ELITE BASKETBALL GAME EXTERNAL LOAD VARIES BETWEEN DIFFERENT TEAMS AND COMPETITION

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Original scientific paper
DOI 10.26582/k.56.1.12

Abstract:

Understanding the external load demands of basketball games is fundamental information for training planning and programming. However, there is a scarcity of information about external load during official games at high-level basketball. The purpose of this research was to investigate basketball game external load differences between two elite basketball teams involved in separate competitions. External load demands experienced by forty-six elite basketball players (from two teams) were analyzed using inertial devices during official basketball games. External load was expressed with calculated (PlayerLoad, PL, averaged and in different time epochs) and inertial movement analysis variables (acceleration, deceleration, change of direction and jump). The results showed that the Euroleague team had a higher peak PL in epochs of 30-s ($p<.001$) and 60-s ($p=.02$) with moderate and small effect sizes compared to the Eurocup team. The Eurocup team had a significantly higher number of low and moderate accelerations and changes of direction with effect sizes from 0.34 to 1.15. In conclusion, external load demands in basketball vary depending on the team and league therefore practitioners should consider the specific level and style of play when comprising a training plan. Furthermore, practitioners should rely on their own team's external load values for training load management, rather than attempting to adhere to standards established by external sources.

Keywords: *team sport, workload, inertial technology, physical load management*

Introduction

Basketball is a popular indoor sport in which players engage in high-intensity intermittent activities such as jumping, sprinting, changes of direction, interspersed with periods of low-intensity walking, standing, jogging and moderate-intensity running (Stojanović, et al., 2018). Monitoring game demands in team sports has long been the subject of investigation for scientists and practitioners (Torres-Ronda, Beanland, Whitehead, Sweeting, & Clubb, 2022). Basketball differs from other team sports in the way that is not played with a running clock; from the perspective of performance, coaches perceive this fact both as advantageous and disadvantageous—namely, basketball game extensity is more predictable in terms of active play, but not so much when it comes to the gross time of the game (García, et al., 2022).

The physical demands of the game can be assessed from two perspectives: external and internal (Gamonales, Hernández-Beltrán, Escudero-Tena, & Ibáñez, 2023). External load refers to physical exposure of players to the game itself (acceleration, deceleration, change of direction, etc.), and internal load refers to the physiological reaction to that exposure (heart rate, perceived exertion, blood markers, etc.) (Impellizzeri, et al., 2023). Numerous studies have used various methods to measure the external load of basketball games, including manual video analysis of movement patterns (McInnes, Carlson, Jones, & McKenna, 1995), semi-automated video analysis (Klusemann, Pyne, Hopkins, & Drinkwater, 2013), and accelerometers (Fox, Conte, Stanton, McLean, & Scanlan, 2021). These mentioned methods have been used for purpose of developing more efficient basketball training programs (Schelling & Torres-Ronda, 2013). The literature reports the existence of codependence between the internal (heart rate and sRPE) and external (total player load; PL) load in basketball (Helwig, et al., 2023).

Inertial device technology plays a major part in understanding the physical demands of basketball games. Development of technology and inertial device variables enabled more in-depth understanding of game and training performance (Russell, McLean, Stolp, Strack, & Coutts, 2021). Understanding the nature and requirements of basketball games is a starting point for building sport- and position-specific training and rehabilitation programs (Stojanović, et al., 2018). Previous research implied the need of official game analysis to better understand specific needs of basketball game for the purpose of constructing improved small-sided games that replicate basketball game demands (Svilar & Jukić, 2018). Inertial device technology is still relatively new to the sport, so many federations still prohibit wearing them during official games (i.e., NBA—*National Basketball Association*, Euroleague, FIBA—*Fédération Internationale de Basketball*). That led to a scarce amount of research that investigated physical demands of official basketball games. To the authors' knowledge only a few studies examined external load demands in official basketball game; short summary of which and the current literature can be found in paragraphs to follow.

Traditionally, when using inertial device technology, most of the previous researches that quantified basketball game's external load used average load metrics (Helwig, et al., 2023). More specifically, PL was suggested as one of the key variables to quantify external load (Bredt, Chagas, Peixoto, Menzel, & Andrade, 2020). Various articles reported that there was a difference in game demands between different playing positions (Portes, Jiménez, Navarro, Scanlan, & Gómez, 2020; Salazar, Castellano, & Svilar, 2020; Salazar, Jukić, Castellano, & Svilar, 2020; Vázquez-Guerrero, Suarez-Arrones, Gómez, & Rodas, 2018). Previous research that monitored training and game external and internal load during an entire season at the semi-professional level, found that external and internal load had better association during training sessions than during games (Fox, O'Grady, & Scanlan, 2020). This could be explained by the influence of cognitive and mental load and fatigue on internal load (Coyne, Gregory Haff, Coutts, Newton, & Nimphius, 2018). Furthermore, the same study showed that the number of high intensity changes of direction was the best predictor of fatigue after training sessions and games (Fox, et al., 2020). Recent experiments pointed that physical demands are higher during games than practices, and that pre- and in-season training sessions cannot replicate demands of games, which the authors explained with the influence of frequency of coaches' oral information input during practices (Alonso Pérez-Chao, et al., 2022).

Later studies that quantified elite basketball games implied that external load quantified with rolling averages over various time epochs (commonly known as "most demanding scenarios"), in contrast to average values, more accurately described external demands of basketball game (Salazar, Garcia, Svilar, & Castellano, 2021). Previous research has established, when comparing most demanding scenarios of various elite sports (handball, football, basketball, rink hockey, and futsal), that basketball has the highest number of peak acceleration and deceleration values (García, et al., 2022). This could be due to the fact that many previous researches trying to measure the load of basketball game took either a total or an average load as the main metric without separating low, medium and high intensities (Fox, et al., 2020; Russell, McLean, Impellizzeri, Strack, & Coutts, 2021). Furthermore, previous research showed that the intensity depicted with the most demanding scenarios gradually decreased with passing quarters in contrast to the average load metrics (García, et al., 2022). This is in line with previous research that was conducted at the semi-professional level and with average external load metrics (Scanlan, et al., 2019). Additionally, when these various intensities were prescribed to certain activities during the game, it was identified that movements without a ball was more intense than the ones with the ball (Pernigoni, Ferioli, Butautas, La Torre, & Conte, 2021).

Most basketball federations still prohibit wearing sensors during official games, therefore most researches on external load in basketball was made during practices (O'Grady, Fox, Dalbo, & Scanlan, 2020). Research suggests that basketball training rarely mimics the external load of games (Petway, Freitas, Calleja-González, Leal, & Alcaraz, 2020) and that there is weak relationship between internal and external loads during games compared to training sessions (Fox, et al., 2020). Researchers that have analyzed game demands did it at various levels of basketball, including junior level, national and international senior level as well as the National Basketball Association level, but to the best of our knowledge, there are no previous investigations that examined differences in load demands between different elite basketball leagues and levels (Alonso Pérez-Chao, et al., 2022; Garcia, Salazar, & Fox, 2022; Russell, McLean, Stolp, et al., 2021). That puts the scientific and sport performance community in take that all styles and levels of elite basketball game have same physical demands, which has not been previously proven.

Based on the previous facts, the aim of this article was to analyze differences in game physical demands on two different basketball teams that compete in different European competitions—ABA (*Adriatic Basketball Association*)/Eurocup and ACB (*Asociación de Clubes de Baloncesto)*/Euroleague. All the competitions are played under the same rules, so it is hypothesized that there will be no significant differences in game physical demands between the two teams.

Methods

Design

The study employed an observational, longitudinal design to investigate player participation during games across the seasons spanning from 2018 to 2023. Over this timeframe each team played an average of two games per week from October to June. All players enrolled in the study were ensured a minimum playing time of five minutes per monitored game. Games were scheduled between Tuesday and Friday for Eurocup and Euroleague fixtures, while domestic leagues were typically held on weekends. A total of 32 games from domestic competitions were monitored from the Eurocup and 18 for the Euroleague team, each adhering to FIBA basketball regulations, featuring four 10-minute quarters.

Participants

Forty-six elite male basketball players from two European teams volunteered to participate in this study. On one hand, sixteen players were from a Eurocup team (age: 27.8±3.5 years; height: 198.1±10.4 cm; body mass: 97.4±11.6 kg), a second-tier European basketball competition and competing in ABA League as a domestic competition. On the other hand, thirty players from a Euroleague team (age: 26.3±2.5 years; height: 201.1±9.0 cm; body mass: 100.3±8.3 kg), main European basketball competition, and play ACB league as a domestic competition. All the players and both clubs agreed to participate by giving their written consent after being informed about the purpose of the investigation, the research protocol, and requirements, as well as the benefits and risks associated with the study. In accordance with the Declaration of Helsinki (Harriss, MacSween, & Atkinson, 2019), all the data were analyzed anonymously and with the approval of the ethics committee of the University of Basque Country (UPV/EHU) (M10_2018_027).

Procedures and instruments

External load parameters were monitored by inertial devices (t6; Catapult, Innovations, Melbourne, Australia). Present inertial devices included an accelerometer, gyroscope, and magnetometer, with a recording frequency of 100-Hz, which had been previously validated and used in previous research describing basketball external load demands (Fox, et al., 2021; Salazar, et al., 2021; Scanlan, et al., 2021). Before each game, devices were placed in neoprene vests for secure attachment between the scapulae of each player and worn underneath regular sporting attire. Consistent with previous research in basketball, all warm-up activities and game breaks were excluded from data analyses (Fox, Stanton, & Scanlan, 2018). After the game, data were downloaded for analyses using the company-specific software (OpenField v8, Catapult Innovations, Melbourne, Australia) and finally exported to a customize Microsoft Excel spreadsheet. (v15, Microsoft Corporation, Redmond, USA).

Variables

PlayerLoad (PL), peak PL and inertial movement analysis (IMA) variables were chosen to describe external load demands during the games. PL was calculated as the square root of the sum of the squared rate of change in acceleration across each movement plane multiplied by a scaling factor of 0.01 and relativized by playing time ($AU·min^{-1}$) using the current formula:

PlayerLoad™=[√((〚fwd〛_(t=i+1)-〚fwd〛_(t=i))^2)+√(〚side〛_(t=i+1)-〚side〛_(t=i))^2+√(〚up〛_(t=i+1)-〚up〛_(t=i))^2]/100. (Brown & Greig, 2015)

Accumulated PL in different intensity PL bands were also recorded and used cut-points predefined by manufacturer for band 2 and band 3 (Montgomery, Pyne, & Minahan, 2010). To determine peak PL intensity during games, the moving average method was calculated for PL across three-time epochs: 30-s, 60-s, and 180-s. For each game, the highest intensity obtained by each player for each sample duration was determined. Additionally, IMA variables were also recorded using inertial devices and were determined based on the direction of the movement performed. Specifically, accelerations (ACC) (-45° to 45° direction), decelerations (DEC) (-135° to 135° direction), changes of direction (COD) (-135° to -45° direction for left and 45° to 135°direction for right) and jumps were monitored. All IMA variables were reported as a frequency and relative (AU·min-1) to playing time in three intensity zones: low (<2 m·s-2 for ACC, DEC, COD and <20 cm for jumps), medium (2-3 m·s-2 for ACC, DEC, COD and 20-40 cm for jumps) and high (>3 m·s-2 for ACC, DEC and COD, and >40 cm for jumps).

Statistical analysis

External load variables were calculated as mean ± standard deviation (SD). Before further analysis, data normality and sphericity were supported using the Shapiro-Wilk statistics and Levene's test for equality of variances. Independent sample *t*-tests were conducted to compare physical demands from both leagues. Effect sizes (ES) were calculated to quantify the magnitude of differences in each variable between leagues. ES were interpreted as: trivial, <0.20; small, 0.20-0.59; moderate, 0.60-1.19; large, 1.20-1.99; and very large, ≥2.00 (Hopkins, Marshall, Batterham, & Hanin, 2009). The level of significance was set at p<.05. The statistical analysis was conducted using the software jamovi 2.3 (The jamovi project, 2022) for Windows.

Results

Comparison of IMA variables between the Eurocup and Euroleague players are presented in Table 1. The Eurocup players experienced significantly higher IMA accel low (p<.001, *small*) and medium (p<.001, *small*), IMA cod left low (p<.001, *large*) and medium (p<.001, *moderate*), IMA cod right low (p<.001, *large*), medium (p<.001, *moderate*) and high (p =.043, *trivial*). In contrast, the Euroleague players had higher PL (p<.001, *large*), PL band 2 (p<.001, *very large*), PL band 3 (p<.001, *large*), IMA jump low (p<.001, *small*) and medium (p<.001, *moderate*).

Figure 1 shows comparisons in peak PL across the three time epochs in the Eurocup and Euroleague players. Significant differences were found in peak PL for 30-s (p<.001, *moderate*) and 60-s (p=.02, *small*) time epoch, with higher values exhibited by the Euroleague players.

Discussion and conclusions

The aim of this study was to compare physical demands on two different teams playing at different levels using the same inertial devices. Notably, there are no previous studies that have investigated differences in external load between two elite basketball teams playing separate competitions. The main findings underscore that ACB/Euroleague competitions impose higher physical demands, as expressed in summarized variables like PL and the most demanding scenarios in epochs of 30 and 60 seconds. Understanding the external load is crucial for optimizing training strategies and player performance. Therefore, it is recommended that training staff and players carefully analyze the external load to tailor training programs effectively and enhance players' readiness and performance on the court.

PL variable revealed significantly higher physical demands during ACB/Euroleague games compared to ABA/Eurocup across all levels of intensity (total: ES=-1.54; band 2: ES=-2.31; band 3: ES=-1.96), respectively. Previous research investigating physical demands of various levels of basketball games has indicated that Division I or elite players engage in a greater number of high and mid-

Table1. Descriptive values (mean± standard deviation) and statistical comparisons in selected variables between both analyzed teams

Variables	**ABA-Eurocup (N=32)**		**ACB-Euroleague (N=18)**			
Average intensity (AU·min⁻¹)	M	SD	M	SD	p-value	Effect size
PlayerLoad™	8.44	1.45	10.70	1.45	<.001	-1.54
Player Load Band 2	3.70	0.82	5.52	0.70	<.001	-2.31
Player Load Band 3	1.40	0.57	3.07	1.16	<.001	-1.96
IMA Accel High	0.43	0.18	0.43	0.20	.795	-0.02
IMA Accel Low	1.71	0.64	1.50	0.57	<.001	0.34
IMA Accel Medium	0.62	0.24	0.53	0.25	<.001	0.34
IMA CoD Left Low	7.58	2.20	4.89	2.05	< .001	1.25
IMA CoD Left Medium	1.47	0.44	1.19	0.49	<.001	0.61
IMA CoD Left High	0.51	0.20	0.48	0.22	.095	0.15
IMA CoD Right Low	7.76	1.99	4.70	2.07	<.001	1.51
IMA CoD Right Medium	1.51	0.44	1.13	0.54	<.001	0.77
IMA CoD Right High	0.50	0.20	0.46	0.24	.043	0.19
IMA Decel Low	1.79	0.52	1.85	0.73	.356	-0.08
IMA Decel Medium	0.63	0.21	0.63	0.24	.854	-0.01
IMA Decel High	0.30	0.12	0.29	0.15	.263	0.10
IMA Jump Count Low Band	0.36	0.20	0.45	0.24	<.001	-0.39
IMA Jump Count Med Band	0.26	0.15	0.38	0.18	<.001	-0.78
IMA Jump Count High Band	0.23	0.12	0.22±	0.12	.389	0.08

Note. AU: arbitrary units, Accel: acceleration, CoD: change of direction, Decel: deceleration; SD: standard deviation.

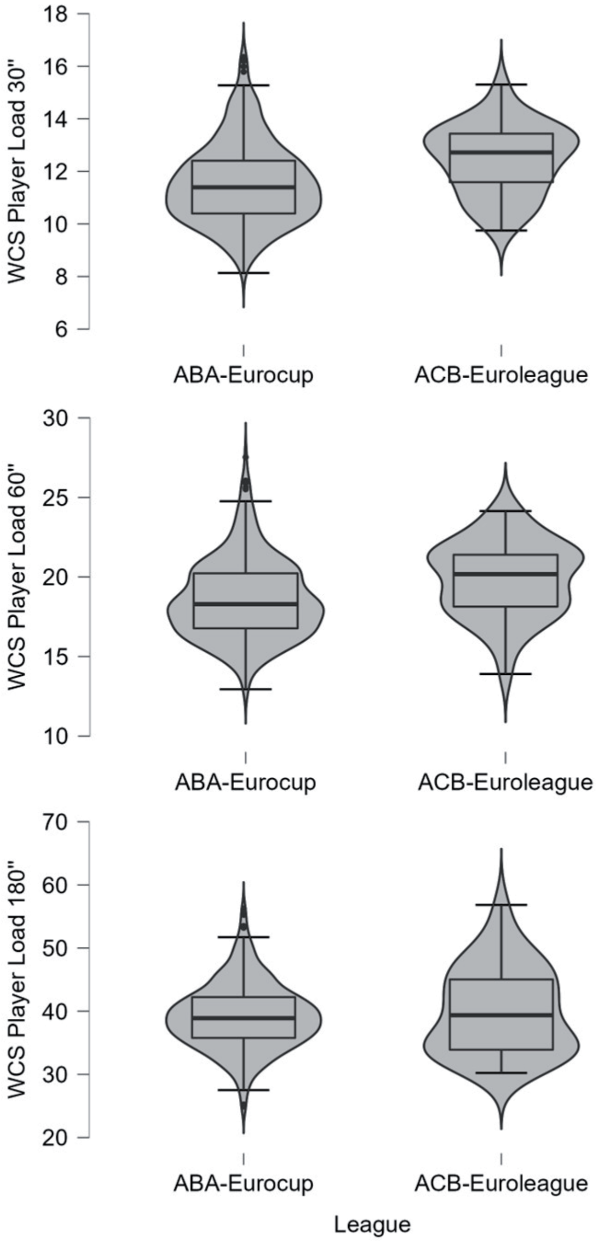

Figure 1. Peak intensities from both analyzed teams for PlayerLoad™ (AU·min⁻¹) variables in the three examined time epochs (30'', 60'' and 180'').

level activities compared to lower division players (Ferioli, et al., 2020). It is important to note that the study highlighted differences between the demands on elite, semi-professional, and amateur basketball games, unlike ours, which specifically showcases disparities between the two European elite levels. Unlike our methodology, which utilized both inertial devices and time motion analysis, the prior study solely relied on time motion analysis, hence comparisons between the two techniques should be approached cautiously.

Moreover, previous research suggests that PL variable could serve as a sufficient guide for adjusting workload intensities for training sessions (Fox, et al., 2021). However, the substantial differences observed in PL variable, individual variables and in the most demanding scenarios between elite teams/leagues in our study diverge from this notion. These findings underscore that if such distinctions in external load exist among elite teams, general conclusions regarding basketball external load cannot solely rely on a single external load variable. Therefore, understanding these nuanced differences in external load between elite basketball teams is paramount for developing tailored training prescriptions that effectively optimize player performance and minimize the risk of injury.

In contrast to PL variable, IMA variables indicate that Eurocup/ABA team exhibited higher values for low and medium intensity acceleration and change of direction metrics (ES=0.34-1.51) compared to ACB/Euroleague team. These findings are in line with previous study with sub-elite and elite U18 players, which demonstrated that higher level of basketball games demand a reduced proportion of low and medium intensity actions (Trapero, et al., 2019). These results suggest two possible interpretations. First, the higher the level of the competition, the more selected and trained players are, promoting more informed decisions and more economized movement (Zhang, et al., 2017). Second, the variation in load demands is consequence of different playing styles in each league, indicating that each league or team may exhibit specific characteristics of physical demands. This implies that success in a particular league depends not only on individual basketball skills but also on the ability to withstand the physical demands associated with a certain style of basketball game. Furthermore, the Eurocup/ABA team showed larger values in low and medium level change of direction and acceleration actions, while the ACB/Euroleague team exhibited larger values in low and medium jump actions. This difference could be attributed to the variation in playing styles or the dominance of specific playing positions within each team's tactics. As previous studies have shown, different playing positions in basketball demand specific configuration of external load factors that contribute to their game, with change of direction being a primal component for guards and forwards and jumping being a primal component for centers (Salazar, et al., 2020). These findings underscore the significance of league-specific playing styles in influencing physical demands of basketball.

The results concerning the most demanding scenarios indicate that the Euroleague/ACB league demands higher frequency of external load when peak demands were measured in epochs of 30-s ($p<.001$, *moderate*) and 60-s ($p=.02$, *small*), but not in 180-s. This suggests that when a longer epoch was considered, external load seems similar, possibly due to the game rules or specific characteristics, while shorter epochs provided insights into the load demands during live basketball gameplay. Previous research suggests that traditional average results underestimate the peak physical demands that occur during the game, hence calculating the most demanding scenarios as rolling average was considered more suitable for describing these situations (Vázquez-Guerrero & Garcia, 2021). Furthermore, it is important to note that previous studies have demonstrated that most demanding scenarios fluctuate from quarter to quarter and between playing positions (Garcia, et al., 2022), thus these results should be interpreted with caution.

Lastly, it is important to acknowledge several limitations. Firstly, the absence of internal load measures in this investigation suggests that the findings may not fully represent the physiological demands of basketball games. Future research may incorporate a holistic workload monitoring to provide a more comprehensive understanding of physical demands inherent in basketball gameplay. Secondly, the substantial differences in PL observed in our study may be attributed to disparities in game situation cutting. Even minor discrepancies in cutting actions can result in significant changes in PL variables, which are influenced by time dynamics (Garcia, et al., 2022). Thirdly, we only analyzed a portion of the season rather than all games within a season, overlooking potential variations in external load demands across the season's progression, as previously noted in the literature (Conte, Kolb, Scanlan, & Santolamazza, 2018).

In conclusion, understanding the demands of a basketball game is crucial for effective training and performance optimization. This study contributes to this understanding by highlighting variations in external load variables among different teams and styles of play. The findings suggest that practitioners should rely on their own team's external load values for training load management, rather than attempting to adhere to standards established by external sources. Moreover, the results underscore the importance of contextual factors in explaining team-to-team differences in external load. Future studies should delve deeper into these contextual factors to unravel the mechanisms underlying such variations. In practice, it is recommended that practitioners use their team's external load data as a guiding principle during basketball practice planning, rather than relying on values obtained from other teams or external sources. By doing so, practitioners can tailor training regimens more effectively to meet the specific demands of their team's style of play and enhance overall performance.

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Submitted: October 22, 2023
Accepted: June 15, 2024
Published Online First: June 27, 2024

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