performance (Lyons, Al-Nakeeb, & Nevill, 2006a, 2006b; Royal et al., 2006). For example, players who feel less fatigued in the season may be able to jump higher and more frequently to improve their rebound statistics; similarly, such players may improve their defensive readiness to commit fewer fouls, or may improve their decision making skills and thus enhance their passing and shooting performances (Dezman et al., 2001; Trninić et al., 2002).

The pattern of seasonal variation in game statistics is likely to depend on team quality, because the best teams will have the best players in enhanced training environments, which will have an impact on game performances. Additionally, there may be an effect of a player's duration on court, also resulting in differences in game performance. From a physiological perspective, Caterisano and colleagues (Caterisano, Patrick, Edenfield, & Batson, 1997) studied the effects of playing time during a basketball season on several fitness parameters and showed that non-starters experienced aerobic detraining throughout the season, unlike starters, who maintained their aerobic capacity. This lack of conditioning could increase fatigue and a fatigued player may, for example, commit more fouls when defending. The results of the one study to investigate differences in basketball game-related statistics between starters and non-starters (Sampaio, Janeira, Ibáñez, & Lorenzo, 2006b) suggested that defensive performances discriminate between players (fouls committed and defensive rebounds). It is possible that starters exhibit a higher conditioning status that leads to a superior jumping ability (and defensive rebounding performance) and a better aerobic capacity (and fewer fouls committed).

The aim of the present study was to identify any within-season differences in basketball players' game-related statistics according to team quality and playing time.

Methods

Sample and variables

Data were collected from all 306 games played by the 18 participating teams in the 2007–2008 regular season of the Asociación de Clubs de Baloncesto (ACB), the Spanish professional basketball league. The game-related statistics recorded were normalized according to a player's time on court and included: 2- and 3-point field-goal attempts (both successful and unsuccessful), free-throws (both successful and unsuccessful), defensive and offensive rebounds, assists, steals, turnovers, and fouls (both committed and received). Inter- and intra-observer reliability scores were above 0.95 and 0.97 respectively for all game-related statistics. Players who participated for less than one-quarter of the season (eight games) or less than half a game period (5 min) were excluded from the sample. The final database contained 5309 records from 198 players.

Dependent variables

A factor analysis using principal components and varimax rotation was performed on the game-related statistics to reduce the dimensions of the analysis. Kaiser-Meyer-Olkin measure of sampling adequacy was adequate (0.78) and the anti-image correlation matrix revealed that all variables were above the acceptable level of 0.5. Analysis of the commonalities revealed defensive and offensive rebounding had values below acceptable levels of 0.5 (0.22 and 0.36 respectively). If the commonality for a variable is less than 50%, the factor solution contains less than half of the variance in the original variable, and thus the explanatory power of that variable might be better represented by the individual variable. The obtained principal components model accounted for 82% of

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the total variance. Five factors were extracted with eigenvalues above 1.0, and a criterion of 0.40 for identifying substantial loadings on factors was used. The extracted factor scores were saved as variables to be used in the data analysis and were named as follows: free-throws, 2-point field-goals, 3-point field-goals, passes, and errors (see Table I).

Independent variables

A two-step cluster with log-likelihood as the distance measure and Schwartz's Bayesian criterion was performed to classify teams according to their quality and to classify players according to playing time. The variables used in team quality classification were points scored, points allowed, and winning percentages. From this analysis, three automatically determined clusters were obtained: stronger teams ($n = 1212$ records from 76 players, seven teams averaging a 69 ± 8 winning percentage), intermediate teams ($n = 2367$ records from 65 players, six teams averaging a 43 ± 5 winning percentage), and weaker teams ($n = 1730$ records from 57 players, five teams averaging a 32 ± 5 winning percentage). The variable used in the playing time classification was minutes played. Two automatically determined clusters resulted from this analysis to categorize players as important ($n = 2451$ records from 196 players, 18 teams averaging 28 ± 4.0 min) or less important ($n = 2858$ records from 191 players, 18 teams averaging 16 ± 3.8 min).

Repeated measurement of fitness variables in professional players can be heavily influenced by participation rates that are compromised by injuries, match commitments, inter-club transfers, and general player availability (Clark et al., 2008). Seasonal changes have been addressed by comparing variables in two (Casajús, 2001), three (Mohr et al., 2003), and four different periods (Metaxas et al., 2006). When analysing game-related statistics from basketball professional leagues, it is possible to gather data from all competitions with high reliability that are available in the public domain. This makes it possible to have up to four records per month. Therefore, the seasonal variation was analysed as follows: first month (average values from games played between round 1 and 4); second month (average values from games played between round 5 and 8); third month (average values from games played between round 9 and 12); fourth month (average values from games played between round 13 and 16); fifth month (average values from games played between round 17 and 21); sixth month (average values from games played between round 22 and 26); seventh month (average values from games played between round 27 and 30); and eighth month (average values from games played between round 31 and 34).

Data analysis

A mixed linear model was applied to identify the main effects and interactions of team quality (stronger, intermediate, weaker), playing time (important, less important), and within-season months (first, second, third, fourth, sixth, seventh, eighth) on the previously identified factors (free-throws, 2-point field-goals, 3-point field-goals, passes, errors) and game-related statistics (defensive and offensive rebounds). Effect sizes were calculated to show the magnitude of the effects. Effect size magnitudes are assessed using the following criteria: <0.20 = trivial, 0.20–0.59 = small, 0.60–1.19 = moderate, 1.20–2.0 = large, and >2.0 = very large (Hopkins, 2002). This statistical technique: (1) allows handling of data where observations are not independent because it correctly models correlated errors; (2) can be more appropriate when handling missing data because it includes incomplete

Table I. Factor loadings, eigenvalues, and variance explained using factor analysis (principal components method)

	Factor				
Variable	1	2	3	4	5
Successful 3-point field-goals	−0.03	−0.10	0.93	0.00	−0.02
Unsuccessful 3-point field-goals	−0.05	−0.20	0.90	0.07	−0.06
Successful 2-point field-goals	0.09	0.92	−0.12	−0.02	0.01
Unsuccessful 2-point field-goals	0.08	0.91	−0.18	−0.04	0.04
Successful free-throws	0.95	0.03	0.00	0.01	0.00
Unsuccessful free-throws	0.96	0.05	−0.04	0.00	0.00
Assists	0.03	−0.19	0.00	0.74	−0.07
Recovered balls	0.04	0.11	0.04	0.68	0.07
Turnovers	0.05	0.00	0.02	0.32	0.71
Fouls committed	0.00	0.04	−0.10	−0.27	0.76
Fouls received	0.84	0.11	−0.04	0.10	0.06
Eigenvalue	2.8	2.1	1.2	1.1	1.0
Variance	28.3	21.2	12.1	10.8	10.3
Designation	Free throws	2-point field-goals	3-point field-goals	Passes	Errors

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cases in the analysis, instead of applying listwise deletion to drop cases with missing values; (3) allows participants to be measured at different points in time; and (4) is asymptotically efficient for both balanced and unbalanced designs, allowing unequal numbers of repeated measurements.

The statistical analyses were performed using Statistica software release 7.0 and statistical significance was set at $P \leq 0.05$.

Results

Table II presents the descriptive results for rebounding performances (defensive and offensive) and for the principal components analysis factors (free-throws, 2-point field-goals, 3-point field-goals, passes, errors) according to team quality, season period, and playing time.

No statistically significant effects or interactions were observed for seasonal period. However, the results of the mixed linear model allowed identification of several statistically significant main effects for team quality and playing time, but only two statistically significant interactions (Table III).

The team quality main effect was identified in all variables with the exception of free-throws, offensive rebounds, and errors (Figure 1, the y-axis represents factor scores from the principal components analysis for the five factors and performance over time for defensive and offensive rebounds). The stronger teams had better values in all variables, followed by the intermediate and then the weaker teams.

A playing time main effect was identified for offensive rebounds, free-throws, 2- and 3-point field-goals, passes, and errors (Figure 2). The important players (long playing times) fared better in all these variables, with the exception of offensive rebounds, than less important players. No differences were observed in defensive rebounding.

The interaction between team quality and playing time was statistically significant for 2-point field-goals and errors (Figure 3 and Figure 4). For 2-point field-goals, no differences were observed between important players (long playing times) between teams. For less important players (shorter playing times), differences were observed between stronger teams and both intermediate and weaker teams. For errors, no differences were observed between less important players on all teams. However, differences were observed between important players on stronger teams versus weaker teams.

Discussion

The aim of this study was to examine within-season differences in game-related statistics of basketball players according to team quality and playing time.

Table II. Descriptive results for rebounding performances (defensive and offensive) and for the principal components analysis factors (free-throws, 2-point field-goals, 3-point field goals, passes, and errors) according to team quality, season period, and playing time

					Principal components analysis (factors scores)				
Variable	Level	N	Defensive rebounds	Offensive rebounds	Free-throws	2-point field-goals	3-point field-goals	Passing	Errors
Team quality	Stronger teams	2096	0.17 ± 0.05	0.08 ± 0.02	−0.03 ± 0.00	0.05 ± 0.01	0.04 ± 0.01	0.08 ± 0.02	−0.02 ± 0.01
	Intermediate teams	1788	0.17 ± 0.06	0.08 ± 0.03	0.03 ± 0.00	−0.04 ± 0.01	0.00 ± 0.01	−0.04 ± 0.01	0.01 ± 0.00
	Weaker teams	1425	0.15 ± 0.03	0.08 ± 0.03	0.01 ± 0.00	−0.03 ± 0.01	−0.05 ± 0.01	−0.06 ± 0.02	0.03 ± 0.01
Season period	First month	624	0.16 ± 0.04	0.08 ± 0.03	−0.04 ± 0.02	0.01 ± 0.00	−0.03 ± 0.01	0.07 ± 0.02	0.05 ± 0.02
	Second month	623	0.16 ± 0.04	0.08 ± 0.03	−0.03 ± 0.01	0.01 ± 0.00	−0.02 ± 0.01	−0.03 ± 0.01	−0.01 ± 0.00
	Third month	638	0.17 ± 0.04	0.08 ± 0.02	0.02 ± 0.01	−0.01 ± 0.00	−0.02 ± 0.01	−0.04 ± 0.01	0.06 ± 0.02
	Fourth month	633	0.17 ± 0.05	0.08 ± 0.03	−0.02 ± 0.01	0.01 ± 0.00	−0.04 ± 0.02	−0.05 ± 0.01	−0.03 ± 0.01
	Fifth month	768	0.17 ± 0.04	0.08 ± 0.02	0.01 ± 0.01	0.02 ± 0.01	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00
	Sixth month	782	0.17 ± 0.04	0.08 ± 0.02	0.03 ± 0.01	−0.02 ± 0.00	0.04 ± 0.01	0.01 ± 0.00	−0.02 ± 0.01
	Seventh month	614	0.17 ± 0.03	0.08 ± 0.01	0.03 ± 0.02	−0.03 ± 0.01	0.03 ± 0.01	0.01 ± 0.00	0.03 ± 0.01
	Eigth month	627	0.17 ± 0.04	0.08 ± 0.01	0.01 ± 0.02	0.04 ± 0.01	0.04 ± 0.00	0.02 ± 0.01	−0.09 ± 0.03
Playing time	Less important players	2451	0.17 ± 0.06	0.08 ± 0.01	−0.09 ± 0.02	−0.12 ± 0.04	−0.11 ± 0.04	−0.11 ± 0.02	0.27 ± 0.06
	Important players	2858	0.17 ± 0.02	0.08 ± 0.02	0.08 ± 0.01	0.10 ± 0.03	0.09 ± 0.02	0.09 ± 0.02	−0.23 ± 0.07

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Table III. Results of the effects of team quality and seasonal period and their interaction on the previously identified factors (principal components analysis, PCA) and other game-related statistics (mixed linear model)

Variable	Effect	*F*	*P*	Effect size
First PCA factor	Team quality	1.31	0.27	—
Free-throws	Seasonal period	0.42	0.89	—
	Playing time	34.07	0.00	0.17
	Team quality × seasonal period	1.49	0.11	—
	Team quality × playing time	1.83	0.16	—
	Seasonal period × playing time	0.86	0.53	—
Second PCA factor	Team quality	5.54	0.00	0.09 (SI); 0.08 (SW)
2-point field-goals	Seasonal period	0.47	0.86	—
	Playing time	71.86	0.00	0.22
	Team quality × seasonal period	0.38	0.98	—
	Team quality × playing time	6.22	0.00	—
	Seasonal period × playing time	0.95	0.46	—
Third PCA factor	Team quality	4.94	0.01	0.09 (SW)
3-point field-goals	Seasonal period	0.43	0.89	—
	Playing time	55.98	0.00	0.20
	Team quality × seasonal period	1.23	0.25	—
	Team quality × playing time	0.43	0.65	—
	Seasonal period × playing time	0.92	0.49	—
Fourth PCA factor	Team quality	9.88	0.00	0.12 (SI); 0.13 (SW)
Passes	Seasonal period	0.98	0.44	—
	Playing time	49.08	0.00	0.21
	Team quality × seasonal period	0.59	0.87	—
	Team quality × playing time	1.68	0.19	—
	Seasonal period × playing time	0.75	0.63	—
Fifth PCA factor	Team quality	2.84	0.06	—
Errors	Seasonal period	1.46	0.18	—
	Playing time	336.12	0.00	0.52
	Team quality × seasonal period	0.79	0.68	—
	Team quality × playing time	5.72	0.00	—
	Seasonal period × playing time	0.38	0.91	—
Defensive rebounds	Team quality	4.57	0.01	0.08 (IW); 0.10 (SW)
	Seasonal period	0.68	0.69	—
	Playing time	0.00	0.97	—
	Team quality × seasonal period	0.73	0.75	—
	Team quality × playing time	0.05	0.95	—
	Seasonal period × playing time	1.09	0.36	—
Offensive rebounds	Team quality	0.95	0.39	—
	Seasonal period	0.35	0.93	—
	Playing time	4.23	0.04	0.06
	Team quality × seasonal period	1.25	0.23	—
	Team quality × playing time	1.49	0.23	—
	Seasonal period × playing time	0.80	0.59	—

Note: SW = statistical significant differences between stronger and weaker teams ($P \leq 0.05$); IW = statistically significant differences between intermediate and weaker teams ($P \leq 0.05$); SI = statistically significant difference between stronger and intermediate teams ($P \leq 0.05$).

Our results indicate that the amount of time a player plays is not only related to scoring (i.e. free throws and field-goal shooting) and passing, but also to errors made. These performance profiles did not vary over the length of the season – that is, no seasonal variation was identified for these high-level basketball performances. Therefore, the present results are in line with those of Drinkwater et al. (2005).

Athletes anecdotally report an accumulation of fatigue over the duration of a competitive season. However, the perception of accumulated fatigue is generally not supported in the fitness testing literature (Koutedaki, 1995). Indeed, previous results from Drinkwater et al. (2005) illustrate that fitness levels in high-performance basketball programmes do not change substantially over the competitive season. If accumulated fatigue over a season were observed, one might also expect that the fatigue would impair performance of technical skills (Gabbett, 2008; Royal et al., 2006) and choice reaction time (Lorist, Kernell, Meijman, & Zijdewind, 2002). However, our results indicate that game-related statistics do not vary significantly

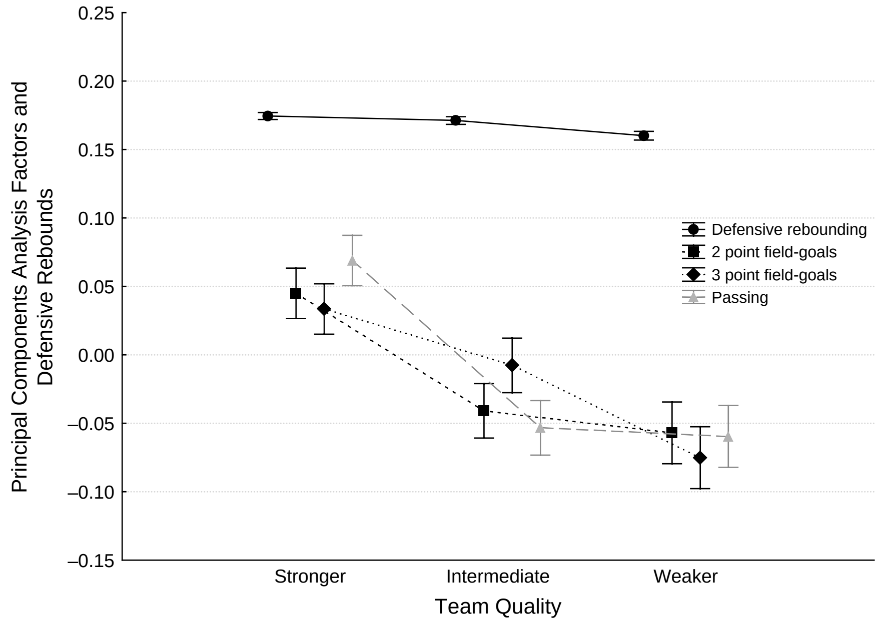

Figure 1. Variation in players' performance of defensive rebounds and principal components analysis factors (2-point field-goals, 3-point field-goals and passing; these results are the factor scores) according to team quality (only the statistically significant results are presented).

by seasonal period. The highest level performers typically are very consistent in their performances across a variety of sports (Hopkins & Hewson, 2001; Stewart & Hopkins, 2000). That we studied high-level performers likely indicates that they were able to maintain consistency in their performance. Since the highest level of performers have the highest fitness (Drinkwater, Hopkins, McKenna, Hunt, & Pyne, 2007), there may be a link between fitness and consistency of performance late in the season.

Our results also indicate that teams that perform the best in the overall standings are the most effective at scoring points, with no differences between intermediate and weaker teams. That stronger teams are the most effective at scoring would is self-evident. What is interesting about our findings is that, while statistically significant, the effect size of both 2- point and 3-point field-goal shooting would be considered "trivial" (i.e. ES <0.10 each). What would normally be considered trivial effect sizes are

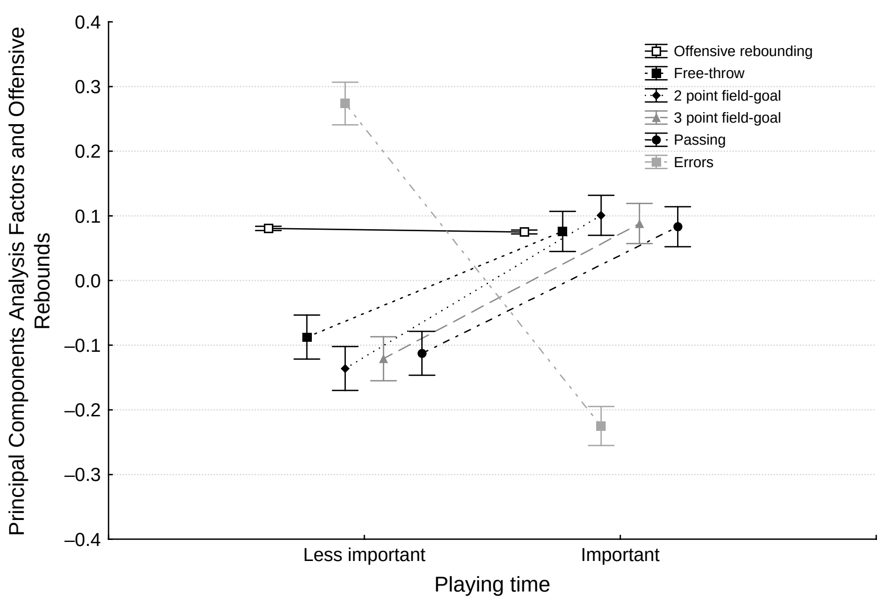

Figure 2. Variation in players' performance of offensive rebounds and principal components analysis factors (free-throws, 2-point field goals, 3-point field goals, passing, and errors; these results are the factor scores) according to playing time (only the statistically significant results are presented).

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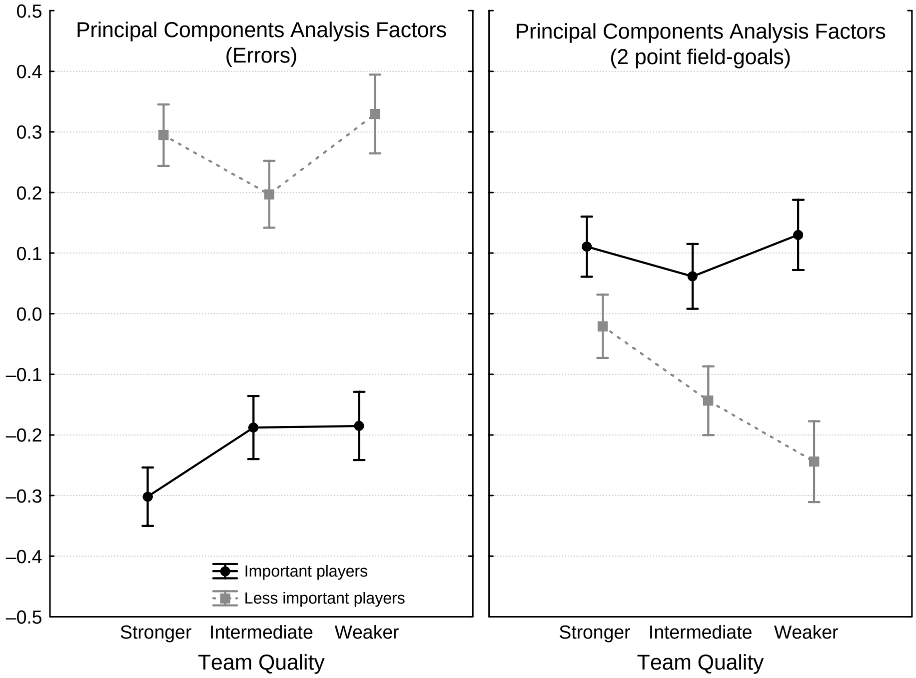

Figure 3. Variation in players' performance of principal components analysis factors (errors and 2-point field-goals; these results are the factor scores) according to team quality and playing time (only the statistically significant results are presented).

interesting here because, in the approximately 1230 games of the 2008–2009 NBA regular season, the average number of points scored per game was 100 ± 13, with an average point difference between the winning and losing teams of just 11 points. With a standard deviation of 13 points, a small Cohen's effect size equates to only 2.5 points, a figure that is accurate considering 14% of games (173 games) were decided by a single 3-point field-goal or less.

Team quality was also related to passes and defensive rebounds. Considering the dominant right-of-way of attacking players, basketball is generally considered an offensively based game. However, the opportunity to stop a team from scoring with defensive pressure (e.g. steals, defensive rebounds) can be a key determinant of success of a team (Trninić, Dizdar, & Dežman, 2000). Thus, while the ability to score is obviously an important

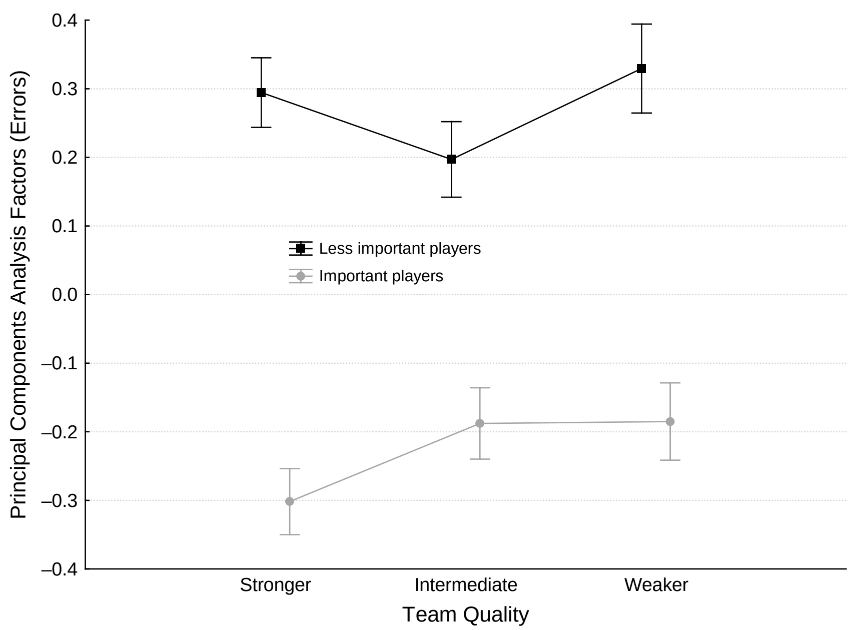

Figure 4. Variation in players' performance of principal components analysis factors (errors; these results are the factor scores) according to team quality and playing time (only the statistically significant results are presented).

determinant of a team's success, coaches should not ignore defensive skills. Another interesting result was that intermediate and weaker teams were only differentiated by defensive rebounds, thus enhancing the importance of this variable. High-level performances in defensive rebounding are associated with: (1) game rhythm, because more defensive rebounds implies more fast-break ball possessions; (2) players' somatotype, as taller and stronger players secure more rebounds; (3) technical and tactical preparation, pivoting, blocking, anticipation, securing, and pulling the ball away; and (4) muscular fitness, particularly in stretch–shortening cycle jumping performances (Sampaio & Janeira, 2003).

Our results also indicate that the most valuable players (i.e. those played most) performed significantly better in all game-related statistics, except in defensive rebounds. Importantly, player quality was inversely related to errors committed (ES = 0.52). Because playing time is decided by coaches, this result may suggest that, deliberately or not, coaches are more aware of errors than any other of the variables analysed. The *F*-ratios were also statistically significant for all forms of scoring and passing, suggesting that all players on a team must be proficient in certain components of the game, specifically scoring (i.e. free-throws and field-goal shooting) and ball possession skills (i.e. passing and errors), whereas such skills as defensive rebounding are roles more often performed by particular players (Drinkwater, Pyne, & McKenna, 2008). With only two members of the team contributing heavily to defensive rebounding (i.e. the "power forward" and the "centre"), defensive rebounding did not contribute in a consistent way to the value of all players. While offensive rebounding did appear statistically significant, the numbers of offensive rebounds is generally much lower and they are taken by a wider variety of player positions.

The interaction between team quality and performance in 2-point field-goals suggests limited differences between important players from all teams, but marked differences between less important players from all teams. This finding is in line with previous results indicating that teams with the best performance records depend more on non-starting players, whereas teams with the worst performance records depend more upon starters (Sampaio et al., 2006b). It is possible that weaker teams are more limited in the quality of bench players and, therefore, these players participate less in the game. Accordingly, differences between important and less important players in 2-point field-goals are minimal, which may help coaches to increase bench players' participation and also improve important players' recuperation. This topic should be addressed in future research.

The results of this study should help coaches and players to better understand how performance profiles change according to team quality and playing time. For example, a weaker team must improve mainly in defensive rebounding, whereas an intermediate team must improve in 2-point field-goals and passing. Also, a less important player could benefit from focusing on committing fewer errors.

Conclusion

There appears to be no seasonal variation in high-level basketball performances. Although offensive plays determine success in basketball, the results of the current study indicate that securing more defensive rebounds and committing fewer errors are also important. Furthermore, the identified trends allow the creation of performance profiles according to team quality and playing time during all seasonal periods. Therefore, basketball coaches (and players) will benefit from being aware of these results, particularly when designing game strategies and when taking tactical decisions.

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