Clustering performances in the NBA according to players' anthropometric attributes and playing experience

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ABSTRACT

The aim of this study was: (i) to group basketball players into similar clusters based on a combination of anthropometric characteristics and playing experience; and (ii) explore the distribution of players (included starters and non-starters) from different levels of teams within the obtained clusters. The game-related statistics from 699 regular season balanced games were analyzed using a two-step cluster model and a discriminant analysis. The clustering process allowed identifying five different player profiles: Top height and weight (HW) with low experience, TopHW-LowE; Middle HW with middle experience, MiddleHW-MiddleE; Middle HW with top experience, MiddleHW-TopE; Low HW with low experience, LowHW-LowE; Low HW with middle experience, LowHW-MiddleE. Discriminant analysis showed that TopHW-LowE group was highlighted by two-point field goals made and missed, offensive and defensive rebounds, blocks, and personal fouls; whereas the LowHW-LowE group made fewest passes and touches. The players from weaker teams were mostly distributed in LowHW-LowE group, whereas players from stronger teams were mainly grouped in LowHW-MiddleE group; and players that participated in the finals were allocated in the MiddleHW-MiddleE group. These results provide alternative references for basketball staff concerning the process of evaluating performance.

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Introduction

The recruitment of basketball players is regarded as a key factor to achieve successful game performances. In the National Basketball Association (NBA), a component of this information may relate to anthropometric attributes and playing experience (Drinkwater, Pyne, & McKenna, 2008; Tarlow, 2012), as identified in available research (Alejandro, Santiago, Gerardo, Carlos, & Vicente, 2015; Popovic et al., 2013; Štirn, Dolinar, & Erčulj, 2016; Tomovic, Batinic, Saranovic, & Antic, 2016; Torres-Unda et al., 2013). Dežman, Trninić, and Dizdar (2001) suggested that the specific-position of basketball players were traditionally determined by their weight and height. Specifically, the tallest and heaviest players tend to play the role of the key positions close to the basket, while smaller players are placed in perimeter positions (Latin, Berg, & Baechle, 1994; Ostojic, Mazic, & Dikic, 2006; Sallet, Perrier, Ferret, Vitelli, & Baverel, 2005). This basic spatial distribution allows the smaller players to move quickly the ball down the court, as the larger and stronger players take advantage of height and weight close to the basket to perform the high efficacy shots during the basketball game (Drinkwater et al., 2008).

Players' experience may be another important factor to be considered in the selection process. Multiple studies have suggested that playing experience is related to performance in team sports (Black, Gabbett, Naughton, & McLean, 2016; Ozmen, 2012; Swann, Keegan, Piggott, &

Crust, 2012; Williams & Ford, 2008). In particular, expert players set more specific goals, selected more technique-oriented strategies, made more strategy attributions, and displayed higher levels of self-efficacy than non-experts and novices (Cleary & Zimmerman, 2001; Kitsantas & Zimmerman, 2010). In addition, research has identified that experts have better performance than novices in using advance visual cues to guide their anticipatory responses (Williams, 1993). Similarly, more experienced soccer referees appeared better at anticipating and reading play and ultimately were more economical with their movements (Weston, Castagna, Impellizzeri, Rampinini, & Breivik, 2010). Some research has also summarized from psychological perspectives that expert players have an advantage over novice players in: i) reading game ability (Livingston, Nacke, & Mandryk, 2011); ii) decision-making ability (Travassos et al., 2013); and iii) anticipation ability (Gabbett & Abernethy, 2013; Rowe, Horswill, Kronvall-Parkinson, Poulter, & McKenna, 2009).

In basketball, previous studies suggest that early sport experiences may affect basketball skill acquisition (Santos, Mateus, Sampaio, & Leite, 2016). The expert players probably have better performances in assists, free throws and three point field goals than novice players (García, Ibáñez, Parejo, Cañadas, & Feu, 2010; Ibáñez, Santos, & García, 2015; Sampaio,

Godoy, & Feu, 2004). Besides, the expert players are better able to deal with both moderate and high intensity fatigue conditions and maintain a higher level of performance (Ibáñez, Feu, García, Parejo, & Cañadas, 2009; Lyons, Al-Nakeeb, & Nevill, 2006; Sampaio et al., 2009). Moreover, Tarlow (2012) suggested postseason experience has a positive impact on a team success in the play-off season. Therefore, the development of technical and physical performance profiles considering anthropometric characteristics and playing experience can help reveal new trends to recruit valuable players. Similarly, it can allow coaching staffs to make well-informed decisions, in particular by using different line-ups combinations in different match-ups.

In addition, the process of selecting players also considers the complementary roles of starter and non-starter players. In fact, when the starter players do not perform as expected, are fatigued or in foul trouble, non-starter players play a key role in maintaining performance levels (Clay & Clay, 2014; Gómez, Silva, Lorenzo, Kreivyte, & Sampaio, 2017; Sampaio et al., 2009). In the NBA, the competitive season imposes a great amount of psychological and physiological stress on players because the typical competitive 82 regular season games over a time span of 5.5 months (2–5 games per week). Considering the length of the basketball season in the NBA, the starters may experience greater accumulated fatigue than those who are not playing so consistently (nonstarters) (Gonzalez et al., 2013). Thus, coaches have to deal with the management of on-court and bench players and anticipate substitutions caused by fatigue, foul trouble, poor performance, defensive changes and critical moments (Clay & Clay, 2014; Gómez, Lorenzo, Ortega, Sampaio, & Ibáñez, 2009; Sampaio, Ibáñez, Lorenzo, & Gómez, 2006).

Based on the above considerations, the aim of the present study was to (i) group basketball players' into similar clusters based on a combination of anthropometric characteristics and playing experience and then identifying a small subset of performance variables that discriminate between the previous clusters; and (ii) explore the distribution of players (included starters and non-starters) from different levels of teams within the obtained clusters.

Methods

Sample and variables

This study used a descriptive design (Thomas, Silverman, & Nelson, 2015).

Archival data were obtained from open-access official NBA records during the 2015–2016 regular season (available at <http://stats.nba.com>). A total of 699 regular season games were selected based on the balance score inclusion criteria with final score differences equal to or less than 10 points. This criteria is based on the available literature that considers this scoring margin as recoverable for any of the confronting teams and, therefore, denoting that the game was not unbalanced to a way that one team was clearly superior to the opponent (Ferreira, Volossovitch, & Sampaio, 2014). The game-related statistics were transformed to per-minute statistics (original statistics/min $\times$ 40) according to players' game duration on the court

(Kubatko, Oliver, Pelton, & Rosenbaum, 2007). The players who played less than 500 minutes in the whole season were excluded from the sample because those players' transformed data were regarded as unreliable per-minute statistics (Kubatko et al., 2007). In addition, the players who played less than five minutes were also excluded from the sample (Sampaio, Janeira, Ibáñez, & Lorenzo, 2006), which finally limited the sample to 354 players with 12,724 performance records (the current sample selected accounts for the 57% of the total sample). The team quality was decided by final team ranking in the NBA league (Sampaio, Lago, Casais, & Leite, 2010). The weaker teams were the ones that only played the regular season stage whereas the stronger teams were the ones that played the play-off season but did not enter the conference finals. The final teams played the conference finals and final.

According to the available literature (Gómez, Lorenzo, Barakat, Ortega, & Palao, 2008; Lorenzo, Gómez, Ortega, Ibáñez, & Sampaio, 2010; Mateus et al., 2015; Sampaio & Janeira, 2003; Zhang et al., 2017), a total of twenty variables were selected for analysis (see Table 1).

In order to test the validity of data sets, a sub-sample of 20 games (final score differences equal to or less than 10 points) was randomly selected and observed by two experienced analysts (basketball coaches with more than 5 years of experience in basketball performance analysis). The results were contrasted with the gathered data in the website and perfect Intra-class Correlation Coefficients (ICC = 1.0) were obtained for free-throws, two and three-pointers (both made and missed), offensive and defensive rebounds, turnovers, steals, blocked shots, personal fouls. For the assists, pass made and touches, the results were lower but still very acceptable (ICC = 0.91). There was a formal approval of all procedures from the Local Institution of Research Review Board.

Statistical analysis

Records were screened for univariate outliers (cases outside the range Mean $\pm$ 3SD) and distribution tested in order to proceed to the inferential analysis (Kerlinger & Pedhazur, 1973). A two-step cluster with log-likelihood as the distances measure and Schwartz's Bayesian criterion was carried out to group basketball players into the different groups (Gómez, Lorenzo, Ibanez, & Sampaio, 2013; Gómez et al., 2017; Mateus et al., 2015; Sampaio, Drinkwater, & Leite, 2010), using experience, weight and height as variables. A descriptive discriminant analysis was conducted to identify which variables best discriminate the previously obtained clusters. Discriminant analysis is robust for these derived rate variables (Norusis & Inc, 2004). Interpretation of the obtained discriminant function was based on examination of structure coefficients greater than |0.30|, which means that variables with higher absolute values were best placed to discriminate between groups (Kerlinger & Pedhazur, 1973). Validation of discriminant models conducted using the leave-one-out method of cross-validation (Norusis & Inc, 2004). Cross-validation analysis evaluated the usefulness of discriminant functions when classifying new data. This method involved generating the discriminant function on all but one of the participants (n-1) and then testing for group membership on that participant. The process was repeated for each participant (n times) and the percentage of

Table 1. Selected game events and variables.

Groups	Events and variables: operational definitions
Anthropometric attributes	Height and Weight
Experience	The player accumulated experience on the court from the first year of entering NBA to the last year of professional career (limited the whole NBA phase)
Technical variables	Two-point field goals made (2PM): The number of two-point field goals that a player or team has successfully made.
	Two-point field goals missed (2PMs): The number of two-point field goals that a player or team has unsuccessfully made.
	Three-point field goals made (3PM): The number of three-point field goals that a player or team has successfully made.
	Three-point field goals missed (3PMs): The number of three-point field goals that a player or team has unsuccessfully made.
	Free Throws made (FTM): The number of free throws that a player or team has successfully made.
	Free Throws missed (FTMs): The number of free throws that a player or team has unsuccessfully made.
	Offensive Rebounds (OREB): The number of rebounds that a player or team has collected while they were on offence.
	Defensive Rebounds (DREB): The number of rebounds that a player or team has collected while they were on defence.
	Assists (AST): An assist occurs when a player completes a pass to a teammate that directly leads to a field goal.
	Turnovers (TOV): A turnover occurs when a player on offense loses the ball to the defence.
	Steals (STL): A steal occurs when a defensive player takes the ball from a player on offence, causing a turnover from offensive players.
	Blocked Shots (BLK): A block occurs when an offensive player attempts a shot, and a defensive player tips the ball, blocking their chance to score.
	Personal Fouls (PF): The total number of fouls that a player has committed.
	Touches (TCHS): The number of times a player touches and possesses the ball during the game.
	Passes Made (PASS): The total number of passes a player made during the game.
Physical variables	Distance Run (DIST): The total distances in miles that a player covered while on the court.
	Average Speed (SPD): The average speed in miles per hour of all movements (standing, walking, jogging, running, and sprinting) by a player while on the court.

correct classifications was taken as the mean for the n trials. Moreover, the distribution of all players (included starters and non-starters) from different levels of teams (included each team in NBA) within obtained cluster groups were performed by separately setting up custom and cross tables using IBM SPSS Statistics for Windows (Armonk, NY: IBM Corp). Statistical significance was set at 0.05.

Results

The two-step cluster analysis allowed obtaining five different groups of players: Top height and weight with low experience (TopHW-LowE); Middle height and weight with middle experience (MiddleHW-MiddleE); Middle height and weight with top experience (MiddleHW-TopE); Low height and weight with low experience (LowHW-LowE); Low height and weight with middle experience (LowHW-MiddleE). Table 2 contains the means and standard deviations from

the variables according to the cluster solutions and the structure coefficients from both functions.

The discriminant analysis revealed three statistically significant functions ($P \leq 0.001$), however, the first two yielded 88.8% of cumulative variance (canonical correlations of 0.80 and 0.51, respectively). The reclassification of the cases in the original groups was moderate (59%). The first function had stronger emphasis on offensive ($SC = 0.63$) and defensive rebounds ($SC = 0.65$), whereas the second function was mainly emphasized by performance obtained in passing-related variables like touches ($SC = -0.82$), passes made ($SC = -0.81$). Additionally, in shooting aspects, three-point field goals made ($SC = -0.41$) and missed ($SC = -0.41$) were emphasized in the function 1, while two-point field goals made ($SC = -0.34$) and missed ($SC = -0.34$) were highlighted in the function 2. Furthermore, blocked shots ($SC = 0.58$), personal fouls ($SC = 0.32$) and turnovers ($SC = -0.45$) were also respectively emphasized in the function 1 and function 2. The assists ($SC_1 = -0.49$; $SC_2 = -0.57$) were the only variable commonly highlighted in both functions.

Discriminant variables from each cluster group

The top height and weight with low experience group (TopHW-LowE) presented highest association with discriminant variables (two-point field goals made and missed, offensive and defensive rebounds, blocks, personal fouls) from both functions. The middle height and weight with middle experience group (MiddleHW-MiddleE) presented lowest association with explained variables (turnovers) from both functions. The middle height and weight with top experience group (MiddleHW-TopE) showed a similar profile as (TopHW-LowE) group. The low height and weight with low experience group (LowHW-LowE) presented lowest association with discriminant variables (passes made and touches). The low height and weight with middle experience group (LowHW-MiddleE) presented highest association with explained variables (three-point field goals made and missed and passing-related variables).

The specific distribution of all players (included starters and non-starters) from different levels of teams within five cluster group (see Table 3)

In general, all players from weaker teams are mainly distributed in the LowHW-LowE group. All players from stronger teams are allocated in the LowHW-MiddleE group while those from final teams are mainly grouped in the MiddleHW-MiddleE group. In addition, starters and non-starters from weaker teams were mostly grouped in the MiddleHW_MiddleE and LowHW_LowE group. Starters and non-starters from stronger teams were mainly grouped in the LowHW_MiddleE group while their counterparts from final teams were mostly grouped in the MiddleHW_MiddleE group. It is worth noting that stronger and final teams tend to put more -bench players from TopHW_LowE group.

Besides, the detailed describe of the proportion of the five cluster groups in each team in the NBA is also presented for descriptive purposes (see Figure 1-3).

Table 2. Descriptive statistics of different performance profiles groupings.

Variables	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Function1 (73.2%)	Function2 (15.6%)
	TopHW-LowE	MiddleHW-MiddleE	MiddleHW-TopE	LowHW-LowE	LowHW-MiddleE		
Height	210.61 ± 3.62	202.73 ± 4.03	204.97 ± 5.27	198.02 ± 4.79	187.72 ± 3.99	-	-
Weight	112.97 ± 6.08	101.74 ± 5.69	106.98 ± 9.04	93.10 ± 5.85	85.28 ± 4.99	-	-
Experience	3.41 ± 2.54	5.98 ± 1.81	12.79 ± 2.47	1.52 ± 1.17	6.63 ± 3.28	-	-
2PM	5.77 ± 1.86	4.33 ± 1.80	4.49 ± 2.19	3.74 ± 1.40	4.23 ± 1.65	0.26	-0.34*
2PMs	5.74 ± 2.18	4.58 ± 1.72	4.95 ± 2.42	4.28 ± 1.52	4.99 ± 1.78	0.13	-0.34*
3PM	0.45 ± 0.75	1.40 ± 0.87	1.10 ± 1.02	1.49 ± 0.69	1.65 ± 0.72	-0.41*	0.23
3PMs	0.98 ± 1.47	2.92 ± 1.66	2.37 ± 2.15	3.11 ± 1.25	3.31 ± 1.36	-0.41*	0.28
FTM	2.74 ± 1.24	2.62 ± 1.57	2.49 ± 1.55	2.14 ± 1.08	2.75 ± 1.68	0.03	-0.21
FTMs	1.19 ± 0.93	0.79 ± 0.40	0.93 ± 0.69	0.72 ± 0.48	0.64 ± 0.36	0.25	-0.12
DREB	7.33 ± 1.72	5.52 ± 1.67	6.00 ± 2.06	4.31 ± 1.34	3.69 ± 0.97	0.65*	-0.11
OREB	2.83 ± 1.00	1.61 ± 1.10	1.74 ± 1.06	1.08 ± 0.66	0.75 ± 0.47	0.63*	-0.19
AST	2.10 ± 1.06	2.87 ± 1.71	2.97 ± 1.25	3.10 ± 1.74	5.59 ± 2.20	-0.49*	-0.57*
BLK	1.31 ± 0.64	0.66 ± 0.43	0.78 ± 0.55	0.50 ± 0.37	0.30 ± 0.23	0.58*	-0.17
STL	0.97 ± 0.46	1.16 ± 0.44	1.06 ± 0.39	1.19 ± 0.44	1.37 ± 0.53	-0.22	-0.07
TOV	2.11 ± 0.65	1.95 ± 0.74	1.99 ± 0.70	1.96 ± 0.78	2.61 ± 0.93	-0.14	-0.45*
PF	4.23 ± 0.91	3.30 ± 0.86	3.69 ± 1.12	3.43 ± 0.95	3.10 ± 0.77	0.32*	-0.12
TCHS	68.88 ± 11.56	63.60 ± 14.28	66.16 ± 12.18	61.81 ± 18.37	85.94 ± 18.39	-0.21	-0.82*
PASS	50.08 ± 9.72	44.75 ± 12.54	47.50 ± 10.51	43.57 ± 16.01	63.66 ± 15.67	-0.19	-0.81*
DIST	2.75 ± 0.14	2.78 ± 0.12	2.67 ± 0.30	2.88 ± 0.10	2.84 ± 0.13	-0.29	0.23
SPD	4.11 ± 0.20	4.16 ± 0.18	4.01 ± 0.19	4.32 ± 0.15	4.25 ± 0.19	-0.29	0.23

Means ± Standard deviations and structure coefficients (SC) of technical and physical performance for five clusters. **Abbreviations:** 2PM = Two-point field goals made; 2PMs = Two-point field goals missed; 3PM = Three-point field goals made; 3PMs = Three-point field goals missed; FTM = Free Throws made; FTMs = Free Throws missed; DREB = Defensive Rebounds; OREB = Offensive Rebounds; AST = Assists; BLK = Blocked Shots; STL = Steals; TOV = Turnovers; PF = Personal Fouls; TCHS = Touches; PASS = Passes Made; DIST = Distance Run (Miles); SPD = Average Speed (MPH).

Table 3. The distribution of all players (included starters and non-starters) from different levels of teams in the five cluster groups.

Player	Team	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
		TopHW-LowE	MiddleHW-MiddleE	MiddleHW-TopE	LowHW-LowE	LowHW-MiddleE
ALL players	Weaker teams	44 (26%)	32 (19%)	14 (8%)	48 (28%)	31 (18%)
	Stronger teams	29 (21%)	31 (23%)	24 (18%)	18 (13%)	35 (26%)
	Final teams	10 (21%)	13 (27%)	8 (17%)	8 (17%)	9 (19%)
Starters	Weaker teams	10 (25%)	11 (28%)	6 (15%)	5 (13%)	8 (20%)
	Stronger teams	7 (17%)	11 (26%)	9 (21%)	2 (5%)	13 (31%)
	Final teams	3 (17%)	6 (33%)	3 (17%)	2 (11%)	4 (22%)
Non-starters	Weaker teams	34 (26%)	21 (16%)	8 (6%)	43 (33%)	23 (18%)
	Stronger teams	22 (23%)	20 (21%)	15 (16%)	16 (17%)	22 (23%)
	Final teams	7 (23%)	7 (23%)	5 (17%)	6 (20%)	5 (17%)

TopHW-LowE: Top height and weight with low experience; MiddleHW-MiddleE: Middle height and weight with middle experience; MiddleHW-TopE: Middle height and weight with top experience; LowHW-LowE: Low height and weight with low experience; LowHW-MiddleE: Low height and weight with middle experience.

Figure 4 presents the territorial map from the cases and created clusters within the space from the first and second discriminant functions. The players from TopHW-LowE group had better performances in explained variables related to function 1.

Discussion

The aim of the present study was to (i) group basketball players' into similar clusters based on a combination of anthropometric characteristics and playing experience and then identifying a small subset of performance variables that discriminate between the previous clusters; and (ii) explore the distribution of players (included starters and non-starters) from different levels of teams within the obtained clusters.

Describing different game performance profiles

The top height and weight with low experience group (TopHW-LowE) presented highest association with discriminant variables (two-point field goals made and missed, offensive and defensive rebounds, blocks, personal fouls) from both functions. The findings of our study are in line with several studies (Erculj and Strumbelj,

2015; Gómez, Gasperi, & Lupo, 2016; Sampaio et al., 2006) suggesting that the tallest and heaviest players are highly specialized in rebounding, blocking and inside shooting, likely because the use of 1 on 1 situations to solve the possessions with players close to the basket is much required. Additionally, players from this group committed more fouls in comparison with other groups. A possible explanation would be that players with lower experience are not able to accurately predict and anticipate the behaviour of the opponents (Aglioni, Cesari, Romani, & Urgesi, 2008), while another possibility would be that tallest and heaviest players often defend 1-on-1 penetrations at the rim, which increases the probability of committing fouls (Koh, John, & Mallett, 2011).

The middle height and weight with middle experience group (MiddleHW-MiddleE) presented lowest association with discriminant variables (turnovers) from both functions. In fact, more experienced athletes are able to correctly assess and respond to a dynamic environment to avoid unforced errors or make mistakes (Mori, Ohtani, & Imanaka, 2002). Additionally, previous research has shown that ideal average playing experience level in the NBA league would be 4.33 seasons for each player because these players who maintain peak performance can have better collective performance and success (Tarlow, 2012).

Weaker teams

Stronger teams

Final teams

Figure 1. TopHW-LowE: Top height and weight with low experience; MiddleHW-MiddleE: Middle height and weight with middle experience; MiddleHW-TopE: Middle height and weight with top experience; LowHW-LowE: Low height and weight with low experience; LowHW-MiddleE: Low height and weight with middle experience. **Note:** The distribution of all players from different levels of teams (included each team in NBA) within five cluster groups.

The middle height and weight with top experience group (MiddleHW-TopE) presented association with discriminant variables (two-point field goals made and missed, offensive and defensive rebounds, blocks, personal fouls) from both functions. This is supported by Ibáñez et al. (2009) believed that the expert players maintain a higher defensive intensity during the game than the inexperienced players and they can select optimal moment and reach a better position in which the defensive pressure is less to shoot through perceiving environmental information and adapting their behaviour accordingly.

The low height and weight with low experience group (LowHW-LowE) presented lowest association with explained variables in passes made, and touches, whereas the low height and weight with middle experience group (LowHW-MiddleE) presented highest association with discriminate variables in passing-related variables. Moreover, players from both groups comprised of point guards or shooting guards with extremely high values in three-point field goals made and missed. In fact, guards play a central role in ball handling and distribution in

the NBA league, especially in game pace control, passing and organizing offensive tactics, and keeping a higher long-range shooting ability (Fewell, Armbruster, Ingraham, Petersen, & Waters, 2012; Gómez et al., 2016; Sampaio et al., 2009). However, our study noticed that despite the super athleticism of NBA players, players with lower height and weight remain the one that prefer to perform offensive tasks in the perimeter position and the abilities of organizing and reading game improved as playing experience increased. Indeed, Sampaio et al. (2004) suggested that passing-related variables discriminated between senior and junior basketball players' performances, which is a measure of playing experience and maturity. Besides, the previous studies showed that younger players lack cooperation with teammates and do not show tactical intention or involvement, mainly watching the other players' performance during the game, due to their self-centred personalities and their limited attention spans (Díaz del Campo, Gonzalez Villora, Garcia Lopez, & Mitchell, 2011). Thus, younger players with low height and weight should

Weaker teams

Stronger teams

Final teams

Figure 2. TopHW-LowE: Top height and weight with low experience; MiddleHW-MiddleE: Middle height and weight with middle experience; MiddleHW-TopE: Middle height and weight with top experience; LowHW-LowE: Low height and weight with low experience; LowHW-MiddleE: Low height and weight with middle experience. **Note:** The distribution of starters from different levels of teams (included each team in NBA) within five cluster groups.

invest enough time to join in collective tactical activities to learn how to create space and explore optimal passing timing to help teammates to score.

The specific distribution of all players (included starters and non-starters) from different levels of teams within five cluster group

In general, all players from weaker teams are distributed in the LowHW-LowE group. All players (included starters and non-starters) from stronger teams are allocated in the LowHW-MiddleE group while their counterparts from final teams are mainly grouped in the MiddleHW-MiddleE group.

All players (especially for non-starter players) from weaker teams are generally distributed in the LowHW-LowE group. Our findings indicated that weaker teams tend to select younger players with low height and weight. In fact, according

to the rule of draft system in the NBA league, the 14 teams (weaker teams) who did not qualify for the Playoffs have priority to select best players, and then the rest of the teams (stronger and final teams) choose in reverse order of the regular season ranking (the team with the best record goes last) (Taylor & Trogon, 2002). However, although NBA draft order appeared to value anthropometric and athletic variables, players with heavier and higher anthropometric characteristics are negatively related to draft status (Moxley & Towne, 2015). Thus, younger players with lower height and weight may be selected preferentially by weaker teams.

In addition, all players (included starters and non-starters) from stronger teams are mostly allocated in the LowHW-MiddleE group, which means that stronger teams tend to select and possess the players (especially for shooting and point guards) with the abilities of the excellent organizing and shooting out of three-point line. In fact, Zhang et al. (2017) demonstrated that players from stronger teams have

Weaker teams

Stronger teams

Final teams

Figure 3. TopHW-LowE: Top height and weight with low experience; MiddleHW-MiddleE: Middle height and weight with middle experience; MiddleHW-TopE: Middle height and weight with top experience; LowHW-LowE: Low height and weight with low experience; LowHW-MiddleE: Low height and weight with middle experience. **Note:** The distribution of non-starters from different levels of teams (included each team in NBA) within five cluster groups.

better performance in terms of three-point field goals than weaker teams in the NBA. Furthermore, Mateus et al. (2015) highlighted that with the development of the modern basketball game, three-point field goals play a key role in team success. Thus, this might be important information for coaches and scouts to select and evaluate players.

Finally, all players (included starters and non-starters) from final teams are mainly grouped in the MiddleHW-MiddleE group, which means that final teams seem to be more willing to select basketball players who make fewer turnovers during game. Indeed, Teramoto and Cross (2010) suggested that the teams that played in the Conference Finals make better shooting efficiency and fewer turnover rates because these factors are particularly related to winning the series in the First Rounds and the Conference Semifinals. Thus, it is necessary to select basketball players making a correct response for complex tactics strategy when setting up the final teams. In addition, it is worth noting that stronger and final teams tend to put more bench players from TopHW_LowE group. It is possible that stronger and final

teams do not give priority to select players, which lead these teams to take the challenge to select and recruit some younger players with taller and heavier physical advantage into bench position in order to secure rebounds in offence and defence and increase inside shooting (Gonzalez et al., 2013; Sampaio et al., 2006; Soebbing & Mason, 2009).

Conclusion

In summary, five different performance profiles were obtained by cluster analysis. TopHW-LowE group highlighted two-point field goals made and missed, offensive and defensive rebounds, blocks, personal fouls; MiddleHW-MiddleE group made fewest turnovers; MiddleHW-TopE group showed a similar profile as TopHW-LowE group; LowHW-LowE group made fewest passes and touches; LowHW-MiddleE group emphasized three-point field goals made and missed and passing-related variables. Furthermore, all players from weaker teams are mostly distributed in the LowHW-LowE group. All players

Figure 4. Territorial map from the cases and classified clusters.

(included starters and non-starters) from stronger teams are allocated in the LowHW-MiddleE group while their counterparts from final teams are mostly grouped in the MiddleHW-MiddleE group. These findings can be used to set up teams and optimize preparation for individual player groupings in order to improve game performances of the players and teams.

Practical applications and limitations

The findings of this study contribute to understanding the influence of players' anthropometric characteristics and playing experience on technical and physical performance. Therefore, the obtained results provide a strong and direct basis to guide both players' recruitment strategies and interventions aimed at improving team rosters in the NBA or even other league.

There are limitations in the current research that should be considered in further studies concerning player's performance profile. Firstly, our study considered playing experience as NBA playing experience, meaning that in the future, the previous years of playing experience in other leagues can also be accounted. Secondly, the criterion of evaluating team quality is based on the final ranking in the NBA league, which might be a criterion of lacking temporal sensitivity, thus, future studies can be developed upon a more longitudinal assessment. Finally, the

current research do not combine with situational variables which means that future studies are supposed to examine the influence of players' anthropometric characteristics and playing experience on technical and physical performance under different situational variables.

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