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Original Article

Exploring interactions between performance and efficiency among junior female basketball players: a canonical analysis approach

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Abstract
One of the most crucial functions for basketball coaches is strategized practice sessions, based on the demands of the competition. The aim of this research was to determine relations of situational performance and efficiency among junior female basketball players. In accordance with the aim, the research was conducted on a sample of 48 female players and each of the players played for more than 8min. per game. They were measured in 6 variables of situational performance and in 12 variables of situational efficiency. Situational performance variables were measured and an average of 3 matches was taken into consideration. There were no great variations of values within each variable of situational performance or situational efficiency considering that this is a elite sample of female participants. Correlation between the first set of variables of situational efficiency and the first factor of the set of variables of situational performance is statistically significant. An insight into the factorial structure of situational efficiency variables led to the conclusion that the extracted factor can be called the factor of general situational efficiency. Using canonical correlation analysis, a statistically significant correlation (CanR=0.912; p=0.047), which provided an in-depth insight into the complex interactions of performance and efficiency of elite basketball female players in competitive conditions, was identified. Study clearly indicated the correlation between the variables of situational efficiency and of situational performance. The results of this study may give coaches important information regarding planning and programming of contemporary technical and tactical as well as training programmes for junior female basketball players.
Key words: Wimu Pro device, training, sports monitoring, final four, elite

Introduction

One of the most crucial functions for basketball coaches is strategized practice sessions, based on the demands of the competition (Lorenzo et al., 2010). Successful performance in basketball, like other team-based sports, is widely attributed to a unique combination of talented and technical, trained physical, tactical, and psychosocial characteristics (Launder & Piltz, 2013). Over the last ten years, studies have examined the requirements of elite players and team performances throughout many dimensions in order to better understand the requirements of basketball match-play (Fort-Vanmeerhaeghe et al., 2016).

The popularity of female team sports has been on the rise, yet there remains a pressing need for these sports to receive equal treatment as their male counterparts. Despite this, a noticeable imbalance persists, with male athletes often receiving more attention even during training sessions. Moreover, the transfer of findings from studies conducted on male athletes to female athletes could lead to inaccuracies (Stanković et al., 2023).

During a basketball game, different movement structures alternate, as well as their intensity, frequency and duration (Gómez-Carmona, Bastida-Castillo, Ibáñez, et al., 2020; A. Heishman et al., 2020; Pero et al., 2020; Valenzuela et al., 2020). Thus, rebounds occur approximately every 60sec., and there is a high frequency of acceleration and short sprints as well as high levels of the load (Heishman et al., 2018; Legg et al., 2017; McInnes et al., 1995). Even though basketball requires sudden and intense changes in the course and direction of movement, as well as high frequencies of initiating dribbling and movements in posture, stoppings and physical touch permitted by the game rules, some authors believes that there is a link between the abilities required to play basketball and the playing positions (Stanković et al., 2022). One of the most commonly used performance outcomes of interest in basketball is each players action in real match situations, which is commonly demonstrated by game related statistics (Ziv et al., 2010). It should be emphasized that the analysis of a performance indicator during a match offers a possibility of an in-depth insight into complexity and dynamics of the game itself (Calleja-González et al., 2016; Vázquez-Guerrero et al., 2020).

The load is made up of two parts: an external load and an interior load. The former denotes a dosage, whereas the latter denotes a reaction (Espasa-Labrador et al., 2021). In the literature, there are three basic

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approaches for monitoring external load: 1) video analysis, 2) location analysis (GPS and LPS, respectively), and 3) accelerometery (in conjunction with additional sensors such as a magnetometer or gyroscope) (Fox et al., 2017). The latter two techniques have sparked the most interest in the employment of wearable devices to estimate external load (Petway et al., 2020). Previous studies (Scanlan et al., 2015, 2019) have investigated basketball's physical demands using video-based movement analysis methodologies based on a subjective visual prediction of sport-specific movement intensity. Advancements in micro-technology have enabled the use of local positioning systems (LPS) to track players indoors, providing greater reliability and validity level than standard GPS systems (Vazquez-Guerrero et al., 2019). Hence, it should be emphasized that the volume and intensity of work were measured with the WIMU Pro device (García-Rubio et al., 2020; Gómez-Carmona, Bastida-Castillo, González-Custodio, et al., 2020; Hernández-Belmonte et al., 2019), which is considered to be a reliable and valid technology for measuring these variables. Likewise, studying the interaction of performance and efficiency among junior female basketball players has been rather rare on samples of elite basketball players (Paulauskas et al., 2019). Monitoring allows coaching staff to study team and player match performances in order to improve the training/match efficiency (Gòmez et al., 2009). In that regard, the aim of the current research is to identify interactions between performance and efficiency among junior female basketball players.

Material and Methods

Participants Sample

A total of 48 junior female basketball players were included during a junior Final Four held in Madrid, Spain. Each of the players played for more than 8min. per game. Players parents were all advised on the research aim and all the participants were informed of having the possibility to withdraw from measurements at any time without any consequences. Likewise, the research protocol was confirmed by the Ethics Committee and the study was fully held in accordance with the Declaration of Helsinki (ref. No. 840/23).

Participants Sample

Situational performance variables were measured and an average of 3 matches was taken into consideration:

1. Distance in meters run at the speed higher than 18km/h (PERF_1);
2. Accelerations during movement (PERF_2);
3. Decelerations during movement (PERF_3);
4. Total number of rebounds in 3 matches (PERF_4);
5. Player load (PERF_5);
6. Minute load (PERF_6);
7. Minutes spent in the game (PERF_7).

For all the players, the observed variables were normalized at the played 1min. PERF_2 and PERF_3 represented an overall number of significant changes in speed per game, whereas PERF_4 was defined by time spent in the air with both feet off the floor for longer than 0.4s. PERF_5 of players represented a vector quantity derived from triaxial accelerometery data which quantifies high-resolution movements. Numerical value greater than 60 represented a heavy load.

Furthermore, the total of 12 variables for assessment of situational efficiency were measured:

1. Free throw percentage (EFFCY_1);
2. 2 point percentage (EFFCY_2);
3. 3 point percentage (EFFCY_3);
4. Points (EFFCY_4);
5. Defensive rebounds (EFFCY_5);
6. Offensive rebounds (EFFCY_6);
7. Rebounds (EFFCY_7);
8. Assists (EFFCY_8);
9. Steals (EFFCY_9);
10. Turnovers (EFFCY_10);
11. Blocks (EFFCY_11);
12. Personal fouls (EFFCY_12).

Measurement Procedure

The observed Final Four Tournament lasted for three days with a rest day between the first and second day. An hour before the start of a match each player was given a WIMU Pro device (Mancha-Triguero et al., 2021; Vazquez-Guerrero et al., 2020; Vázquez-Guerrero et al., 2020), which was used to reliably measure variables of situational performance, and approximately 50min. before the start of a match the teams started warming up. The total of 4 antennas were placed around the court and the entire system was connected through a wireless network with computers with two authorized persons in charge of monitoring the process. The process of taking measurements lasted 90min. On the other side, situational efficiency variables were collected by two basketball experts, from the official match reports and are consider to be valid and reliable.

Statistical Analysis

Following parameters of descriptive statistics were calculated: arithmetic mean, standard deviation, median, minimal and maximal value. The Kolmogorov-Smirnov normality test was used to examine existence of significant deviation from normal distribution. With the aim of identifying the relationship between the variables, canonical correlation analysis was used and the structure of a significant canonical pair was determined (Friman et al., 2007). The type I error was set to 5%. All data were processed using statistical software package Statistica 13.0 (Dell Inc., Tulsa, OK, USA).

Results and discussion

Before conducting canonical correlation analysis, the Kolmogorov-Smirnov normality test was used to examine if data were normally distributed, and it was determined that most variables did not deviate significantly from a normal distribution. Table 1 shows results of descriptive statistics for all the observed variables.

Table 1. Situational performance and situational efficiency variables descriptives

	AS±SD	Med	Min	Max
PERF_1	397.57±150.19	393.01	55.00	781.17
PERF_2	649.96±220.08	623.00	40.67	1086.67
PERF_3	311.51±98.51	303.50	41.67	479.33
PERF_4	83.23±43.27	76.50	15.33	203.50
PERF_5	50.93±17.40	50.96	14.67	85.10
PERF_6	0.58±0.19	0.59	0.17	0.92
PERF_7	20.59±8.12	20.50	8.00	36.30
EFFCY_1	38.00±31.86	42.85	0.00	100.00
EFFCY_2	34.12±20.71	40.00	0.00	75.00
EFFCY_3	24.66±29.80	13.90	0.00	100.00
EFFCY_4	6.49±4.59	5.50	0.00	18.50
EFFCY_5	2.83±1.85	2.52	0.00	6.33
EFFCY_6	1.37±1.34	1.00	0.00	4.33
EFFCY_7	4.21±2.71	3.50	0.00	9.67
EFFCY_8	0.73±0.73	0.67	0.00	2.50
EFFCY_9	1.07±1.02	1.00	0.00	4.00
EFFCY_10	1.53±1.14	1.32	0.00	4.70
EFFCY_11	0.25±0.52	0.00	0.00	2.30
EFFCY_12	1.83±1.16	1.52	0.00	4.00

Legend: AS±SD – arithmetic mean±standard deviation, Med – median, Min – minimal value, Max – maximal value, PERF_1 – distance in meters run at the speed higher than 18 km/h, average from 3 matches, PERF_2 – accelerations (changes in movement rhythm – average from 3 matches), PERF_3 – deceleration (rapid decrease in movement speed/average from 3 matches), PERF_4 – total number of rebounds from 3 matches/average, PERF_5 – player load (total from 3 matches/average), PERF_6 – player load per min/average from 3 matches, PERF_7 – minutes spent in the game/average, EFFCY_1 – free throw percentage/average, EFFCY_2 – 2 point percentage/average, EFFCY_3 – 3 point percentage/average, EFFCY_4 – points/average, EFFCY_5 – defensive rebounds/average, EFFCY_6 – offensive rebounds/average, EFFCY_7 – rebounds/average, EFFCY_8 – assists/average, EFFCY_9 – steals/average, EFFCY_10 – turnovers/average, EFFCY_11 – blocks/average, EFFCY_12 – personal fouls/average

Table 1 shows that this is an elite sample and it can be identified that there were no great variations of values within each variable of situational performance or situational efficiency. As it can be seen from the average calculated for 3 matches, female players run 395.57m at a speed higher than 18km/h, which indicates players relatively low dynamics of the game and thus provides great opportunities for progress in this element of the game. Indications of the obtained values have been found in the previous studies of the mentioned area. When referring to acceleration, it is the number of changes in rhythm during movement while playing which represents one of major prerequisites for creating spatial advantages and starting one's own shot, the average value (AS=649.96), in comparison to the previous studies, represents a good value (Bredt et al., 2018; Lamas et al., 2015; Okubo & Hubbard, 2006). However, there is the question of methods and conditions for measuring them and thus for drawing conclusions.

The average number of rebounds of 83.23 in three matches is in conformity with the previous studies on senior men's basketball, even though the game rules were rather different at the time, which indicates the necessity of analysing external loads according to new rules rather than for those drawn for junior women's population (Conte et al., 2019; Kondo & Someya, 2016; Miura et al., 2010).

When talking about variables for assessment of situational efficiency, it should be pointed out that the obtained values range within the framework of values obtained from the previous studies on women's and men's junior basketball players (Gasperi et al., 2020; Portes et al., 2020). The exception is variable which indicates a very low percentage of free throws scored by shooting from the free throw line of only 38%, so this is certainly an aspect of the game to which the coaches of the analysed teams should adequately devote significant time during the training process. This is because a throw scored by shooting from the free throw line amounts to approximately 20% of the total points scored in a basketball game (García et al., 2013; Gómez et al., 2018; Kozar et al., 1994) and is therefore an extremely important factor in the success achieved by teams in a basketball game.

Table 2 shows values resulted from testing the statistical significance of canonical correlations of the observed variables.

Table 2. Results of canonical correlation analysis:

	Factor 1		Factor 2
PERF_1	0.727	**EFFCY_1**	0.544
PERF_2	0.637	**EFFCY_2**	0.006
PERF_3	0.777	**EFFCY_3**	-0.211
PERF_4	0.640	**EFFCY_4**	0.516
PERF_5	0.959	**EFFCY_5**	0.532
PERF_6	0.933	**EFFCY_6**	0.284
PERF_7	0.892	**EFFCY_7**	0.504
		EFFCY_8	0.588
		EFFCY_9	0.497
		EFFCY_10	0.585
		EFFCY_11	0.129
		EFFCY_12	0.160
CanR=0.912; $CanR^2$=0.832; $\chi^2(84)$=106.9; p=0.047			

Legend: CanR – coefficient of canonical correlation, $CanR^2$ – coefficient of canonical determination, df – degrees of freedom, p – statistical significance level, PERF_1 – distance in meters run at the speed higher than 18 km/h, average from 3 matches, PERF_2 – accelerations (changes in movement rhythm – average from 3 matches), PERF_3 – deceleration (rapid decrease in movement speed/average from 3 matches), PERF_4 – total number of rebounds from 3 matches/average, PERF_5 – player load (total from 3 matches/average), PERF_6 – player load per min/average from 3 matches, PERF_7 – minutes spent in the game/average, EFFCY_1 – free throw percentage/average, EFFCY_2 – 2 point percentage/average, EFFCY_3 – 3 point percentage/average, EFFCY_4 – points/average, EFFCY_5 – defensive rebounds/average, EFFCY_6 – offensive rebounds/average, EFFCY_7 – rebounds/average, EFFCY_8 – assists/average, EFFCY_9 – steals/average, EFFCY_10 – turnovers/average, EFFCY_11 – blocks/average, EFFCY_12 – personal fouls/average

As it can be seen from Table 2, only correlation between the first set of variables of situational efficiency and the first factor of the set of variables of situational performance is statistically significant. Considering only the first canonical pair is statistically significant, only the factorial structure of Factor 1 should be interpreted. Furthermore, it can be seen that only the variables of situational performance of the first root indicate an interpretable significance. Since all factors have a numerical value greater than 0.6, the factor can be called the factor of *general situational performance*.

An insight into the factorial structure of situational efficiency variables led to the conclusion that the extracted factor can be called the factor of *general situational efficiency*. This unequivocally identifies and confirms the correlation between situational efficiency variables and situational performance variables (Tyler et al., 2020). Although a large number of factors affects the success of the basketball game, it is certain that one part of the variance of the overall success on the impact on situational efficiency in basketball, can be explained by the analysed set of variables of situational performance.

This study provides three main strengths. First, this study was conducted during a junior Final Four Tournament, as one of the most elite competitions in this sport. Second are hard to access elite participant sample, whereas the third is concerning practical applicability of the WIMU Pro device in basketball. But on the other hand, this study has some limitations. Although there were insufficient number of analysed matches, this is less than what most tournaments encounter throughout the course of a regular season. Likewise, the fatigue influence during tournament may be influential factor on results obtained in this study.

Conclusion

Variables used in the study show that this is an elite sample with no considerable variations in resulting values within each of the variables of situational performance and situational efficiency. Furthermore, the study clearly indicated the correlation between the variables of situational efficiency and variables of situational performance, whereas canonical correlation analysis confirmed that the parameters of situational efficiency correlated with the parameters of situational performance.

The results of this research can provide expert coaches with important guidelines in planning and programming contemporary training programmes. Given that basketball is a multi-structural and complex sport, the authors believe that it must be approached in an adequate way. One of concrete, measurable and objective factors representing part of the variance of an overall success in basketball, is addressed in this paper. However, in order to allocate them with the use value, the key moment would be to repeat the measurements of this type in following seasons, especially in finals of the European Championship for juniors, which would further provide modal values of the measured parameters. Currently, the study results will be used to obtain certain figures that will be only the initial indicator of the value of the measured variables. The study results will make a new contribution in the near future in the optimization of basketball training, based primarily on the functionalrunning component. Furthermore, the practical significance is reflected in the performance of the implemented and demonstrated protocols in the daily evaluation of training sessions and competitions, and in accordance with their planning and programming.

Declaration of competing interest

The authors declare no conflicts of interest or funding associated with this manuscript.

Ethics approval statement

This study was approved by the Human Research Ethics Committee University of Novi Pazar and followed the Helsinki Declaration guidelines. Before participating in the study, players and their parents/guardians signed informed consent.

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