Influence of ball possession and playing position on the physical demands encountered during professional basketball games

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ABSTRACT: Understanding the game demands encountered in basketball provides useful insight for developing specific, individualized and team-based training sessions. This study quantified and compared the game activity demands encountered by basketball players of different playing positions: i) strictly when in possession of the ball and ii) overall during live playing time (irrespective of ball possession). The activity demands encountered by 44 (22 guards, 14 forwards, 8 centres) adult, professional, male basketball players were assessed across 10 official games. Time-motion analysis was used to determine the frequency and proportion (%) of playing time performing recovery (REC), low- (LIA), moderate- (MIA), and high- (HIA) intensity activities. Linear mixed models were constructed to examine differences in dependent variables between playing positions, accounting for repeated measures. Guards, forwards, and centres spent 11.9±5.9%, 3.5±1.3%, and 2.9±1.1% of live playing time in possession of the ball, respectively. Guards performed more activities at all intensities (total movements, REC, LIA, MIA, and HIA) than forwards ($P < 0.05$) and centres ($P < 0.05$) when in possession of the ball. The proportion of time spent performing HIA in possession of the ball was greater for forwards ($P = 0.001$) and centres ($P = 0.001$) than guards. During live playing time overall across games, centres performed more HIA per minute ($P = 0.049$) and spent a greater proportion of time performing HIA ($P = 0.047$) than guards. Activities performed when in possession of the ball and during live playing time across basketball games are affected by playing position. These data highlight the need to develop position-specific training drills, particularly with ball possession.

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INTRODUCTION

Understanding the demands imposed on basketball players during games provides useful insight for developing specific individualized and team-based training sessions [1]. Game demands can be assessed in terms of physiological responses (e.g. heart rate, metabolic measurements) and physical activities performed (e.g. frequency and duration of activities, distance covered, PlayerLoad) [2, 3]. Current evidence suggests that an increasing number of studies are focusing on quantifying the external demands encountered by basketball players across games [3–5]. One of the most frequently used approaches for measuring activity demands in basketball is time-motion analysis (TMA) [3, 6]. Typically, TMA is employed to calculate the frequencies of, and durations spent performing, various activities across basketball games. Existing literature has strongly established the intermittent nature of basketball games, during which players perform changes in activity type every 1–3 s [4, 7–10]. Within TMA studies [4, 6, 7], basketball movements are usually classified according to their relative intensity into recovery (REC, including standing/walking), low-intensity activities (LIA, including jogging and low-intensity specific movements), moderate-intensity activities (MIA, including running and moderate-intensity specific movements), and high-intensity activities (HIA, including sprinting, high-intensity specific movements, and jumping). Systematic evidence shows that male basketball players spend ~28–63% of time recovering and ~14–40%, ~11–28%, and ~11–20% of time performing LIA, MIA, and HIA respectively during games [3].

While existing data provide detailed information regarding the physical demands imposed on basketball players during games, dribbling activities have been quantified in a limited number of studies [8, 9, 11]. This observation is surprising considering that team success partially depends on the activities performed by the player in possession of the ball (e.g. controlling possession, scoring) [12]. In this regard, adult, male basketball players spend up to ~10% of

live playing time dribbling the ball [8]. Despite the important contribution of dribbling to the overall activity demands faced during basketball games, no studies have described the intensities at which these dribbling activities, or other activities when in possession of the ball (e.g. making an offensive move to score, passing the ball, securing a rebound), are performed. Understanding the precise physical activities performed when players are in possession of the ball will provide important insights for developing more specific training strategies.

Differences in basketball game demands between competitive levels, [4, 8, 10, 13] countries, [3] sex, [3, 9] and game quarters [7, 10, 14] have been well established in the literature. Likewise, some studies have compared game activity demands between playing positions in basketball [7, 8]. In this regard, guards have been reported to perform more frequent changes in movement types per minute compared to forwards and centres, demonstrating a greater intermittent profile during basketball games [3, 7, 8]. Furthermore, guards spend more time performing HIA (i.e. sprints and high-intensity shuffles) and spend less time in REC than forwards and centres during games [3, 7, 11, 15]. A greater proportion of playing time performing sprinting and shuffling movements was also observed in forwards compared to centres [3]. Despite some initial insights being provided regarding differences in game demands according to playing position, systematic evidence [3] suggests that further research is still needed to definitively understand positional differences in basketball game demands.

Indeed, some limitations should be acknowledged when interpreting the results of previous research examining basketball game demands according to playing position. First, most existing TMA studies exploring position differences in basketball game demands analysed collegiate or junior players [15–17] thus available knowledge does not sufficiently include adult, professional players. This discernment is important given that adult, professional basketball players may perform activities differently during games given that they likely possess better developed physical characteristics and technical-tactical skills compared to younger players [18, 19] and players competing at lower levels [19–22]. Secondly, the limited TMA studies comparing game demands between playing positions in adult, professional basketball players included small sample sizes (n = 10–13) from a single team [8, 23]. To overcome these limitations, studies recruiting a large sample of adult, professional players from various teams are needed to develop a more holistic understanding of basketball game activity demands according to playing position. A comprehensive set of position-specific TMA game data will further assist in developing more specific training programmes according to positional needs.

Therefore, the aim of this study was to quantify and compare the activity demands between playing positions: i) when players are in possession of the ball and ii) overall during live playing time (irrespective of ball possession) across official games in professional, adult, male basketball players.

MATERIALS AND METHODS

Subjects

Data were collected from 44 professional, adult, male basketball players (age: 26.5±4.4 years, stature: 197.7±8.2 cm, body mass: 94.7±10.7 kg) competing in the Italian first (n = 25) and second (n = 19) divisions (i.e. Serie A and Serie A2). The players were grouped according to playing positions including guards (n = 22, age: 26.6±4.9 years, stature: 191.3±5.3 cm, body mass: 87.7±7.7 kg), forwards (n = 14, age: 25.8±3.1 years, stature: 201.2±3.1 cm, body mass: 98.4±5.9 kg), and centres (n = 8, age: 27.3±5.1 years, stature: 208.9±4.4 cm, body mass: 107.4±9.8 kg). Players were recruited from 6 separate basketball teams (i.e. 3 teams for each division). Throughout the data collection period, coaching staff reported players to train 6–10 times per week, with session duration typically lasting between 60 and 120 min. In addition to on-court basketball training, players performed strength sessions twice per week and specific conditioning sessions once per week. First division teams played 1–2 games per week, while second division teams completed 1 game per week. All players included in this study were members of the teams since the start of the preparation period and were required to have played ≥10 min in at least 1 game to be considered for the individual player analysis. All reserve players (those who play < 10 min per game) were excluded from the study.[4] After verbal and written explanation of the experimental design and potential risks and benefits of the study, written informed consent was gathered from all players. The study was approved by the Independent Institutional Review Board of MAPEI Sport Research Centre in accordance with the Helsinki Declaration (2013).

Design

A between-subject, observational study design was used to compare activity demands when in possession of the ball and during live playing time between playing positions during official games throughout the regular competitive period (season 2015–16 and 2016–17). A total of 70 individual game samples were collected across 10 official games (i.e. each player was analysed on 1–2 occasions). Each individual player (and team) was only monitored during one of the two seasons considered, with a maximum of 3 weeks separating games when players were considered on 2 occasions. Games were randomly selected for analysis during the competitive season; however, games with differences in the final score exceeding 20 points were excluded a priori. Consequently, the analysed game had relatively consistent score differences (mean = 11±5 points). All games were administered following FIBA rules, using a 24-s shot clock, and 4 x 10-min quarters with 2-min inter-quarter breaks and a 15-min half-time break.

Time-motion analysis

All games were video-recorded using a fixed camera (GoPro hero 4 silver edition, San Mateo, CA, USA), positioned to allow a full view of the court. All games were captured at a sample rate of 30 Hz and resolution of 1080 p. Games were recorded for their entire duration,

including all stoppages in play. Manual frame-by-frame software (SICS VideoMatch Basket, version 5.0.5) was used to determine player activities when in possession of the ball and during live playing time. As previously described, [4, 24, 25] player physical demands were classified into 8 movement categories as follows: (i) standing/walking: activity of no greater intensity than walking without any distinction between standing still and walking or between different intensities of walking; (ii) jogging: movement (forwards or backwards) at an intensity greater than walking but without urgency; (iii) running: forwards or backwards movement at an intensity greater than jogging and a moderate degree of urgency but which did not approach an intense level of movement; (iv) sprinting: forward or backwards movement at a high intensity, characterized by effort and purpose at or close to maximum; (v) low-: (vi) moderate-: (vii) high- specific movements: movements differing from ordinary walking or running performed respectively at low intensity without urgency, at medium intensity with a moderate degree of urgency and at high intensity with urgency and (viii) jumping: the time from the initiation of the jumping action to the completion of landing. Specific movements mainly included the stance position, shuffling, rolling, reversing, screening, and cross-over running activities [25]. Movements were then grouped according to their relative intensity into REC (standing/walking), LIA (jogging and low-intensity specific movements), MIA (running and moderate-intensity specific movements), and HIA (sprinting, high-intensity specific movements, and jumping) [4, 6, 7]. The frequency of occurrence and the duration of each movement were determined when players were in possession of the ball and during live playing time (i.e. game activity when the game clock was running). Activity frequencies were calculated as the total number of events (n) performed when in possession of the ball and during live playing time, and normalized according to duration (n/min) for each player. Activity durations were determined as a percentage (%) of time when each player was in possession of the ball and during live playing time. All video analyses were performed by two expert members of the research team. All measures possessed acceptable intra- and inter-tester reliability (Table 1).

Statistical analysis

The TMA descriptive results are reported as means±standard deviations (SD). Before running linear mixed effect models, boxplots and histograms were used to determine potential influential data points. Following analysis, visual inspections of residual plots were used to determine deviations from homoscedasticity or normality. Linear mixed models were constructed to examine activity differences between playing positions, accounting for individual repeated measures. Each playing position (3 levels) and the different leagues (2 levels) were included as fixed effects in the model, while individual players were included as a random effect. 'Step-up' model construction strategies were employed, similar to that used in previous team sports research [26]. Each process began with an unconditional model containing only a fixed intercept and the random factor. The model was then implemented by adding each single fixed effect one at a time. The order in which each fixed effect was added to the model was guided by extensive experience in team sports. The Akaike information criterion (AIC) and degrees of freedom for each model were visually compared with the previous model, in which a lower AIC represented a better model fit. For all models, the best fit for the data was found by including both the playing position and league. However, no differences between leagues were found, confirming the similar game activity demands faced by players across leagues and the professional status of both leagues. The *t* statistics from the mixed model were converted into Cohen's *d* effect sizes (ES) and associated 95% confidence limits (CL). ES were interpreted as follows: ≤0.20, *trivial*; >0.20–0.60, *small*; >0.60–1.2, *moderate*;

TABLE 1. Intra- and inter-tester reliability of time-motion analysis variables.

Variable	Activity category	ICC (90% CI)		CV% (90% CI)	
		Inter-operator	Intra-operator	Inter-operator	Intra-operator
Frequency	REC	0.97 (0.91–0.99)	0.99 (0.97–1.00)	9.1 (6.6–15.5)	5.3 (4.1–7.8)
	LIA	0.96 (0.89–0.99)	0.99 (0.97–1.00)	8.0 (5.7–13.4)	4.1 (3.1–6.1)
	MIA	0.88 (0.67–0.96)	0.91 (0.77–0.97)	14.9 (10.6–25.6)	12.5 (9.5–18.7)
	HIA	0.93 (0.80–0.98)	0.95 (0.89–0.98)	15.2 (10.9–26.3)	12.1 (9.2–18.1)
Duration	REC	0.99 (0.98–1.00)	1.00 (1.00–1.00)	3.4 (2.4–5.6)	1.9 (1.4–2.7)
	LIA	0.98 (0.94–0.99)	0.99 (0.99–1.00)	6.8 (4.9–11.5)	3.7 (2.8–5.4)
	MIA	0.93 (0.80–0.98)	0.90 (0.75–0.96)	11.8 (8.5–20.1)	14.0 (10.6–21.1)
	HIA	0.96 (0.87–0.99)	0.97 (0.92–0.99)	13.2 (9.5–22.7)	10.7 (8.2–16.1)

Abbreviations: ICC, intraclass correlation coefficient; CI, confidence intervals; CV, coefficient of variation; REC, Recovery; LIA, low-intensity activities; MIA, medium-intensity activities; HIA, high-intensity activities.

>1.20–2.0, *large*; >2.0–4.0, *very large*; >4.0, *extremely large* [27]. Statistical significance was set at $P < 0.05$. All statistical analyses were conducted using the *lme4*, *lmerTest* and *compute.es* packages in R statistical software (version 3.6.2) [28].

RESULTS

Guards, forwards, and centres spent 11.9±5.9%, 3.5±1.3%, and 2.9±1.1% of live playing time in possession of the ball, respectively. Pairwise comparisons between positions showed that a greater proportion of live playing time was spent in possession of the ball for guards compared to forwards ($P < 0.001$, estimated ±95%CL = 7.95±3.04, ES±95%CL = 1.39±0.59, *large*) and centres ($P < 0.001$, 8.68±3.69, 1.58±0.75, *large*). No significant differences in the proportion of live playing time in possession of the ball were found between forwards and centres ($P = 0.71$, 0.13±0.72, 0.73±3.95, *moderate*).

Mean±SD for each game activity variable when in possession of the ball and during live playing time according to playing position are presented in Table 2. Statistical outcomes for positional comparisons in game activities when in possession of the ball are presented in Table 3. When in possession of the ball, guards performed more total activities per minute compared to forwards (all $P < 0.05$, ES range: 0.67–1.38, *moderate-large*) and centres (all $P < 0.05$, ES range: 0.74–1.63, *moderate-large*). Non-significant differences (ES range: 0.06–0.25, *trivial-small*) were evident in activity frequencies when in possession of the ball between forwards and centres. Furthermore, the percentage of time spent performing HIA when in possession of the ball was greater for forwards ($P = 0.001$, ES±95%CL = -1.02±0.57, *moderate*) and centres ($P = 0.001$, -1.21±0.72, *large*) compared to guards. Conversely, guards spent a greater proportion of time performing LIA when in possession of the ball compared to centres ($P = 0.002$, 1.10±0.72, *moderate*) and MIA compared to both forwards ($P = 0.003$, 0.85±0.56, *moderate*) and centres ($P = 0.001$, 1.17±0.72, *moderate*).

Statistical outcomes for positional comparisons in game activities during live playing time are presented in Table 4. Regarding live playing time, centres performed more HIA per minute ($P = 0.049$, -0.68±0.69, *moderate*) and spent a greater proportion of time performing HIA ($P = 0.047$, -0.69±0.69, *moderate*) compared to guards. Non-significant, *trivial-moderate* differences were observed between positions for all other comparisons in game activities during live playing time.

TABLE 2. Frequency and duration of game activities according to playing position when in possession of the ball and during live playing time in professional, male basketball players.

	REC	LIA	MIA	HIA	All movements
			In possession of the ball		
			Frequency (n/min)		
Guards	1.17±0.64	1.70±1.01	0.84±0.49	1.18±0.48	4.88±2.02
Forwards	0.51±0.29	0.55±0.29	0.22±0.17	0.89±0.36	2.16±0.67
Centers	0.60±0.29	0.38±0.23	0.15±0.11	0.86±0.37	1.99±0.72
			Duration (%)		
Guards	28.3±10.7	34.6±13.9	18.0±9.2	19.0±13.2	-
Forwards	25.9±11.3	28.2±11.9	10.7±7.8	35.2±16.0	-
Centers	33.5±16.1	21.5±10.8	8.3±6.4	36.7±11.4	-
			Live playing time		
			Frequency (n/min)		
Guards	6.55±0.88	11.37±1.59	3.81±1.26	3.47±1.46	25.20±3.62
Forwards	6.00±1.09	10.99±1.16	3.42±1.01	3.54±1.27	23.95±2.84
Centers	5.82±1.41	10.52±1.21	3.43±1.01	4.23±1.55	24.01±2.27
			Duration (%)		
Guards	36.6±8.0	44.4±6.4	10.6±3.6	8.4±4.2	-
Forwards	35.6±9.7	45.3±4.6	10.1±3.2	9.0±3.7	-
Centers	36.1±11.6	42.7±6.2	10.4±3.7	10.8±5.3	-

Abbreviations: REC, recovery; LIA, low-intensity activities; MIA, medium-intensity activities; HIA, High-intensity activities.
Note: Live playing time encompasses game activities when players were on the court and the clock was running.

TABLE 3. Comparison in frequency and duration of game activities when in possession of the ball between playing position in professional, male basketball players.

	Guards vs. Forwards			Guards vs. Centers			Forwards vs. Centers		
	Estimate ±95% CI	**ES±95% CI**	***P* value**	**Estimate ±95% CI**	**ES±95% CI**	***P* value**	**Estimate ±95% CI**	**ES±95% CI**	***P* value**
				Frequency (n/min)					
REC	0.60±0.34	0.94±0.56	**0.001**	0.55±0.42	0.88±0.70	**0.013**	-0.06±0.45	-0.09±0.72	0.805
LIA	1.04±0.49	1.13±0.57	**<0.001**	1.27±0.60	1.42±0.74	**<0.001**	0.23±0.64	0.25±0.72	0.475
MIA	0.60±0.23	1.38±0.59	**<0.001**	0.69±0.28	1.63±0.76	**<0.001**	0.09±0.30	0.20±0.72	0.572
HIA	0.31±0.25	0.67±0.55	**0.017**	0.34±0.31	0.74±0.69	**0.033**	0.03±0.32	0.06±0.72	0.861
All movements	2.53±1.05	1.28±0.58	**<0.001**	2.88±1.28	1.51±0.75	**0.000**	0.35±1.17	0.18±0.72	0.613
				Duration (%)					
REC	1.46±7.74	0.10±0.53	0.709	-6.32±9.47	-0.45±0.69	0.191	-7.77±10.11	-0.54±0.73	0.133
LIA	5.98±6.70	0.48±0.54	0.082	13.74±8.37	1.10±0.72	**0.002**	7.76±8.85	0.62±0.73	0.088
MIA	7.22±4.55	0.85±0.56	**0.003**	9.85±5.66	1.17±0.72	**0.001**	2.63±6.00	0.31±0.72	0.386
HIA	-15.19±7.92	-1.02±0.57	**0.001**	-17.72±9.86	-1.21±0.72	**0.001**	-2.53±10.45	-0.17±0.72	0.631

Abbreviations: ES, effect size (values above zero: greater for guards compared to forwards and centers or greater for forwards compared to centers); CI, confidence intervals; REC, Recovery; LIA, low-intensity activities; MIA, medium-intensity activities; HIA, high-intensity activities.
Note: *P* value is bolded when < 0.05.

TABLE 4. Comparison in frequency and duration of game activities during live playing time between playing position in professional, male basketball players.

	Guards vs. Forwards			Guards vs. Centers			Forwards vs. Centers		
	Estimate ±95% CI	**ES±95% CI**	***P* value**	**Estimate ±95% CI**	**ES±95% CI**	***P* value**	**Estimate ±95% CI**	**ES±95% CI**	***P* value**
				Frequency (n/min)					
REC	0.44±0.74	0.31±0.53	0.245	0.71±0.90	0.53±0.69	0.124	0.27±0.96	0.20±0.72	0.579
LIA	0.35±0.87	0.21±0.53	0.431	0.82±1.07	0.52±0.69	0.133	0.47±1.14	0.29±0.72	0.412
MIA	0.45±0.64	0.38±0.54	0.166	0.26±0.78	0.22±0.68	0.517	-0.19±0.84	-0.16±0.72	0.644
HIA	-0.00±0.80	0.00±0.54	0.995	-0.99±0.98	-0.68±0.69	**0.049**	-0.99±1.05	-0.67±0.74	0.066
All movements	1.26±1.72	0.39±0.54	0.153	0.80±2.11	0.25±0.67	0.452	-0.46±2.25	-0.14±0.72	0.687
				Duration (%)					
REC	0.48±6.19	0.04±0.53	0.878	1.46±7.52	0.13±0.68	0.700	0.98±8.05	0.09±0.72	0.809
LIA	-0.95±3.92	-0.13±0.53	0.631	1.75±4.76	0.25±0.68	0.467	2.70±5.10	0.37±0.72	0.297
MIA	0.80±2.01	0.21±0.53	0.430	-0.03±2.46	-0.01±0.67	0.981	-0.83±2.62	-0.22±0.72	0.531
HIA	-0.40±2.52	-0.09±0.53	0.751	-3.16±3.08	-0.69±0.69	**0.047**	-2.75±3.29	-0.59±0.73	0.102

Abbreviations: ES, effect size (values above zero: greater for guards compared to forwards and centers or greater for forwards compared to centers); CI, confidence intervals; REC, Recovery; LIA, low-intensity activities; MIA, medium-intensity activities; HIA, high-intensity activities.
Note: *P* value is bolded when < 0.05.

DISCUSSION

This is the first study providing normative data representing the activity demands encountered by basketball players when in possession of the ball. Furthermore, the present study presents the most comprehensive set of available data (44 players, 70 game samples) describing player game activity according to playing position across live playing time. Generally, playing position influenced player activity when in possession of the ball. Specifically, guards performed more activities at all intensities than forwards and centres (*moderate-large* ES), while the proportion of time spent undergoing HIA was greater for forwards and centres compared to guards (*moderate-large* ES). Conversely, the activity demands during live playing time

(irrespective of being in possession of the ball) were similar between playing positions (*trivial-small* ES), except for centres, who more frequently performed and spent a greater proportion of time performing HIA than guards (*moderate* ES).

A thorough understanding of the physical activities performed when players are in possession of the ball is fundamental for developing specific individual and team-based drills during basketball training. As expected, guards spent the greatest time in possession of the ball (*large* ES) as they are required to dribble from the defensive to the offensive half-court during transitions with the overall aim of driving fast breaks or leading offensive plays [18]. As such, guards are usually selected according to their physical characteristics (e.g. agility and ability to sustain high-intensity efforts and changes of direction) and technical skills (e.g. shooting, passing, and dribbling) [20, 29, 30]. In line with the results of the present study, Scanlan et al. [8] showed that guards were in possession of the ball, executing only dribbling tasks, for a greater proportion of live time during games than frontcourt players (i.e. forwards and centre) (~9.0% vs ~1.5% of live playing time). However, this is the first study quantifying all scenarios when players are in possession of the ball, not strictly dribbling activities as previously quantified [8, 9].

The specific physical demands encountered when in possession of the ball were greatly affected by playing position. In this regard, guards performed more than double the activities per minute in possession of the ball than forwards and centres (~5 vs ~2 n/min; *large*), reinforcing their importance in pushing the ball and keeping the pace/tempo of the offensive play [18]. Furthermore, we found that guards completed more REC, LIA, MIA, and HIA per minute than forwards and centres when in possession of the ball (*moderate-large* ES). These findings are likely a consequence of the greater proportion of time spent in possession of the ball by guards, highlighting the importance of developing position-specific drills for guards dribbling at various intensities with frequent changes in movement type.

When comparing the proportion of time spent performing different game activities in possession of the ball, guards performed a *moderately* greater proportion of LIA compared to centres and a *moderately* greater proportion of MIA compared to both forwards and centres. However, forwards and centres spent ~35% of time in possession of the ball performing HIA, which is considerably higher (*moderate-large* ES) than the 19±13% of time in possession of the ball spent by guards performing HIA. This result is likely a consequence of the existing differences in technical and physical characteristics of players occupying different playing positions [20, 30] and may also be attributed to the tactical strategies adopted across teams [18]. For example, forwards and centres are not typically involved in driving the ball across the court during transitions at varied intensities, and therefore when they gain possession of the ball they carry out rapid, intense movements (e.g. making an offensive move to score, securing a rebound). In support of this notion, when further analysing the different types of activities constituting HIA in the present study, forwards (14.3%) and centres (15.2%) spent roughly three times as much time jumping when in possession of the ball compared to guards (5.1%), and approximately double the proportion of time performing specific movements at high intensities (forwards = 21.0%; centres = 14.6%) when in possession of the ball compared to guards (8.3%). Considering that this is the first study to describe the activity demands performed when in possession of the ball during basketball games, comparison of the findings with previous studies is not possible. Future studies should investigate the activity demands carried out when in possession of the ball during basketball games across various player samples (e.g. youth, female, and amateur players) and using the time course of specific actions (e.g. fast break, isolations, ball screens) to further expand the evidence base on this topic.

The present study also investigated differences in game activity demands between playing positions overall during live playing time (irrespective of being in possession of the ball). A few studies [8, 23] have described differences in physical demands between playing positions during professional, male basketball games. Despite the practical limitations associated with use of TMA (i.e. time- and labour-intensive data analysis and interpretation), this approach has been readily adopted in the literature to quantify the activity demands encountered by players during basketball games, as the use of microsensors is not always permitted [3, 31]. The results of the present study demonstrate that centres perform greater HIA per minute and spend a greater proportion of time performing HIA compared to guards (*moderate* ES) during live playing time in games. Accordingly, García et al. [23] recently reported that professional Spanish centres perform more jumps and reach greater peak velocities (measured with microsensors) than professional Spanish guards during official games. In line with this finding, the centres in the present study performed a greater number of jumps (1.39 vs 0.94) and high-intensity specific movements per minute (2.19 vs 1.63) compared to guards. In addition, the proportion of live time spent performing HIA was *moderately* greater for centres than guards, likely as a consequence of the larger contribution of high-intensity specific movements (6.6% vs 4.6%) and jumps (2.2% vs 1.5%) performed by centres compared to guards. While several physical (e.g. strength and power production) and technical-tactical (e.g. technical skill and coaching staff decisions) factors contribute to basketball performance, these results confirm the importance of sustaining high-intensity efforts during professional basketball games. Consequently, basketball practitioners are encouraged to consider the pronounced differences between playing positions. Specifically, the greater number of movements performed at high intensities and the higher proportion of time spent carrying out intense movements such as screening, positioning to secure rebounds, and 1-on-1 situations likely underpin the *moderately* greater HIA performed by centres compared to guards across live playing time. Guards are usually less involved in scenarios involving high-impact body contact and collisions with opponents than forwards and centres [23]. Consequently, basketball practitioners should

include position-specific exercises at high intensities during training drills to ensure that players are prepared to meet the game demands likely to be encountered.

There are some limitations of the present study that must be acknowledged. First, despite TMA representing a valid [2, 3, 24] and reliable [4, 24] approach to quantify game demands, issues may arise from the qualitative definition of player activity classifications. Hence, future studies should adopt other available technologies (e.g., wearable microsensors) to further explore differences in playing positions on this topic. Second, the recruited basketball players in this study were competing in the same male national tournament, and therefore the findings might not be generalizable to basketball players competing in other male or female competitions. Third, activity demands were determined as average values across entire games in the present study. Thus, this positional differences in game activities representing the most demanding passages of the play (worst-case scenario) were not explored.

PRACTICAL APPLICATIONS

The present study permits some useful evidence-based practical recommendations to be generated. Accordingly, the large data set we provided regarding game activity frequencies and durations for professional, adult, male basketball players may permit more precise conditioning exercises to be developed by high-performance staff for optimal player preparation across different seasonal phases. Furthermore, basketball practitioners could consider the data we provided indicating player activity demands strictly when in possession of the ball for the development of individual and team-based training sessions. Specifically, when training offensive skills in possession of the ball, forwards and centres should perform the required tasks at high intensities (e.g. 1-on-1 play on a quarter court or rebound exercises), while guards should develop their dribbling ability at both higher (e.g. sprinting, accelerating, decelerating, and changing directions) and lower (e.g. stationary or low-velocity dribbling skills) intensities. In contrast, when considering the activity demands encountered by players during live playing time overall across games, considerable overlap exists across positions, and therefore subsequent positional training plans are likely to possess overlap across positions when administered in team environments. However, drills for centres should specifically focus on developing high-intensity specific movements, body contacts, collisions, and jumps given the heightened HIA demands observed in this position, while guards should spend sufficient time performing varied exercises with the ball given the high proportion of playing time they spend in possession.

CONCLUSIONS

The activity demands encountered when in possession of the ball and overall during live playing time in adult, professional basketball games are affected by playing position. When in possession of the ball, guards perform more activities at all intensities per minute than forwards and centres, while the proportion of time spent at high intensities is greater for forwards and centres compared to guards. The activity demands overall during live playing time (irrespective of being in possession of the ball) are similar between playing positions, except for centres, who more frequently perform and spend a greater proportion of time performing HIA than guards. These data highlight the need to develop position-specific training drills, particularly when in possession of the ball.

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Conflict of interest declaration

The authors report no conflict of interest for this manuscript.

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