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Running head: Seasonal variation, team quality and playing time in basketball statistics

**EFFECTS OF SEASON PERIOD, TEAM QUALITY AND PLAYING TIME ON
BASKETBALL PLAYERS' GAME RELATED STATISTICS**

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 method was applied to game-related statistics gathered from the official boxscores that reduced the analysis to five factors (free-throws; 2-point field-goals; 3-point field-goals; passing and errors) and two variables (defensive and offensive rebounds). A two step cluster classified teams according to their quality in stronger (ST 69 ± 8 winning percentage), intermediate (IN 43 ± 5 winning percentage) and weaker teams (WK 32 ± 5 winning percentage); individual players were classified based on playing time as important (IMP 28 ± 4 minutes) and less important (LES 16 ± 4 minutes). Seasonal variation was analysed monthly in eight periods. A mixed linear model was applied to identify the main effects and interaction between team quality and playing time within the season months in the previously identified factors and game-related statistics. No significant effect from season period was found. A team quality effect was identified and the stronger teams had higher performances in 2 point field-goals and passing factors. The weaker teams had lower performances in defensive rebounding (ST= 0.17 ± 0.05 ; IN= 0.17 ± 0.06 ; WK= 0.15 ± 0.03 $p=0.001$). While playing time was significant in almost all variables, the errors were the most important factor when contrasting IMP and LES, as expected, with lower values to IMP. The identified trends may help coaches and players by creating performance profiles according to team quality and playing time. However, these performance profiles seem to be independent from the season period.

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

INTRODUCTION

The maintenance of high-levels of performance during a sports season is a complex but key target for all ball team sports. Approaches utilized to investigate the demands placed on players during competition include match and time motion analyses (Drust et al., 2007; Carling et al., 2008). Basketball match analysis research has shown that winning teams outperform losing teams in shooting field-goals and securing defensive rebounds (Sampaio & Janeira 2003; Trninić et al., 2002). These results suggest that the performance of a winning team is supported by increased opportunities to attempt more field-goals and by the quality of player decision making and field-goal proficiency within a well defined strategic and tactical environment. More recently, one study analysed 870 regular season games played between 2000 and 2006 and suggested that, unlike game winners, season winners are teams with enhanced performances in passing and defensive skills (Ibañez et al., 2008). The defensive variables used were the ball steals and the blocked field-goals, which are tasks much dependent upon players' assertiveness and fitness levels (Dezman et al., 2001; Sampaio et al., 2006a).

Available research on seasonal variation in game-related statistics is scarce and only performed with fitness variables. Mohr and collaborators (2003) reported large seasonal changes in the fitness levels and physical performance of soccer players during matches, with significant improvements during the season. However, one study identified performance changes in physiological variables in mid-season while there was a noticeable decline in some indicators towards the end of the competitive season (Clark et al., 2008). 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 et al., 2006). Also, there are 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).

While unlike the three substitutions allowed in soccer, basketball rules allow for unlimited player substitutions and a better control for players fatigue, seasonal changes are still

unknown. Research on this topic is limited to the study of Drinkwater and collaborators (2005) using mixed modelling in fitness variables to estimate mean changes within and between basketball competitive seasons. Fitness testing consisted of assessment of aerobic fitness (20-m shuttle run) and power (vertical jump and 20-m sprint) and were then categorized by the phase of the year (early phase = January-April, middle phase = May-August, or late phase = September-December). The results from the effect sizes allowed verifying 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 may be possible that changes in fitness will have some effect on game technical performance (Lyons et al., 2006a; Lyons et al., 2006b; Royal et al., 2006). For example, a player feeling less fatigued in the season may be able to jump higher and more frequently to improve his rebound statistics; also, the player may improve defensive readiness to commit fewer fouls; or may improve decision making to have better passing and shooting performances (Dezman et al., 2001; Trninić et al., 2002).

Seasonal variation in game statistics is likely to occur differently according to 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 causing differences in game performance. From a physiological perspective, Caterisano and collaborators (1997) studied the effects of playing time during a basketball season on several fitness parameters and have shown 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 on defence. Only one study investigated the differences in basketball game-related statistics between starters and non-starters (Sampaio et al., 2006b), suggesting that defensive performances discriminate between these players (committed fouls and defensive rebounds). This way, it may be possible that starter players exhibit a higher conditioning status and this would lead to a better jumping ability (and defensive rebounding performance) and a better aerobic capacity (and less committed fouls).

Therefore, the aim of the present study was to identify the 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 participant teams in the 2007-2008 regular season from Asociación de Clubs de Baloncesto (ACB), the Spanish professional basketball league. The gathered game-related statistics were normalized according to player's duration on court and included: two and three 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 respectively above 0.95 and 0.97 for all game-related statistics. Players with less participation than one quarter of the season (8 games) or with less than half a game period (5 minutes) were excluded from the sample. The final database contained 5309 records from 198 players.

Dependent variables

A factor analysis with principal components method and varimax rotation was performed with the game-related statistics in order to reduce the dimensions of 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. The analysis of the communalities revealed defensive and offensive rebounding had values below acceptable levels of 0.5 (0.22 and 0.36 respectively). If the communality for a variable is less than 50%, the factor solution contains less than half of the variance in the original variable, thus, the explanatory power of that variable might be better represented by the individual variable. The obtained principal components model accounted for 82% from the total variance. Five factors were extracted with eigenvalues above 1.0 and the criterion of 0.40 for identifying substantial loadings on factors was used. The extracted factor scores were saved as variables to be

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used in the data analysis and were named, respectively: free-throws; 2 point field-goals; 3 point field-goals; passing and errors (see Table 1).

* Table 1*

Independent variables

A two step cluster with log-likelihood as 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 resulted: stronger teams (n=1212 records from 76 players, 7 teams averaging 69 ± 8 winning percentage), intermediate teams (n=2367 records from 65 players, 6 teams averaging 43 ± 5 winning percentage) and weaker teams (n=1730 records from 57 players, 5 teams averaging 32 ± 5 winning percentage). The variable used in playing time classification was minutes played. Two automatically determined clusters resulted from this analysis to categorise players as important (n=2451 records from 196 players, 18 teams averaging 28 ± 4.0 minutes) or less important (n=2858 records from 191 players, 18 teams averaging 16 ± 3.8 minutes).

The repeated measurements 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 (Casajus, 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 fact opens the possibility of having up to four records each 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

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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 eight 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 between team quality (stronger, intermediate, weaker), playing time (important, less important) and within season months (first, second, third, fourth, sixth, seventh, eight) in the previously identified factors (free-throws; 2 point field-goals; 3 point field-goals; passing; errors) and in the game-related statistics (defensive and offensive rebounds). The effect sizes were calculated to show the magnitude of the effects. Magnitudes of effect sizes 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: (i) allows handling data where observations are not independent because it correctly models correlated errors; (ii) can be more appropriate when handling missing data because it will include incomplete cases in the analysis, instead of applying listwise deletion to drop cases with missing values; (iii) allows subjects to be measured at different points in time and (iv) is asymptotically efficient for both unbalanced designs, allowing unequal numbers of repeated measurements. The statistical analyses were performed using Statistica software release 7.0 and significance was set at $P \leq .05$.

RESULTS

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

* Table 2*

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No statistically significant effects or interactions were identified for seasonal period. However, the results from the mixed linear model allowed identifying several statistically significant main effects for team quality and playing time, but only two statistically significant interactions (Table 3).

* Table 3*

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

* Figure 1*

The playing time main effect was identified in offensive rebounding, free-throws, 2 and 3 point field-goals, passing and errors (Figure 2). The players with important playing time had better performances in all these variables, with the exception of offensive rebounds. No differences were found in defensive rebounding.

* Figure 2*

The interaction between team quality and playing time was statistical significant for the 2 point field goals and the errors (Figure 3). In 2 point field goals, no differences were found between players with important playing time between teams. In players with less important playing times the differences were identified between stronger teams versus intermediate and weaker teams. In errors, no differences were found between players with less important playing time in all teams. However, differences were found between players with important playing time in stronger teams versus weaker teams.

* Figure 3*

DISCUSSION

The purpose of this study was to investigate the within season differences in game-related statistics of basketball players according to team quality and playing time. Our results

indicate that the amount of time a player is played is not only related to scoring (i.e. free throws and field goal shooting) or passing, but is most related to the errors. These performance profiles did not vary over the duration of the season, i.e., no seasonal variation was identified for these high-level basketball performances. Therefore, the present study confirms the results by Drinkwater et al. (1995) by using game-related statistics.

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 programs overall do not substantially change over the competitive season. If accumulated fatigue over a season were true, we may also expect that the fatigue would impair performance of technical skills (Royal et al., 2006; Gabbett, 2008) and choice reaction time (Lorist et al., 2002). However, our results indicate that game-related statistics do not significantly vary by seasonal period. The highest level performers typically have very high levels of consistency in their performances across a variety of sports (Hopkins & Hewson, 2001; Stewart & Hopkins, 2000). Considering that we have studied high-level of performers likely indicates that they were able to maintain consistency in their performance. Since the highest level of performers have higher fitness levels (Drinkwater et al., 2007), there may be a link between fitness level and consistency of performance late in the season.

Our results also indicate that teams which perform the best in the overall standings are the most effective at scoring points, with no differences between intermediate and weaker teams. Certainly the statement that stronger teams are the most effective at scoring would be 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 interesting here because, in the approximately 1230 games of the 2008-09 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 an SD of 13, a small Cohen’s *d* equates

to only 2.5 points, a figure that seems accurate considering 14% of games (173 games) were decided by a single three point field-goal or less.

Team quality was also related to passing and defensive rebounding. 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 determiner in the success of a team (Trninić et al., 2000). So, while the ability to score is obviously an important determiner of a team's success, coaches should not ignore defensive skills. An also important result was that intermediate and weaker teams were only differentiated by defensive rebounding and therefore enhancing the importance of this variable. High-level performances in defensive rebounding are associated with i) game rhythm, because more defensive rebounds implies more fast-break ball possessions; ii) players somatic characteristics, taller and stronger players secure more rebounds; iii) technical and tactical preparation, pivoting, blocking, anticipation, securing and pulling the ball away, and, iv) muscular fitness, particularly in stretch shortening-cycle jumping performances (Sampaio & Janeira, 2003).

Results also indicate that most valuable players (i.e. are played the most) performed significantly better in all game-related statistics, except in defensive rebounding. Most dominantly, 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 most aware of errors than any other of the analyzed variables. F-ratios were also statistically significant for all forms of scoring and passing, suggesting that all player 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), while roles such as defensive rebounding are more often performed by particular players (Drinkwater et al., 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 number 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 may suggest smaller differences between important players from all teams, but severe differences between teams in less important players. This finding is confirming previous results indicating that teams with the best performance records depend more upon non-starter players while conversely teams with the worst performance records depend more upon starter players (Sampaio et al., 2006b). It may be speculated that weaker teams are more limited in bench players quality and, therefore these players participate less in the game. Accordingly, differences between important and less important players in 2 point field-goals is quite small and this may help coaches to increase bench players participation and also to improve important players recuperation. This topic should be addressed in further research.

The results from this study may allow coaches and players to better understand the basketball game by inspecting 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 seems to be no seasonal variation in high-level basketball performances. Although there was an importance of the offensive determiners to success in basketball, the results from the current study indicate that securing more defensive rebounds and committing less errors may be much determinant. Also, the identified trends allow creating expectable performance profiles according to team quality and playing time during all seasonal periods. Therefore, basketball coaches (and players) may benefit from being aware of these results, particularly when defining game strategies and when taking the game decisions.

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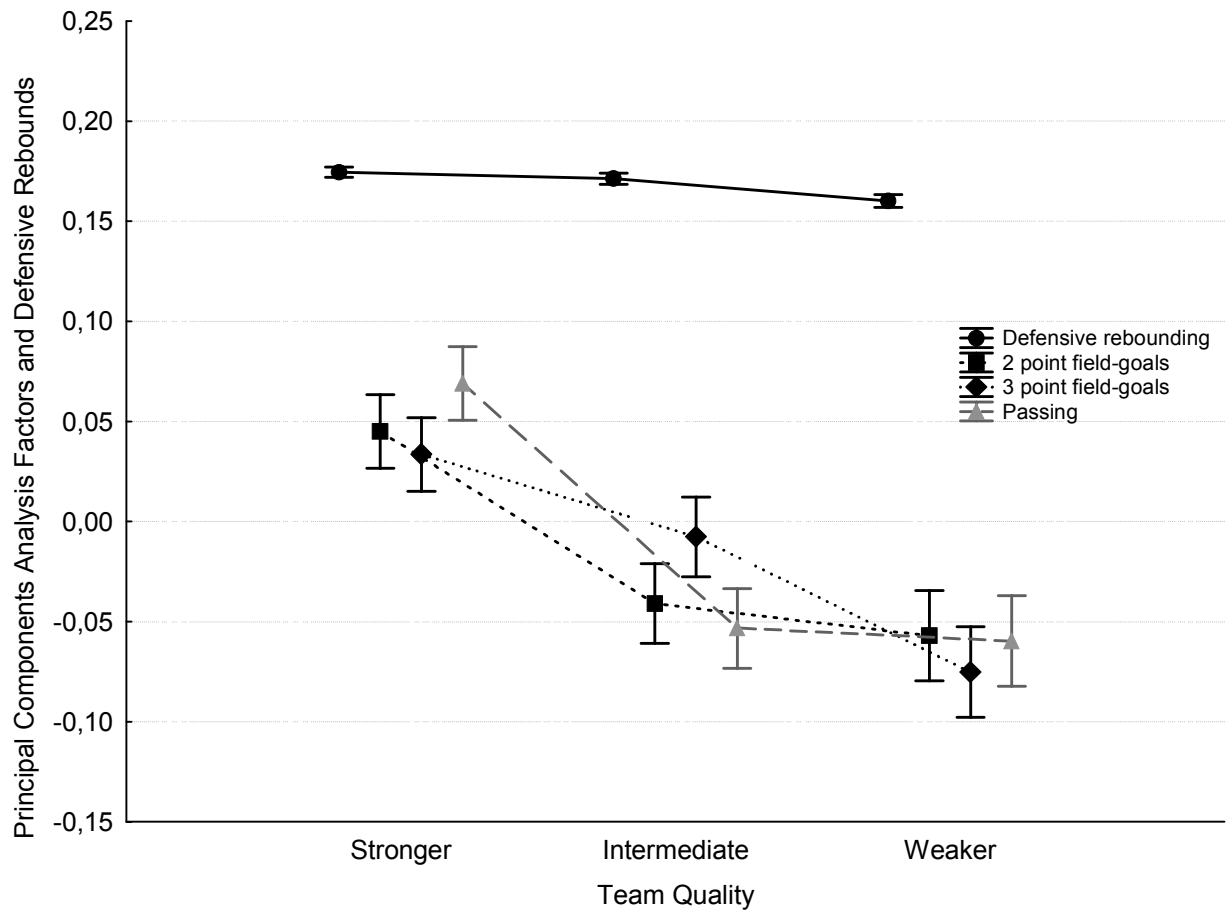


Figure 1. Variation of players' performance in defensive rebounding and principal components analysis factors (2 point field goals, 3 point field goals and passing, these results are the factor scores) according to team quality (only the statistically significant results are presented).

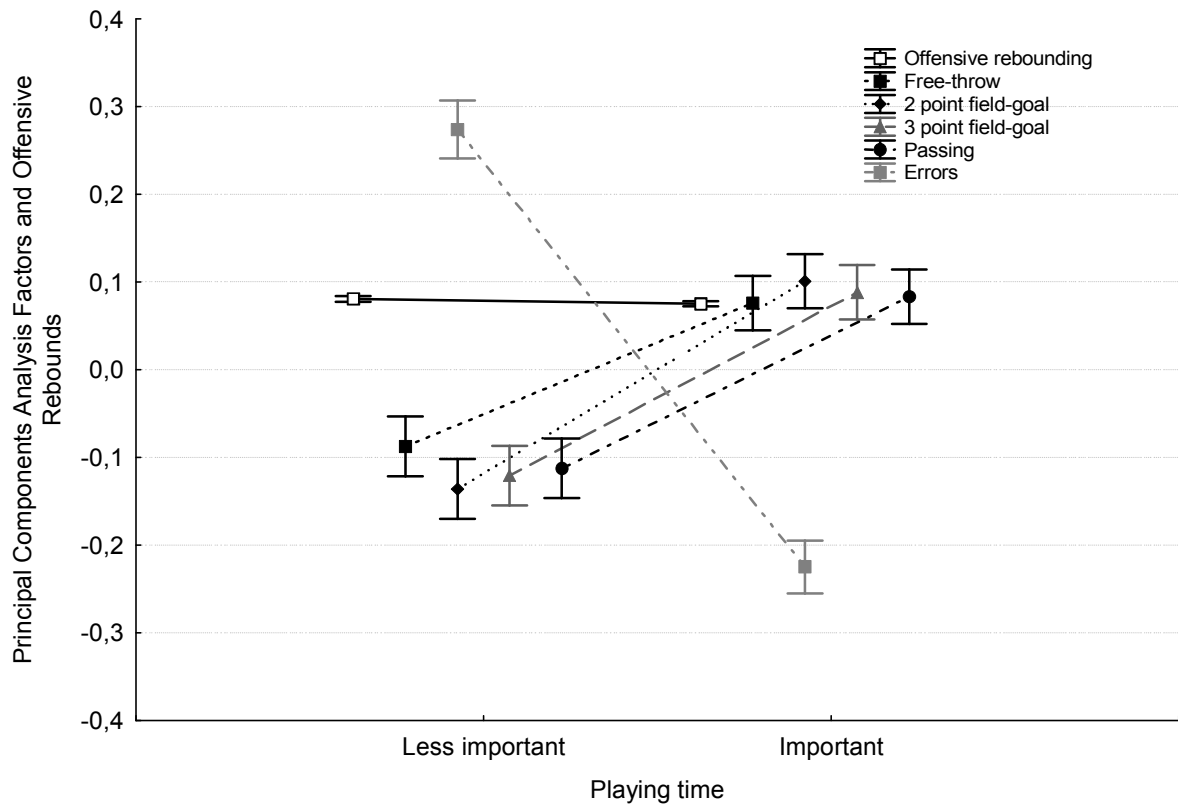


Figure 2. Variation of players' performances in offensive rebounding and principal components analysis factors (free-throws, 2 point field goals, 3 point field goals, passing and errors, these results are the factor scores) according to playing time (only the statistically significant results are presented).

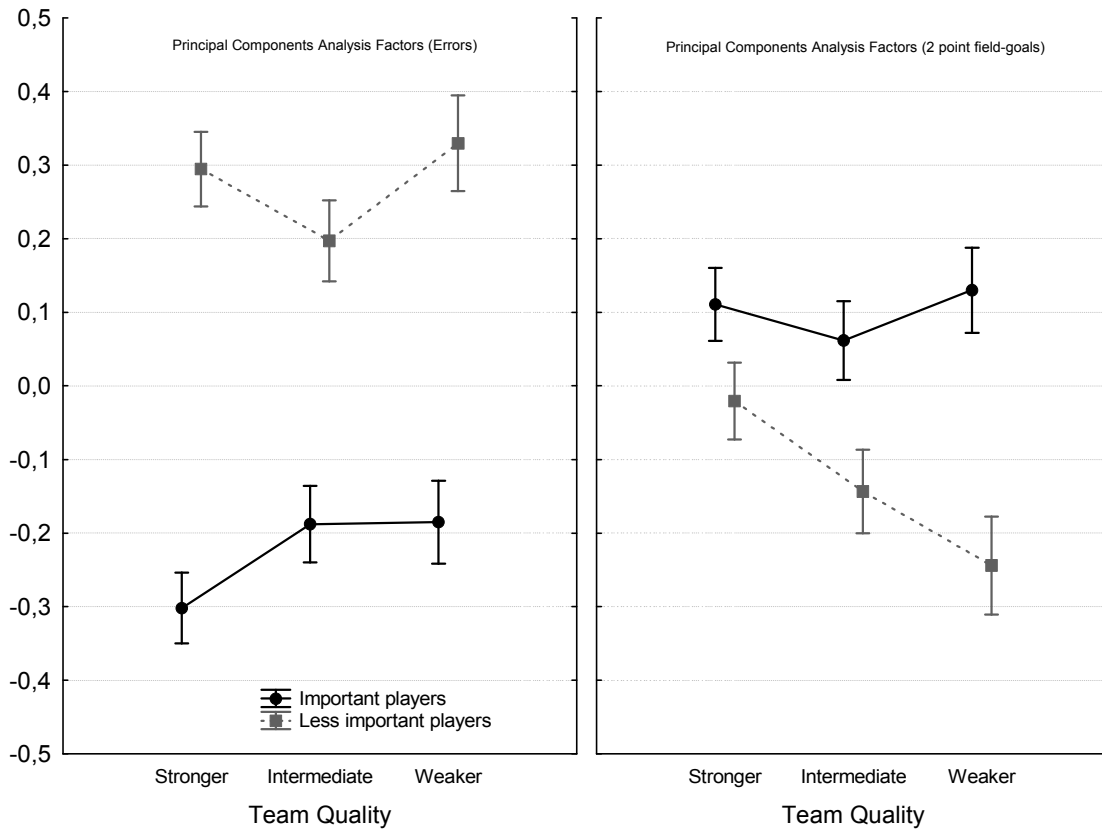


Figure 3. Variation of players' performances in principal components analysis factors (errors and 2 point field-goals, these results are the factor scores) according to team quality and playing time (only the statistically significant results are presented).

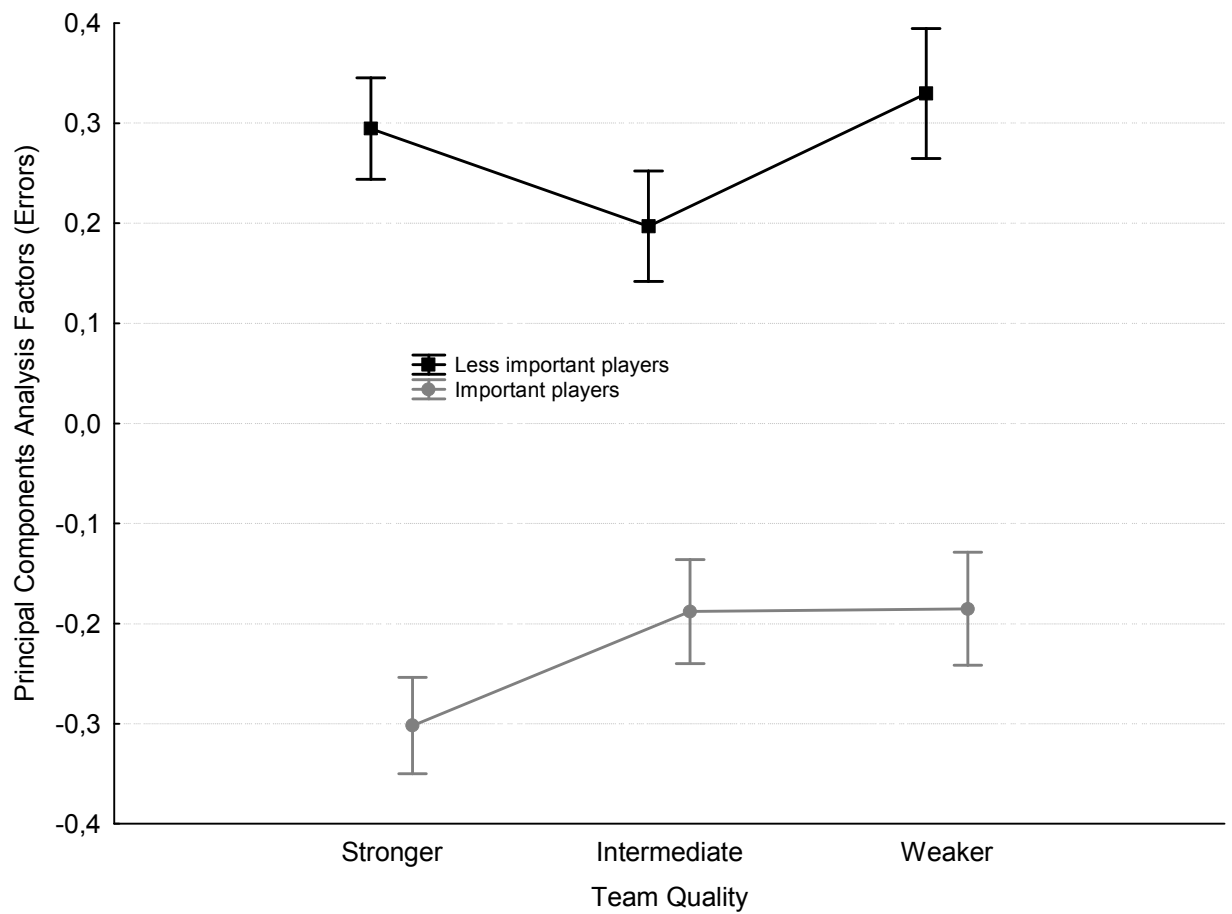


Figure 4. Variation of players' performance in principal components analysis factors (errors, these results are the factor scores) according to team quality and playing time (only the statistically significant results are presented).

WK	Fifth	LES	97	0,05±0,02	0,16±0,09	0,13±0,07	0,28±0,15	0,10±0,08	0,14±0,11	0,18±0,10	0,09±0,05	0,07±0,05	0,07±0,04	0,11±0,05	0,23±0,11	0,16±0,09
WK	Fifth	IMP	115	0,07±0,02	0,19±0,09	0,17±0,06	0,33±0,13	0,13±0,08	0,16±0,10	0,17±0,07	0,07±0,03	0,11±0,04	0,07±0,00	0,12±0,03	0,16±0,03	0,18±0,08
WK	Sixth	LES	88	0,05±0,02	0,12±0,07	0,12±0,07	0,30±0,18	0,15±0,11	0,20±0,16	0,16±0,10	0,09±0,06	0,10±0,08	0,05±0,02	0,12±0,07	0,22±0,10	0,19±0,10
WK	Sixth	IMP	123	0,08±0,01	0,20±0,08	0,17±0,06	0,33±0,12	0,15±0,09	0,20±0,12	0,16±0,07	0,08±0,03	0,12±0,05	0,06±0,00	0,09±0,02	0,17±0,03	0,19±0,07
WK	Seventh	LES	54	0,05±0,02	0,15±0,09	0,10±0,06	0,25±0,12	0,08±0,05	0,10±0,08	0,14±0,07	0,08±0,06	0,11±0,09	0,06±0,03	0,13±0,07	0,23±0,10	0,16±0,07
WK	Seventh	IMP	100	0,07±0,01	0,18±0,07	0,18±0,06	0,34±0,12	0,15±0,08	0,19±0,10	0,16±0,05	0,09±0,04	0,10±0,05	0,07±0,00	0,12±0,02	0,16±0,03	0,19±0,06
WK	Eighth	LES	71	0,06±0,02	0,15±0,09	0,15±0,10	0,29±0,16	0,12±0,11	0,17±0,17	0,16±0,09	0,08±0,05	0,12±0,09	0,07±0,02	0,12±0,06	0,25±0,12	0,17±0,07
WK	Eighth	IMP	97	0,07±0,01	0,19±0,08	0,16±0,05	0,31±0,12	0,14±0,10	0,17±0,12	0,16±0,05	0,07±0,04	0,10±0,04	0,06±0,00	0,09±0,02	0,17±0,03	0,18±0,06