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Research article

Differences in Physical Demands between Game Quarters and Playing Positions on Professional Basketball Players during Official Competition

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Abstract
The purpose of this study was to compare physical demands between game quarters and specific playing positions during official basketball competition. Thirteen professional male basketball players from the Spanish 2nd Division were monitored across all 17 regular-season home games. Physical demands were analyzed using a local positioning system (WIMU PRO™, Realtrack Systems S.L., Almería, Spain) and included peak velocity, total distance covered, high-speed running (>18 $km \cdot h^{-1}$), player load, jumps (>3G), impacts (>8G) and high-intensity accelerations (≥2 $m \cdot s^{-2}$) and decelerations (≤-2 $m \cdot s^{-2}$). A linear mixed model was used to test statistical significance ($p < 0.05$) between independent variables. Furthermore, standardized Cohen's effect size (ES) and respective 90% confidence intervals were also calculated. There was an overall decrease in all variables between the first and fourth quarter during competition. Specifically, total distance covered ($p < 0.001$; ES = -1.31) and player load ($p < 0.001$; ES = -1.27) showed large effects between the first and last period. Regarding differences between positions, guards presented significant increased values compared to centers (p = 0.04; ES = 0.51), whereas centers achieved significant larger results and moderate effects in comparison to guards in peak velocity (p = 0.01; ES = 0.88) and jumps (p = 0.04; ES = 0.86). In conclusion, physical demands vary between game quarters and playing positions during official competition and these differences should be considered when designing training drills to optimize game performance.

Key words: Acceleration, Game Analysis, Team Sport, Performance.

Introduction

Basketball is a stochastic physically demanding team sport in which both the aerobic and anaerobic energy systems are stressed during games (Stojanović et al., 2018). In addition to cognitive requirements, jumps, sprints, accelerations, decelerations and change of directions are crucial to perform specific movements in basketball (Taylor et al., 2017). For instance, rebounding, blocking, shooting, finishing, dribbling or defending in multiple directions are teams' means to achieve their ultimate goal, namely to score and not to concede points (Ben Abdelkrim et al., 2007; 2010a; McInnes et al., 1995). Thus, knowing physical demands during basketball competition could help coaches, athletic performance staff and medical staff to optimize training and game performance.

Previous investigations (McInnes et al., 1995; Oba and Okuda, 2011; Scanlan et al., 2012; 2015) have examined the physical demands of basketball through the use of video-based movement analysis methodologies based on a subjective visual prediction of sport-specific movement intensity. However, their validity and reliability were shown to be limited and they are also a time-consuming strategy (Barris and Button, 2008). Recently, advances in technology have allowed the use of inertial micro-sensors (Montgomery et al., 2010; Reina et al., 2019; Vázquez-Guerrero et al., 2018a) to quantify variables such as high-intensity accelerations, decelerations, jumps and impacts on semiprofessionals (Fox et al., 2018; Scanlan et al., 2019) and professional male basketball players (Svilar et al., 2018a; Vázquez-Guerrero et al., 2018a). Due to the fact that global positioning systems (GPS) only work outdoors (Puente et al., 2017), local positioning systems (LPS) also allow basketball practitioners to complement information from inertial devices with positioning-derived variables such as player speed and total distance covered in different speed zones. Furthermore, it is important to highlight that LPS has been shown to be valid and reliable (Bastida-Castillo et al., 2018) in monitoring players' physical requirements (Gómez-Carmonaet al., 2019; Vázquez-Guerrero et al., 2018b).

It is still controversial whether physical demands tend to diminish at the end of basketball games. While some studies (Scanlan et al., 2012; 2015) have not been able to report significant differences after the analysis of distance and speed parameters, other investigations have found a significant decrease between the first and last quarters in high-intensity actions (Ben Abdelkrim et al., 2007; 2010a; Delextrat et al., 2017; Reina et al., 2019; Vázquez-Guerrero et al., 2019b) and player load (Scanlan et al., 2019; Vázquez-Guerrero et al., 2019b), which presents a valid and reliable estimation of whole-body load provided by inertial micro-sensors (Nicolella et al., 2013). Nevertheless, to date no study has investigated the differences in physical exertion between quarters of official games among professional basketball players using LPS.

Besides being useful in studying possible changes between quarters, microtechnology has also been used to determine the differences in physical demands between specific playing positions. For instance, the exclusive use of inertial microsensors has been applied to report differences in activity demands on professional players across positional roles during training (Svilar et al., 2018b; Vázquez-Guerrero et al., 2018b) and competition (Reina et

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al., 2019; Vázquez-Guerrero et al., 2018a). Although the authors of this research have no knowledge of any study that have combined inertial devices with LPS to examine game demands on professional players, this methodology have already been used to detect differences in under-18 (U18) elite basketball players (Vázquez-Guerrero et al., 2019a; 2019b; 2019c). Therefore, the aim of this study was to describe and compare physical demands between quarters and specific playing positions among male professional basketball players using inertial devices and LPS during official competition.

Methods

Participants

The subjects in this research were professional male basketball players (mean ± SD, age: 19.8 ± 1.7 years; height: 2.00 ± 0.08 m; and body mass: 91.8 ± 15.9 kg), who competed with the same team in three different playing positions: guards (n = 7), forwards (n = 3) and centers (n = 3). All players belonged to a reserve squad of a Euroleague team and participated in the Spanish second division, namely LEB Oro, during the 2018/2019 season and finished in 17th position in the league after winning nine out of the regular season's thirty-four matches. All players and coaches 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. Furthermore, no ethics committee approval was needed because the data were obtained after the players were routinely monitored during training and matches in the course of the competitive season (Winter and Maughan, 2009). Nevertheless, the study fulfilled the provisions of the Declaration of Helsinki (Harriss and Atkinson, 2015).

Design

This observational study was conducted to compare physical demands during official basketball competition. Thirteen elite basketball players were monitored during all 17 official home games in the 2018/2019 season (September-May). Players who suffered injury or played less than 10 minutes in a match were excluded, resulting in a total of 708 single records.

Methodology

All games were completed on the same court in similar environmental conditions. The team played one game a week, usually between Friday and Sunday, after a standard 45-minute warm-up consisting of individual skills such as dribbling, shooting and passing. Players were allowed to drink water ad libitum during recovery periods. Furthermore, the team followed the Futbol Club Barcelona`s "structured training" methodology, which has been specially designed to optimize team-sports performance and is based on coadjuvant and optimizer training. While the former training type aims to allow players to train and maximize their conditional capabilities, the latter focuses on allowing basketball players to compete and perform at their highest potential in competition (Gómez et al., 2019; Martín-García et al., 2018; Tarragó et al., 2019)

Physical demands

Player movements were recorded using WIMU PRO™ (Realtrack Systems S.L., Almería, Spain), which includes four 3D accelerometers (full-scale output ranges are ±16 g, ±16 g, ±32 g, ±400 g. 100 Hz sample frequency), a gyroscope (8000º/s full-scale output range. 100 Hz sample frequency), a 3D magnetometer (100 Hz sample frequency), a GPS (10 Hz sample frequency) and an ultra-wide band positioning system (18 Hz sample frequency). Each inertial device (81x45x16 mm, 70 g) has a gigahertz microprocessor, 8GB flash memory and a high-speed USB interface to record, store and upload data. The units were placed in a custom-made vest located in the center area of the upper back using an adjustable harness, as recommended by the manufacturer (IMAX, Lleida, Spain).

As in previous studies (Puente et al., 2017; Stojanović et al., 2018; Vázquez-Guerrero et al., 2018a), the following variables were used to monitor physical demands, including: A) peak velocity (PV) in $km \cdot h^{-1}$, as the highest value obtained during each game; B) total distance covered (TDC) in meters; C) distance covered >18 $km \cdot h^{-1}$ (D18) in meters; D) player load (PL), expressed in arbitrary units and calculated as the sum of the squared rates of change in acceleration (also known as jerk) in each of the three vectors divided by 100 (Fox et al., 2018; Nicolella et al., 2013; Vázquez-Guerrero et al., 2019c) and E) the number of impacts that surpassed 8 g-forces (IMP), jumps above 3 g-forces (JUM) and high-intensity accelerations ($\geq 2\ m \cdot s^{-2}$) (ACC) and decelerations ($\leq -2\ m \cdot s^{-2}$) (DEC) (Vázquez-Guerrero et al., 2019b; 2019c). In order to compare the activity of players with different playing times, all the variables were normalized by the total time spent on court, defined as the sum of all time that players were on court, excluding only breaks between periods but including all stoppages (Scanlan et al., 2015).

WIMU PRO™ has been shown to have good/acceptable accuracy and inter- and intra-unit reliability for ultra-wide band positioning (Bastida-Castillo et al., 2019; Bastida-Castillo et al., 2019; Bastida Castillo et al., 2018; Gómez-Carmona et al., 2019). This system includes six antennas with ultra-wide band technology positioned 12 meters away from the sidelines of the basketball court. A total of three antennas are placed in each baseline, 17 meters apart, forming a rectangle for better signal emission and reception. All of them were located at a height of seven and half meters from the wooden floor and were connected and calibrated following the manufacturer's instructions. Data were downloaded and analyzed using the manufacturer's specific software (SPRO™, version 950, RealTrack Systems, Almería, Spain).

Statistical analyses

Descriptive data from official competition were reported as mean ± standard deviation (SD). The Pearson correlation matrix with eight performance variables was analyzed to perform a visual inspection of data factorability. Differences in physical demands outcomes 1) between game quarters, and 2) between playing positions, respectively, were assessed fitting linear mixed models. This allowed the authors to model the dependence structure among dependent variables for longitudinal or repeated measures data. The physical demands variables were set as the dependent variable; game quarters (first, second, third and fourth quarter) and playing positions (guard, forward and center) were included as fixed effects; and players were considered as random effects. The significance of the fixed effects associated with the covariate included in the model was assessed using the Wald test. The statistical significance was set at p <.05. After the models were validated, the residuals of the final models were explored for normality, homogeneity and independence assumptions. Normality assumption of the residuals was checked by means of a normal q-q plot of residuals. All data analyses were performed using the Statistical Package for Social Sciences (version 25 for Windows; SPSS, Chicago, IL, USA) and R (The R Foundation for Statistical Computing, Vienna, Austria), R version 3.3.2 (R Core Team, 2016), with the package nlme and lmerTest.

Cohen's effect size (ES) and respective 90% confidence intervals were also calculated. Thresholds for effect size statistics were <0.20, trivial; 0.20-0.59, small; 0.60-1.19, moderate; 1.20-1.99, large; and >2.0, very large (Hopkins et al., 2009). The effect size analyses' calculations were performed with a customized Excel spreadsheet (downloaded and adapted from www.cem.org/effect-size-calculator).

Results

Physical demands for all players between quarters and specific position are shown in Table 1 (means, SD and significant difference), whereas Cohen's d effect size analysis is shown in Figures 1 and 2. Additionally, results from linear mixed models are shown in detail in Table 2 (supplemental material). Total duration for each quarter was as follows: 17.5 ± 1.4 min in the first quarter; 22.9 ± 2.3 min in the second quarter; 20.1 ± 2.1 min in the third quarter; and 23.9 ± 3.3 min in the fourth quarter. This means that the so-called work-to-rest ratio, i.e. the relationship between effective playing and rest time, would be 1:0.7 in the first quarter, 1:1.3 in the second quarter, 1:1 in the third quarter and 1:1.4 in the fourth quarter. Thus, 2Q and 4Q presented the lowest work-to-rest ratios due to a higher number of game interruptions.

The first quarter presented significant differences and small to large effects with the other three quarters in almost all game variables. For instance, the largest differences between the first and fourth quarter were found in TDC ($p < 0.001$; ES = -1.31) and PL ($p < 0.001$; ES = -1.27). Moreover, these two variables also presented significant differences and moderate effects between the third and fourth quarter (TDC $p < 0.001$ and ES = -0.75; PL $p < 0.001$ and ES = -0.72) and between the first and second quarter ($p < 0.001$ and TDC ES = -1.14; PL $p < 0.001$ and ES = -1.08). Additionally, ACC ($p < 0.001$; ES = -0.78) and DEC ($p < 0.001$; ES = -0.67) showed moderate decreases in the fourth quarter compared to the first quarter.

In addition to differences between game quarters, TDC, PV and JUM also showed significant differences between guards and centers. More specifically, centers achieved the lowest values in TDC compared to guards ($p = 0.04$; ES = 0.51) and forwards ($p < 0.05$; ES = 0.47). On the contrary, centers presented the highest values in PV and JUM compared to guards (PV $p = 0.01$ and ES = 0.88; JUM $p = 0.04$ and ES = 0.86) and forwards (PV $p < 0.05$ and ES = 0.57; JUM $p < 0.05$ and ES = 1.07). Furthermore, game variables such as D18, PL, ACC, DEC and IMP did not present significant differences.

Table 1. Means (±SD) in selected physical demands for quarters and playing positions.

		Peak Velocity ($km \cdot h^{-1}$)	Total distance covered (m)	Distance > 18 $Km \cdot h^{-1}$ (m)	Player load (a.u.)	Accelerations > 2 $m \cdot s^{-2}$ (counts)	Decelerations < 2 $m \cdot s^{-2}$ (counts)	Jumps > 3 G (counts)	Impacts > 8 G (counts)
PLAYERS (n = 13)	**1Q**	20.2 ± 1.6†	83.1 ± 9.8†‡§	3.9 ± 2.5†§	1.5 ± 0.2†‡§	4.1 ± 1.2†‡§	3.7 ± 1.2†‡§	0.3 ± 0.2†§	1.4 ± 1.1†§
	2Q	20.1 ± 1.5*	71.6 ± 9.3*‡	3.0 ± 2.0*‡	1.3 ± 0.2*‡§	3.4 ± 1.1*‡	3.1 ± 1.1*‡	0.2 ± 0.2*	1.3 ± 1.0*
	3Q	20.2 ± 1.6	77.1 ± 9.1*†§	3.5 ± 1.8†§	1.4 ± 0.2*†§	3.7 ± 1.1*†§	3.3 ± 1.1*†§	0.3 ± 0.2§	1.4 ± 1.0§
	4Q	20.2 ± 1.5	69.8 ± 9.5*‡	2.9 ± 1.9*‡	1.2 ± 0.2*†‡	3.2 ± 1.1*‡	2.9 ± 1.2*‡	0.2 ± 0.2*‡	1.1 ± 0.9*‡
	TOTAL	20.7 ± 1.5	72.4 ± 8.1	3.2 ± 1.2	1.3 ± 0.2	3.5 ± 1.0	3.1 ± 1.0	0.2 ± 0.1	1.3 ± 0.9
GUARD (n = 7)	**1Q**	19.8 ± 1.3	84.2 ± 9.3	3.5 ± 1.9	1.5 ± 0.2	4.5 ± 1.0	3.8 ± 1.0	0.2 ± 0.2	1.3 ± 0.8
	2Q	19.7 ± 1.1	73.0 ± 10.1	2.7 ± 1.7	1.3 ± 0.2	3.6 ± 1.0	3.2 ± 0.9	0.2 ± 0.2	1.1 ± 0.7
	3Q	19.9 ± 1.2	78.3 ± 7.9	3.2 ± 1.5	1.4 ± 0.2	3.8 ± 0.7	3.4 ± 0.8	0.2 ± 0.2	1.3 ± 0.9
	4Q	19.8 ± 1.3	72.1 ± 10.5	2.7 ± 1.6	1.2 ± 0.2	3.4 ± 1.0	3.1 ± 1.0	0.1 ± 0.2	1.0 ± 0.6
	TOTAL	20.2 ± 1.2¶	73.6 ± 8.6¶	2.9 ± 1.1	1.3 ± 0.1	3.7 ± 0.9	3.3 ± 0.9	0.2 ± 0.1¶	1.1 ± 0.6
FORWARD (n = 3)	**1Q**	20.1 ± 1.6	84.6 ± 10.2	4.1 ± 3.0	1.4 ± 0.2	3.9 ± 1.2	3.4 ± 1.2	0.2 ± 0.1	1.1 ± 0.9
	2Q	20.3 ± 1.5	72.6 ± 9.3	3.4 ± 2.3	1.2 ± 0.2	3.2 ± 1.0	2.9 ± 1.1	0.2 ± 0.1	1.0 ± 0.8
	3Q	20.1 ± 1.4	78.2 ± 8.2	3.9 ± 2.2	1.3 ± 0.2	3.5 ± 1.1	3.0 ± 1.1	0.2 ± 0.2	1.0 ± 0.7
	4Q	20.3 ± 1.5	68.4 ± 8.9	2.9 ± 1.9	1.1 ± 0.2	2.9 ± 1.0	2.5 ± 1.1	0.2 ± 0.1	0.8 ± 0.7
	TOTAL	20.6 ± 1.3	73.5 ± 7.5	3.3 ± 1.3	1.2 ± 0.1	3.2 ± 0.9	2.8 ± 0.9	0.2 ± 0.1	0.9 ± 0.6
CENTER (n = 3)	**1Q**	21.3 ± 1.8	78.6 ± 9.3	4.6 ± 2.8	1.6 ± 0.3	4.2 ± 1.6	3.8 ± 1.4	0.5 ± 0.3	2.3 ± 1.4
	2Q	20.5 ± 1.9	66.7 ± 11.3	3.2 ± 2.0	1.3 ± 0.3	3.4 ± 1.3	3.1 ± 1.4	0.3 ± 0.2	2.1 ± 1.5
	3Q	21.2 ± 2.1	73.0 ± 11.5	3.6 ± 1.8	1.4 ± 0.3	4.0 ± 1.5	3.5 ± 1.5	0.4 ± 0.3	2.1 ± 1.1
	4Q	21.2 ± 1.2	66.4 ± 11.7	3.3 ± 2.2	1.3 ± 0.3	3.3 ± 1.4	3.0 ± 1.5	0.4 ± 0.2	2.1 ± 1.2
	TOTAL	21.8 ± 1.7‖	68.2 ± 6.7‖	3.5 ± 1.3	1.3 ± 0.2	3.6 ± 1.3	3.3 ± 1.3	0.4 ± 0.2‖	2.2 ± 1.2

1Q is first quarter, 2Q is second quarter, 3Q is third quarter and 4Q is fourth quarter. Significant differences (SD) are shown as follows: * = SD with 1Q; † = SD with 2Q; ‡ = SD with 3Q; § = SD with 4Q; ‖ = SD with guard; ** = SD with forward; ¶ = SD with center.

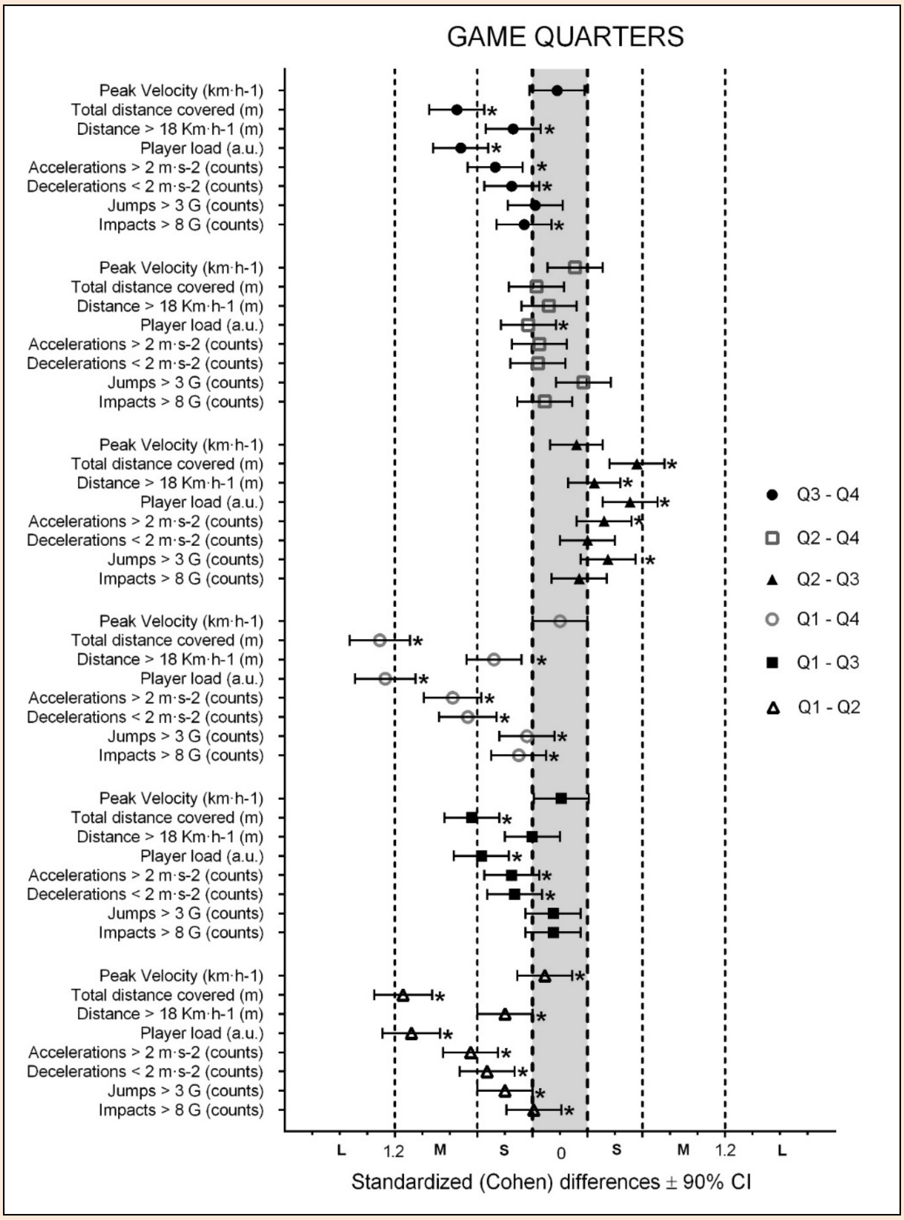

Figure 1. Standardized differences (Cohen's d) and the 90% CI between game quarters for the eight load variables selected. Significant difference is reported with * at the right end of the 90% CI bar. 1Q = first quarter; 2Q = second quarter; 3Q = third quarter; 4Q = fourth quarter; L = Large effect; M = Moderate effect; S = Small effect.

Discussion

The aim of this investigation was to compare professional basketball players' physical demands between quarters and playing positions during official competition. There were several novel findings that can help to achieve a better understanding of athletic performance in games, such as a significant decrease in TDC, PL, D18, ACC, DEC and JUM in the fourth quarter and the significant differences discovered in PV, TDC and JUM between guards and centers. These changes may partly be explained by the specific score, the team's playing model, the player's individual physical exertion and the inherent demands of the specific playing position (Ben Abdelkrim et al., 2007; Scanlan et al., 2015).

Similar to previous research that used total time to normalize absolute values of physical exertion in U18 (Vázquez-Guerrero et al., 2019b) and U19 basketball players (Ben Abdelkrim et al., 2007; 2010b), this investigation also found a significant decrease in the fourth quarter compared to the first quarter in game variables such as TDC, D18, PL, ACC and DEC. However, it still remains controversial whether there is such a variation in physical demands among game quarters after some studies failed to present similar conclusions using live time (Oba and Okuda, 2011; Scanlan et al., 2015). Thus, the use of total time instead of live time (Scanlan et al., 2012) is crucial to understanding these results, since the current research did find significant reductions in the majority of variables studied when period total time was greater. Additionally, it

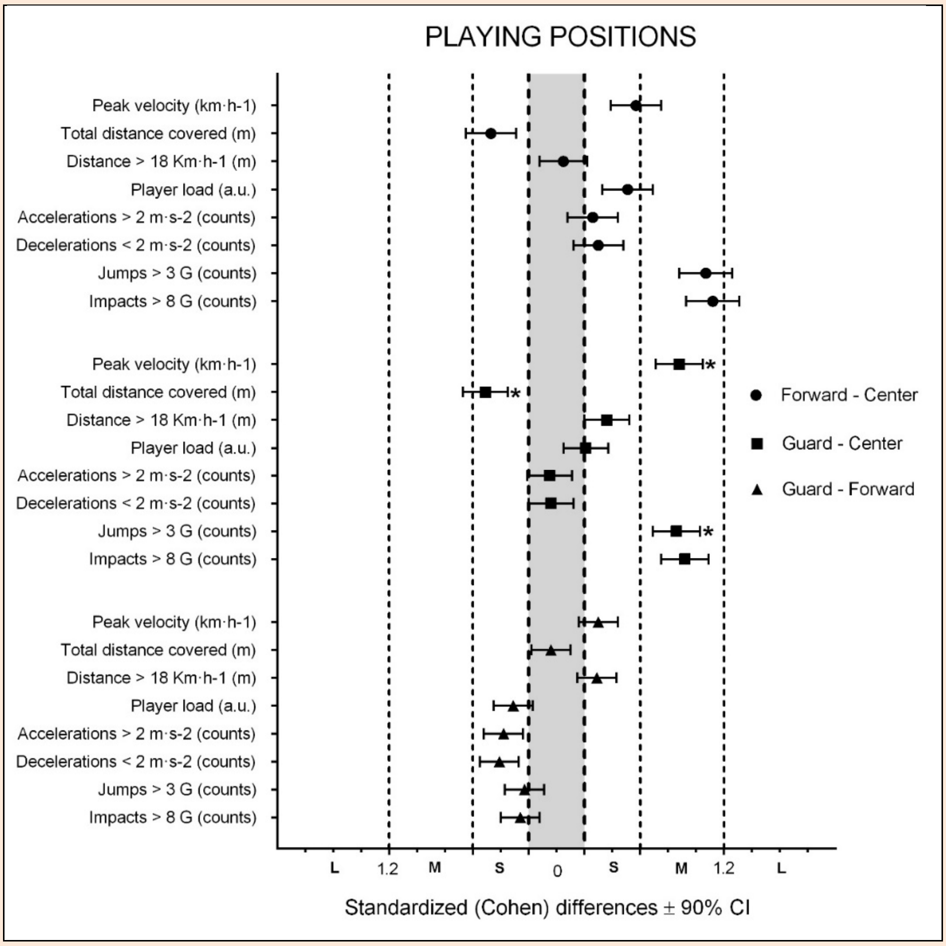

Figure 2. Standardized differences (Cohen's d) and the 90% CI between playing positions for the eight load variables selected. L = Large effect; M = Moderate effect; S = Small effect. Significant difference is reported with * at the right end of the CI bar.

should be mentioned that similar conclusions have been drawn in football, where physical demands do not seem to decrease significantly during matches when live time, or the so-called "effective playing time", is analyzed instead of total time (Castellano et al., 2011; Linke et al., 2018). In addition to this methodological difference, it must also be noted that game pace could diminish in the fourth quarter due to a possible team strategy, with fewer transitions and fewer players involved in each offensive possession. Therefore, caution should be exercised when concluding that the appearance of fatigue might be the cause of a reduction in performance load variables at the end of basketball games (Ben Abdelkrim et al., 2010a).

Although differences between game quarters in all game variables have been found, this research only detected significant differences in TDC, PV and JUM between guards and centers. For instance, TDC was found to be significantly lower in centers compared to guards in this investigation. Available research (Vázquez-Guerrero et al., 2019c) reported similar results (TDC centers = 68.2 $m\cdot min^{-1}$; TDC forwards = 72.6 $m\cdot min^{-1}$; TDC guards = 74.4 $m\cdot min^{-1}$) in U18 elite basketball players. These findings could be explained by the fact that centers tend to remain in more static positions near the three-second zone during set pieces for tactical reasons. As well as TDC, previous studies (Puente et al., 2017; Vázquez-Guerrero et al., 2019c) also reported that centers obtained the lowest values in PV and D18. Conversely, this investigation found that centers achieved the highest PV (21.8 $km\cdot h^{-1}$) and completed the largest number of meters above 18 $km\cdot h^{-1}$ (3.5 $m\cdot min^{-1}$) compared to guards (PV = 20.2 $km\cdot h^{-1}$; D18 = 2.9 $m\cdot min^{-1}$) and forwards (PV = 20.6 $km\cdot h^{-1}$; D18 = 3.3 $m\cdot min^{-1}$). One possible explanation for centers achieving significantly higher maximal speeds and completing more high-speed running distance could be that they usually cover more meters in offensive and defensive transitions from basket to basket and therefore have more time to achieve higher velocities. In addition to TDC and PV, data from inertial micro-sensors also showed differences between positions. In line with previous research (Ben Abdelkrim et al., 2007), the number of jumps averaged by centers (n = 49) tended to be significantly higher than all playing positions (n = 41), possibly due to their shot-blocking and rebounding role. Besides the effort to jump, centers also presented more moderate increased values in IMP than guards and forwards, which can complement the information presented above to describe the specific physical demands of the center position.

Despite the fact that the available research presented inconsistent results when PL among playing positions during competition was compared (Vázquez-Guerrero et al., 2018a; Vázquez-Guerrero et al., 2019c), this research

Table 2. Linear mixed models with selected physical demands parameters as dependent variable.

	PV					TDC					D18					PL				
Variables	**ES**	**SE**	**95% CI**	**t**	**p**	**ES**	**SE**	**95% CI**	**t**	**p**	**ES**	**SE**	**95% CI**	**t**	**p**	**ES**	**SE**	**95% CI**	**t**	**p**
Intercept	19.66	0.27	19.12-20.19	72.18	<0.01	71.62	1.62	68.46-74.77	44.61	<0.01	2.44	0.35	1.76-3.13	6.98	<0.01	1.23	0.05	1.14-1.33	25.62	<0.01
Center	1.53	0.45	0.52-2.54	3.38	<0.01	-6.11	2.58	-11.87-(-0.36)	-2.37	0.04	0.87	0.57	-0.40-2.13	1.53	0.16	0.04	0.08	-0.15-0.22	0.47	0.65
Forward	0.55	0.44	-0.44-1.53	1.24	0.24	-1.32	2.49	-6.88-4.24	-0.53	0.61	0.64	0.55	-0.58-1.87	1.16	0.27	-0.09	0.08	-0.27-0.10	-1.06	0.32
1Q	-0.03	0.17	-0.36-0.29	-0.19	0.85	13.61	1.13	11.39-15.84	12.02	<0.01	1.06	0.24	0.59-1.53	4.46	<0.01	0.28	0.02	0.24-0.33	11.92	<0.01
2Q	-0.15	0.16	-0.47-0.17	-0.92	0.36	1.82	1.11	-0.37-4.01	1.63	0.10	0.17	0.23	-0.29-0.63	0.74	0.46	0.05	0.02	0.01-0.10	2.29	0.02
3Q	0.01	0.16	-0.32-0.33	0.04	0.97	7.51	1.11	5.32-9.71	6.72	<0.01	0.63	0.23	0.17-1.09	2.71	<0.01	0.16	0.02	0.11-0.21	6.80	<0.01
σ_u			0.60					3.31					0.74					0.11		
σ_ϵ			1.36					9.25					1.94					0.19		

	ACC					DEC					JUM					IMP				
Variables	**ES**	**SE**	**95% CI**	**t**	**p**	**ES**	**SE**	**95% CI**	**t**	**p**	**ES**	**SE**	**95% CI**	**t**	**p**	**ES**	**SE**	**95% CI**	**t**	**p**
Intercept	3.40	0.20	3.01-3.80	17.04	<0.01	3.04	0.20	2.66-3.42	15.58	<0.01	0.17	0.04	0.10-0.25	4.61	<0.01	1.16	0.33	0.52-1.81	3.54	<0.01
Center	0.11	0.33	-0.62-0.85	0.35	0.74	0.12	0.32	-0.59-0.83	0.39	0.71	0.15	0.06	0.1-0.30	2.39	0.04	0.93	0.59	-0.38-2.25	1.58	0.14
Forward	-0.44	0.32	-1.15-0.27	-1.37	0.20	-0.44	0.31	-1.13-0.25	-1.42	0.19	-0.01	0.06	-0.15-0.13	-0.18	0.86	-0.35	0.59	1.66-0.96	-0.60	0.56
1Q	0.91	0.13	0.66-1.16	7.12	<0.01	0.78	0.13	0.52-1.03	5.99	<0.01	0.05	0.02	0.01-0.09	2.33	0.02	0.29	0.08	0.13-0.46	3.47	<0.01
2Q	0.15	0.13	-0.10-0.39	1.16	0.25	0.16	0.13	-0.09-0.41	1.27	0.21	-0.02	0.02	-0.06-0.01	-1.23	0.22	0.13	0.08	-0.03-0.29	1.55	0.12
3Q	0.48	0.13	0.24-0.73	3.84	<0.01	0.37	0.13	0.12-0.63	2.94	<0.01	0.04	0.02	-0.00-0.07	1.83	0.07	0.22	0.08	0.06-0.38	2.63	<0.01
σ_u			0.43					0.42					0.09					0.84		
σ_ϵ			1.03					1.04					0.16					0.68		

1Q is first quarter, 2Q is second quarter, 3Q is third quarter, σ_u is a standard deviation of player; σ_ϵ is a standard deviation of residual, ES is coefficient estimate, SE is Standard Error, 95% CI is 95% confidence intervals, t is t-value and p is p-value. We have used "guard" in the playing position variable and "fourth quarter" in the game quarter variable as reference categories for this model.

did not find significant differences between specific positions in this inertial-derived variable. In line with previous research using the same technology with U18 male (Vázquez-Guerrero et al., 2019c) and female players (Reina et al., 2019), this investigation showed that guards perform the highest amount of ACC and DEC, possibly due to a performance of a great number of high-intensity movements such as full-court defense, one-on-one attacks to beat the opponent or actions after different types of screens (Sampaio et al., 2006). Conversely, the present research showed that forwards presented the lowest values in PL, ACC and DEC. Furthermore, recent studies have also concluded that centers presented the lowest number of high-intensity ACC and DEC actions per minute (Reina et al., 2019; Vázquez-Guerrero et al., 2019c). The fact that centers and forwards presented these lower results during competition would be due to two logical principles: 1) big players are usually required to occupy smaller spaces around the basket for tactical reasons (Schelling and Torres, 2016); and 2) bigger players have to apply higher forces to accelerate due to their increased body mass (Ben Abdelkrim et al., 2007; Schelling and Torres, 2016). On the contrary, Svilar et al. (2018b) concluded that centers achieved the highest number of total and high-intensity accelerations and forwards managed to accomplished the highest number of total and high-intensity decelerations during 26 in-season training sessions in professional male basketball players. Therefore, positional role requirements could reflect the specificity of basketball playing positions across training and competition modes.

There are some limitations of this study that should be considered. Firstly, the authors acknowledge that monitoring one team formed with 13 under-20 young basketball players represents a small exclusive sample size. However, this professional team competed in the Spanish 2nd Division (LEB Oro), which constitutes a small exclusive convenience sample. Secondly, the fact that it was only possible to categorize three players as forwards and three different players as centers means that conclusions were reduced to their specific playing style. Finally, another potential limitation could be the use of game load averages to describe competition demands. Therefore, future research should analyze player's physical demands during the most demanding basketball scenarios, also referred to as "worst-case scenarios", to optimize game performance.

Conclusion

The findings from the current study indicate that the physical match demands are different between game quarters and playing positions in professional basketball. Although the players' fatigue could have a negative effect on some game load variables in the fourth quarter, tactical principles, including more stoppages and consequently a longer period duration, could better explain the game load output in the last quarter of the game. Furthermore, understanding the fact that players have different needs could help to bolster training methodologies based on individualization, especially in physical and technical areas.

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Key points

- The highest basketball-specific tasks should include an adequate work-to-rest ratio, namely playing small-sided games or 5 on 5 with a specific official competition density between 1:0.7 and 1:1.4.
- Players should work on their position-specific requirements, especially during off-season and after having accumulated little playing time during competition. For instance:
- Centers should stress more both jumping and contact actions (e.g. pushing and holding) using small-sided games such as 1 on 1 or 2 on 2 situations with the goal of shooting or rebounding.
- Guards should focus more on short and intermittent high-intensity movements, such as defensive shuffle and changes of directions.

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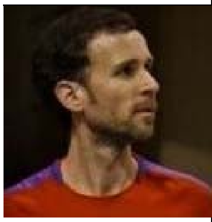

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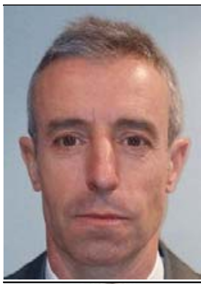

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