Fluctuations in Activity Demands Across Game Quarters in Professional and Semiprofessional Male Basketball

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Abstract

Scanlan, AT, Tucker, PS, Dascombe, BJ, Berkelmans, DM, Hiskens, MI, and Dalbo, VJ. Fluctuations in activity demands across game quarters in professional and semiprofessional male basketball. *J Strength Cond Res* 29(11): 3006–3015, 2015—Examination of activity demands and stoppage durations across game periods provides useful insight concerning fatigue, tactical strategies, and playing pace in team sports such as basketball. Therefore, the aims of this study were to quantify and compare game activity fluctuations across quarters in professional and semiprofessional basketball players. Video-based time-motion analyses were conducted across multiple games. Frequencies, total durations (in seconds), total distances (in meters), and mean velocities (in meters per second) were calculated for low-intensity movement ($\leq$3 m·s^{-1}), high-intensity movement ($>$3 m·s^{-1}), shuffling, and dribbling activity. Frequencies were determined for jumping and upper-body activity; stoppage durations were also calculated. Separate repeated-measures analysis of variance and Cohen's d were used to identify significant differences and quantify the effect sizes between game quarters for all outcome measures, respectively. Pearson correlation analyses were performed to determine the relationship between stoppage duration and all activity measures. The results showed significantly ($p \leq 0.05$) reduced dribbling (3.09 ± 0.03 m·s^{-1} vs. 2.81 ± 0.01 m·s^{-1}) and total (2.22 ± 0.04 m·s^{-1} vs. 2.09 ± 0.03 m·s^{-1}) activity velocities during the third compared with the first quarter in professional players. Furthermore, effect size analyses showed greater decreases in high-intensity (professional: d = 1.7–5.4; semiprofessional: d = 0.3–1.7), shuffling (professional: d = 2.3–3.2; semiprofessional: d = 1.4–2.1), and total (professional: d = 1.0–4.9; semiprofessional: d = 0.3–0.8) activity and increases in dribbling (professional: d = 1.4–4.7; semiprofessional: d = 2.5–2.8) with game progression in professional players. In semiprofessional players, stoppage duration was significantly ($p \leq 0.05$) related to various low-intensity (R = 0.64–0.72), high-intensity (R = 0.65–0.72), and total (R = 0.63–0.73) activity measures. Although not directly measured, the observed game activity fluctuations were likely because of a combination of physiological (e.g., muscle glycogen depletion, dehydration), tactical (e.g., ball control, game pace), and game-related (e.g., time-outs, player fouls) factors. Basketball coaches can use the provided data to (a) develop more precise training plans and management strategies, (b) elevate semiprofessional player performance closer to the professional level, and (c) incorporate tactical strategies to maximize the benefits of stoppages.

Key Words court sport, fatigue, tactics, time-motion analysis, playing level

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Introduction

Basketball is a popular court-based sport with participation rates ranking first among males in the United States (35). This high participation rate has led to the development of many basketball competitions, from amateur to professional levels. Accordingly, the application of sport science to basketball settings has grown in recent times, leading to an increased number of investigations aimed at quantifying the game demands imposed on players. The demands of basketball game play have primarily been quantified through measurement of players' physiological responses (e.g., heart rate, blood metabolite concentrations, blood hormonal concentrations) (4,24,25,29,37). Although physiological measures provide useful insight regarding the internal responses of players, inferences can only be made about the external demands experienced by players across games using these data. The measurement of players' activity levels during basketball game play offers a direct evaluation of the external requirements of the sport (10).

Although video-based time-motion analyses (TMAs) have been readily performed to quantify the activity demands of basketball game play, existing data are largely limited to (a) female players (12,19,26,31), (b) junior (3,5,7,18) and senior (36) players, or (c) practice games (20,25,35). Given the influence of gender (6,14), age (6), and competition setting (24) on player responses during basketball game play, much of the existing data are not transferrable to adult male players. A better understanding of the activity demands associated with competitive adult male basketball game play is needed given the high popularity and growing professionalism of men's basketball leagues around the world (e.g., National Basketball Association in the United States, Euroleague in Europe, National Basketball League (NBL) in Australia). Accordingly, Scanlan et al. (30) provided a comprehensive comparison of match activity demands in elite and subelite adult male basketball players. The results from this study suggest that varied proportions of game time are spent performing at low (30–42%), moderate (53–68%), and high intensities (2–5%) during games, and players change movement intensity approximately every 1.0 seconds (30). Moreover, these demands were shown to vary across playing levels, with greater intermittent jogging and running demands and less walking and sprinting observed in elite players compared with subelite players (30). However, while demonstrating playing level differences and providing a useful understanding of game activity demands in adult male basketball, previous activity data encompass entire adult male games. Therefore, these analyses provide little detail concerning the fluctuations in activity workload that occur across playing periods relative to playing level.

The variability in game demands, particularly in high-intensity activity across playing periods, has been suggested to indicate game-related fatigue and identify tactical trends during team sport competition (7,13,27). Specifically in basketball, equivocal observations have been made concerning game-related fluctuations in activity demands during adult female (19,26) and junior male (5,7) game play. Previously, no changes in activity demands across playing periods have been reported for females competing in the professional British (19) and Japanese (26) competitions. In contrast, significant increases in standing/walking activity, and significant decreases in high-intensity activity with game progression, have been reported in semiprofessional Australian female basketball players (31) and elite junior Tunisian male basketball players (5,7), respectively. Consequently, current evidence suggests that gender and playing level are likely to influence the variations in player activity during basketball game play. However, game-related fluctuations in activity demands for adult male basketball players remain undescribed, with existing data only detailing activity profiles across entire games (30). Thus, greater research attention should be directed toward the assessment of the fluctuations in activity demands during adult male basketball games across varied playing levels.

Existing empirical research has frequently examined the anthropometrical (3,21), physiological (3,29), and activity (3,30) differences between basketball playing levels. However, to the authors' knowledge, only 1 study has compared the fluctuations in game activity demands across playing levels in male basketball players (3). Ben Abdelkrim et al. (3) stated that national junior Tunisian male basketball players experienced greater decrements in high-intensity activity across games when compared with international players. The authors postulated various physiological (e.g., muscle glycogen depletion, temperature elevation, activity-induced muscle damage) and tactical (e.g., increased offensive control, reduced fast-break transitions) factors as underlying mechanisms for the observed fluctuations in game activity across playing levels. These observations contrast the general consensus made for field-based team sports, with greater high-intensity requirements and earlier appearances of fatigue promoting greater declines in performance across game periods at higher playing levels (1,22,33). Discrepancies between basketball and field-based team sports might, however, be because of the limited data available for basketball game play (3) but more importantly differences in the movement patterns and activity demands across games (32). Basketball game play involves frequent stoppages because of game rules and regulations, including time-outs, free throw shooting, player fouls, and out-of-bounds instances. The quantity of stoppage time encountered across basketball competition has been proposed to influence recovery opportunity for players, which in turn might affect activity outputs across game periods (20). Thus, further investigation comparing game activity fluctuations across playing periods between playing levels and considering game stoppage duration is warranted in adult male basketball players.

These data will provide specific insight regarding fluctuations in activity demands and the influence of stoppage duration on activity outputs in adult male basketball players. In turn, an understanding of these responses permits basketball coaches and conditioning professionals to (a) develop more precise conditioning practices to optimize player performance across specific game periods, (b) identify benchmark performance indicators at the professional and semiprofessional level, and (c) develop strategies that make best use of game stoppages for optimal maintenance of player performance across games. Therefore, the aims of this study were to (a) quantify the variation in activity demands experienced across playing periods in adult male basketball players, (b) compare game activity fluctuations between professional and semiprofessional playing levels, and (c) examine the influence of stoppage duration on activity measures during game play. It was hypothesized that (a) decrements in high-intensity and total activity would be apparent across game quarters in professional and semiprofessional basketball players, (b) greater decrements in activity output would occur in the semiprofessional players, and (c) stoppage duration would be related to high-intensity and total activity output across both playing levels.

Methods

Experimental Approach to the Problem

A within-subject observational study design was used to assess fluctuations in activity demands across game quarters for each playing level. Activity outputs were calculated and compared between game quarters independently for each playing level. Furthermore, separate correlational analyses were conducted between stoppage duration and activity measures for each playing level. Video-based TMA procedures were administered to capture player activity during official competition games in professional and semiprofessional adult male basketball players. Professional players were filmed across 2 games, 1 at midseason and 1 toward the end of the 6-month season. Semiprofessional players were filmed across 3 games, 1 at the start, 1 at the middle, and 1 toward the end of the 4-month season. All games consisted of four 12-minute quarters, with 2-minute interquarter breaks and a 10-minute half-time break.

Subjects

Professional ($n = 10$; age: 28.3 ± 4.9 years; age range 22–37 years; body mass: 97.0 ± 13.9 kg; stature: 197.4 ± 8.3 cm) male players competing in the Australian NBL and semiprofessional ($n = 12$; 26.1 ± 5.3 years; age range 18–36 years; 85.9 ± 13.2 kg; 191.4 ± 7.6 cm) male players competing in the Australian State Queensland Basketball League (QBL) volunteered to participate in this study. The NBL is the highest level of competition in Australia, whereas the QBL forms part of a second-tier competition each played during different periods of the year. To be included in the study, players had to actively participate in at least 1 of the analyzed games, which meant they were registered players with the NBL or QBL and free from any contraindications that prevented them from playing.

Before participation, all players had completed independent preseason conditioning programs consisting of a combined training plan of agility, plyometric, anaerobic, and endurance components. All players were completing 3 sessions of training (approximately 6 hours in total) and participating in a maximum of 2 official games per week for the duration of the study. During the weeks of video data collection, only 1 game was completed. Experimental procedures were fully explained to the subjects, and informed consent was obtained from all subjects before commencing data collection. Before video data collection, each player had their body mass and height measured using calibrated electronic scales (Tanita Corp., Tokyo, Japan) and a portable stadiometer (Blaydon, Sydney, Australia). All research procedures were granted prior approval by the Central Queensland University Human Research Ethics Committee.

Procedures

Because of physical limitations of the playing stadia, different video capture methods were used for each playing level. All video data for the professional players were collected using a JVC Everio GZ-HD10 color camcorder (Hagemeyer, NSW, Australia) with a JVC GL-AT30 telephoto conversion lens (Hagemeyer). The camera was at a fixed height (approximately 20 m from the court floor) and distance (approximately 12 m from the sideline) at the halfway point of the court, so that all player activity could be recorded in 1 view. Recordings of professional games were captured at a sample rate of 25 Hz. Video data for the semiprofessional players were collected using 2 wide-angle Basler A602FC color cameras (Basler Vision Technologies, Ahrensburg, Germany). Each camera was fixed at the halfway line at a height of approximately 6 m and distance of approximately 2 m to capture all activity within one half of the court. All semiprofessional game recordings were captured at a sample rate of 7.5 Hz. After video data collection, the frame rate of each video file was normalized to allow comparative analytical procedures to be adopted across playing levels. Each camera view was calibrated using a 4-point transformation using premeasured distance dimensions of the playing area before analysis. Manual frame by frame analysis was used to determine player activity with a customized tracking system (Labview; National Instruments, TX, USA). The calibration process allowed reconstruction of the collected images to account for perspective errors associated with the different camera views, using methods previously described (30). Activity velocity ($m \cdot s^{-1}$) was calculated using the distance data and time between player tracking points (30).

Players were filmed for entire games including all stoppages in play. Activity demands were analyzed only during live game time (7,30,31), and activity categorization was based on activity velocities as per previous basketball TMA methodology (30). Standing/walking ($\leq$1.0 $m \cdot s^{-1}$) and jogging (1.1–3.0 $m \cdot s^{-1}$) activity velocities were grouped as low-intensity activity, whereas running (3.1–7.0 $m \cdot s^{-1}$) and sprinting ($>$7.0 $m \cdot s^{-1}$) activity velocities were grouped as high-intensity activity. These velocity band groupings have been frequently administered in previous team sport TMA studies (27,33). Additionally, all shuffling activity was grouped as 1 category. The determination of jumping, upper-body, shuffling, and dribbling activity was based on the subjective interpretation of the researchers (7,20,30,31). Mean frequency, duration spent (in seconds), and distance traveled (in meters) in each activity category were calculated across each game quarter. Mean activity velocity (meters per second) was also calculated for each activity category and overall across each quarter.

All activity categories were calculated using multidirectional analysis, including backward, forward, and lateral motion (when not deemed to be shuffling). Furthermore, stoppage duration was calculated as the difference between total time (all time on the court excluding interperiod breaks) and live time (game play duration excluding all stoppages, e.g., interperiod breaks, out-of-bounds, free throws, time-outs, fouls) within each quarter for each playing level. Substituted player data were cumulated within each respective position to give a complete activity profile across entire games, rather than relative to playing time (26,30,31). Each activity measure was averaged across the 5 on-court playing positions to overcome the difficulties associated with classifying players who transition between positions based on substitutions made during play (3,8,12,19,20,25,36). All video analyses were performed by a single member of the research team. The intratester reliability of the present TMA methodology has been deemed acceptable with all measures, having displayed adequate intratester reliability (coefficient of variation [CV] = 0–14%; intraclass correlation coefficient [ICC] = 0.84–1.00) for the professional and semiprofessional game procedures (30).

Statistical

Mean and *SD* values were determined for all descriptive and activity measures. The Shapiro-Wilks test and Levene's test for equality verified the normality and homogeneity of variance of the present data before parametric analyses. Separate repeated-measures analysis of variance was used to identify any significant activity differences between game quarters (time effects) independently for each playing level. Bonferroni's post hoc comparisons were used to locate the sources of observed significant interquarter differences for each playing level. Statistical significance was accepted at $p \le 0.05$. Cohen's d was calculated to determine the effect size between playing periods using the following formula: Cohen's $d = (\text{mean}_1 - \text{mean}_2)/SD_{\text{pooled}}$; where $SD_{\text{pooled}} = \sqrt{([SD_1^2 + SD_2^2]/2)}$. The magnitude of Cohen's d was interpreted as trivial <0.2, small 0.2–0.6, moderate 0.6–1.2, large 1.2–2.0, and very large >2.0 (17). Pearson's product-moment correlation coefficients (R) were calculated to measure the relationships between stoppage duration and activity measures across game quarters for each playing level. The criteria used to interpret correlation strength included trivial <0.1, small 0.1–0.3, moderate 0.3–0.5, large 0.5–0.7, very large 0.7–0.9, and almost perfect 0.9–1.0 (17). All statistical analyses were performed using IBM SPSS Statistics (v20.0; IBM Corp., Armonk, NY, USA).

Results

The results for frequency in each activity category for professional and semiprofessional players relative to game quarter are presented in Table 1. Interquarter comparisons revealed no statistically significant frequency differences across game quarters for either playing level in any of the investigated activity categories. Effect size analyses showed large-to-very large decreases in shuffling frequency for professional players (quarters 1–2: $d = 4.4$; quarters 1–4: $d = 3.2$; quarters 2–4: $d = 1.4$; quarters 3–4: $d = 1.3$) and semiprofessional players (quarters 1–4: $d = 1.4$). Furthermore, there was a large decrease observed in high-intensity activity frequency between the first and third quarters in professional players ($d = 1.7$).

Table 1. The frequencies (counts) of various activities performed by professional ($n = 10$) and semiprofessional ($n = 12$) adult male basketball players across game quarters.*

	Low-intensity activity	High-intensity activity	Shuffle	Dribble	Jump	Upper body	Total
Quarter 1							
Professional	444 ± 53	146 ± 16	38 ± 2	9 ± 0	13 ± 0	65 ± 3	715 ± 73
Semiprofessional	281 ± 30	114 ± 7	21 ± 8	9 ± 0	11 ± 0	56 ± 2	492 ± 43
Quarter 2							
Professional	436 ± 37	134 ± 10	31 ± 1	11 ± 0	13 ± 1	68 ± 3	693 ± 42
Semiprofessional	286 ± 35	118 ± 12	15 ± 3	11 ± 1	11 ± 1	54 ± 4	495 ± 42
Quarter 3							
Professional	418 ± 23	121 ± 13	33 ± 6	10 ± 0	11 ± 1	65 ± 4	658 ± 37
Semiprofessional	278 ± 21	112 ± 22	15 ± 4	10 ± 1	12 ± 1	56 ± 7	483 ± 50
Quarter 4							
Professional	433 ± 6	130 ± 11	26 ± 5	11 ± 2	12 ± 1	66 ± 4	678 ± 19
Semiprofessional	291 ± 23	120 ± 26	13 ± 1	10 ± 2	12 ± 1	54 ± 3	500 ± 52

*All data are presented as mean ± *SD*.

Nonetheless, all of these large and very large time effects observed for activity frequencies were not statistically significant for both playing levels.

The durations (in seconds) spent in each activity category across game quarters for each playing level are displayed in Table 2. No statistically significant interquarter differences were apparent between game quarters for either playing level in any activity category. Effect size analyses revealed large-to-very large decreases in high-intensity activity (quarters 1–3: $d = 1.8$; quarters 1–4: $d = 2.9$; quarters 2–4: $d = 5.4$) and shuffling (quarters 1–2: $d = 3.8$; quarters 1–4: $d = 2.4$; quarters 2–4: $d = 1.4$) durations were evident in professional players. Moreover, very large increases in dribbling activity duration were observed across quarters during professional game play (quarters 1–2: $d = 2.5$; quarters 1–3: $d = 4.7$; quarters 1–4: $d = 2.4$). Similarly, large-to-very large decreases in shuffling activity were observed across quarters during semiprofessional game play (quarters 1–2: $d = 1.7$; quarters 1–3: $d = 1.3$; quarters 1–4: $d = 2.1$). In contrast, large-to-very large increases in low-intensity activity (quarters 1–4: $d = 1.5$) and dribbling (quarters 1–2: $d = 2.5$) durations were apparent. Regardless of this, all of these large and very large time effects observed for activity durations were not statistically significant for both playing levels.

The distances (in meters) covered in each activity category across game quarters for each playing level are displayed in Table 3. Although no statistically significant interquarter distance differences were apparent for either playing level in any activity category, effect size analyses revealed large-to-very large decreases in low-intensity activity (quarters 1–3: $d = 6.3$), high-intensity activity (quarters 1–3: $d = 1.9$; quarters 1–4: $d = 3.1$; quarters 2–3: $d = 1.4$; quarters 2–4: $d = 3.2$), shuffling (quarters 1–2: $d = 1.8$; quarters 1–4: $d = 2.3$; quarters 2–4: $d = 1.3$), and total (quarters 1–2: $d = 2.0$; quarters 1–3: $d = 2.1$; quarters 1–4: $d = 4.9$; quarters 2–4: $d = 3.9$) distances in professional players. Furthermore, very large increases in dribbling distance were observed across quarters during professional game play (quarters 1–2: $d = 2.8$; quarters 1–3: $d = 2.7$; quarters 1–4: $d = 2.1$). In semiprofessional players, large-to-very large increases in low-intensity activity (quarters 3–4: $d = 1.5$) and dribbling (quarters 1–2: $d = 2.6$; quarters 1–3: $d = 1.6$) distances were apparent between game quarters. Conversely, large decreases in high-intensity activity (quarters 2–3: $d = 1.7$), shuffling (quarters 1–4: $d = 1.6$; quarters 2–4: $d = 1.7$), and dribbling (quarters 2–3: $d = 1.5$; quarters 2–4: $d = 1.7$) distances were observed between game quarters. All of these large and very large time effects apparent for activity distances were not statistically significant for both playing levels.

The mean velocities in each activity category for professional and semiprofessional players are displayed in Figure 1. Interquarter comparisons revealed professional players worked at significantly reduced dribbling

Table 2. The durations (in seconds) spent performing various activities by professional ($n = 10$) and semiprofessional ($n = 12$) adult male basketball players across game quarters.*

	Low-intensity activity	High-intensity activity	Shuffle	Dribble	Live time	Total time	Stoppages
Quarter 1							
Professional	483 ± 3	193 ± 13	40 ± 2	29 ± 0	745 ± 9	1,387 ± 38	642 ± 29
Semiprofessional	510 ± 24	146 ± 11	31 ± 8	35 ± 2	722 ± 27	1,287 ± 152	565 ± 140
Quarter 2							
Professional	485 ± 4	183 ± 4	34 ± 1	36 ± 4	738 ± 18	1,444 ± 91	706 ± 63
Semiprofessional	523 ± 43	148 ± 10	21 ± 2	43 ± 4	735 ± 45	1,437 ± 300	702 ± 256
Quarter 3							
Professional	490 ± 6	171 ± 12	33 ± 6	39 ± 3	733 ± 23	1,307 ± 60	574 ± 183
Semiprofessional	521 ± 13	144 ± 19	23 ± 4	37 ± 3	725 ± 41	1,229 ± 159	504 ± 124
Quarter 4							
Professional	496 ± 20	166 ± 2	26 ± 8	34 ± 3	722 ± 15	1,267 ± 47	535 ± 62
Semiprofessional	546 ± 23	145 ± 28	18 ± 4	38 ± 4	747 ± 27	1,551 ± 275	804 ± 253

*All data are presented as mean ± *SD*.

TABLE 3. The distances (in meters) covered performing various activities by professional ($n = 10$) and semiprofessional ($n = 12$) adult male basketball players across game quarters.*

	Low-intensity activity	High-intensity activity	Shuffle	Dribble	Total
Quarter 1					
Professional	657 ± 6	843 ± 60	63 ± 8	90 ± 0	1,653 ± 38
Semiprofessional	577 ± 37	805 ± 82	58 ± 30	109 ± 5	1,549 ± 81
Quarter 2					
Professional	642 ± 24	789 ± 31	52 ± 3	108 ± 9	1,591 ± 24
Semiprofessional	583 ± 29	827 ± 37	46 ± 19	145 ± 19	1,601 ± 88
Quarter 3					
Professional	630 ± 1	736 ± 55	56 ± 15	109 ± 10	1,531 ± 72
Semiprofessional	569 ± 20	769 ± 33	41 ± 24	122 ± 10	1,501 ± 166
Quarter 4					
Professional	657 ± 9	705 ± 21	43 ± 9	99 ± 6	1,504 ± 21
Semiprofessional	606 ± 30	812 ± 209	23 ± 3	116 ± 16	1,557 ± 238

*All data are presented as mean ± *SD*.

($F = 9.192$, $p = 0.03$) and total ($F = 11.173$, $p = 0.02$) activity velocities during the third quarter compared with the first quarter. Furthermore, nonsignificant large-to-very large decreases in low-intensity (quarters 1–2: $d = 1.4$; quarters 1–3: $d = 4.4$), high-intensity (quarters 1–3: $d = 2.0$; quarters 1–4: $d = 2.0$), dribbling (quarters 1–4: $d = 4.6$; quarters 2–3: $d = 2.8$; quarters 2–4: $d = 1.4$), and total (quarters 1–2: $d = 2.1$; quarters 1–4: $d = 3.8$; quarters 2–3: $d = 1.7$; quarters 2–4: $d = 5.0$) activity velocities were evident across game quarters in professional players. In addition, nonsignificant large and very large interquarter increases in low-intensity (quarters 3–4: $d = 2.2$) and shuffling (quarters 2–3: $d = 1.7$) activity velocities were observed in professional players. In semiprofessional players, a nonsignificant large decrease in low-intensity activity velocity ($d = 1.6$) and nonsignificant increase in dribbling activity velocity ($d = 1.8$) were found between the first and third quarters.

No statistically significant interquarter differences were evident for stoppage duration for either playing level. Very large nonsignificant decreases in stoppage duration (quarters 1–4: $d = 2.2$; quarters 2–4: $d = 2.7$) were evident across game quarters in professional players. A nonsignificant large increase in stoppage duration ($d = 1.5$) was observed between the third and fourth quarters in semiprofessional players.

Correlation analyses comparing stoppage duration across game quarters with each activity outcome measure revealed significant relationships in the semiprofessional players.

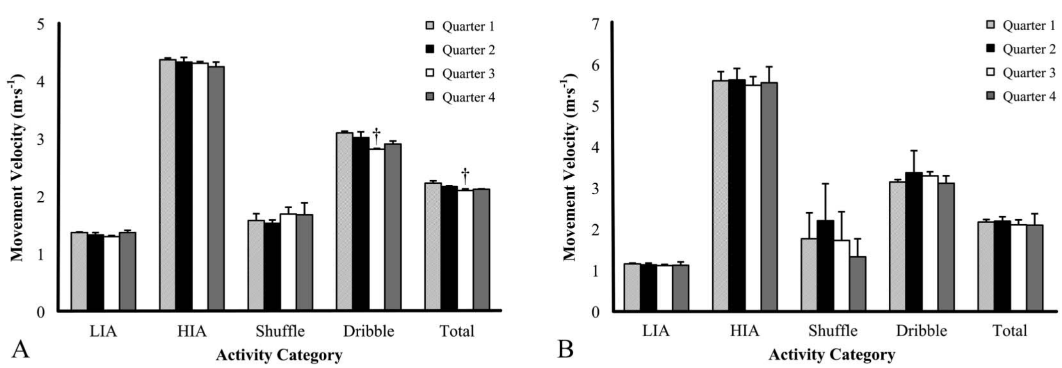

Figure 1. The movement velocities (in meters per second) for various activities performed by (A) professional ($n = 10$) and (B) semiprofessional ($n = 12$) adult male basketball players across game quarters. All data are presented as mean ± *SD*; HIA = high-intensity activity; LIA = low-intensity activity. †Denotes significantly ($p \leq 0.05$) different than quarter 1.

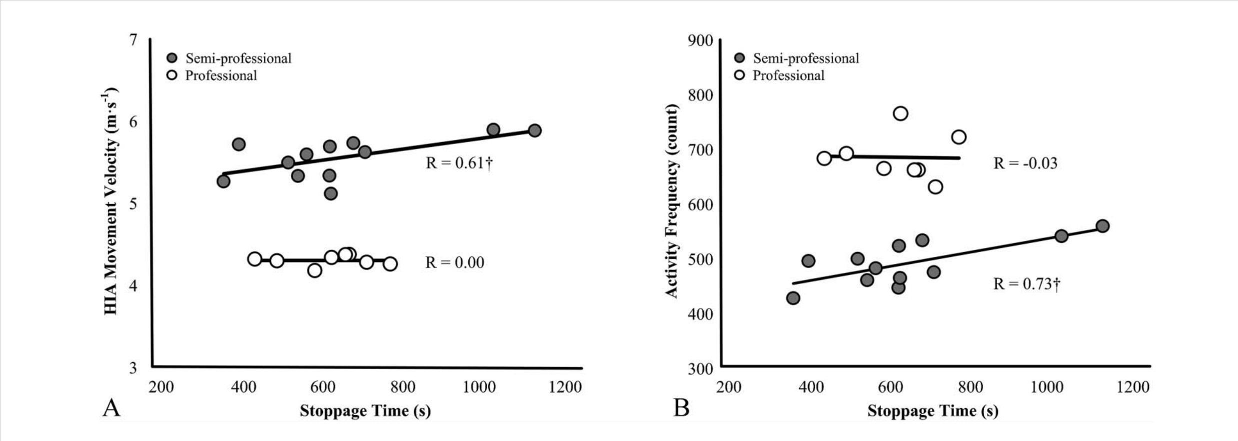

Figure 2. Scatter plots displaying the relationships between game stoppage duration (in seconds) and (A) high-intensity activity (HIA) movement velocity (in meters per second) and (B) total activity frequency (counts) across game quarters during professional ($n = 10$) and semiprofessional ($n = 12$) adult male basketball. †Denotes significant ($p \leq 0.05$) relationship.

Statistically significant large-to-very large correlations were observed between stoppage duration and low-intensity activity distance ($R = 0.69$, $p = 0.01$), duration ($R = 0.64$, $p = 0.03$), and frequency ($R = 0.72$, $p = 0.01$), high-intensity activity frequency ($R = 0.72$, $p = 0.01$) and velocity ($R = 0.65$, $p = 0.02$), as well as total activity frequency ($R = 0.73$, $p = 0.01$) and distance ($R = 0.63$, $p = 0.03$). Scatter plots contrasting the relationships between stoppage duration and high-intensity activity velocity, as well as total activity frequency in professional and semiprofessional players, are shown in Figure 2.

Discussion

This study detailed and compared the activity demands of professional and semiprofessional male basketball across game quarters. Such comparisons have not been previously undertaken during competitive game play in adult male basketball players. Our results suggest that to an extent, professional players experienced greater variation in activity demands when compared with semiprofessional players. Specifically, statistically significant reductions in activity velocities and nonsignificant large-to-very large reductions in high-intensity work and shuffling demands, and increases in dribbling activity, were observed with game progression in professional players. In contrast, infrequent differences were apparent in semiprofessional basketball game play, with relatively consistent work intensities for many activity categories evident across game quarters. Furthermore, stoppage durations appeared to influence the activity demands of semiprofessional players more so than professional players. These results suggest that game fluctuations in activity demands may differ to some extent with playing level, possibly because of the variable effects of fatigue mechanisms, tactical strategy, and competition constraints on game activity.

In this study, although no significant differences in activity distances across game quarters were apparent for either playing level, effect size analyses showed professional players experienced declines in high-intensity activity and total distance covered across game quarters more so than semiprofessional players. These trends, although nonsignificant, concur with those observed in adult athletes competing in other team sports (1,23,33). Previously, greater decrements in high-intensity activity across games in higher level players when compared with lower level players have been reported in rugby league (33) and soccer (1,23). Higher level game play has been suggested to impose increased demands on players during initial game periods, which challenge player fatigue resistance more than lower level game play (1). This notion might explain the trends from this study given previous research has demonstrated greater intermittent and running demands in professional basketball when compared with semiprofessional basketball game play (30). Considering greater work rates during team sport game play has been suggested to lead to earlier fatigue onset (9,13,28), a number of physiological responses might have contributed to the declines in activity work rates presently observed during professional basketball game play including muscle glycogen depletion, temperature elevation, dehydration, inadequate metabolic resynthesis of phosphocreatine and adenosine trisphosphate (ATP), and muscle damage (6,15,33). However, given the practical and regulatory restrictions associated with collecting invasive physiological measures during game play, it is difficult to establish the precise underlying causes of physiological fatigue with game progression. Furthermore, substituted player data were cumulated across games in our analyses, potentially negating the effects of fatigue when players were replaced to permit physiological recovery. Further research is needed to fully elucidate the physiological fatigue mechanisms associated with basketball game play.

Although our findings agree with observations made in other team sports, they contrast those made comparing activity fluctuations relative to playing level in junior male basketball players (3). Previously, Ben Abdelkrim et al. (3) observed greater high-intensity activity decrements during game play in national junior male players compared with international players. The authors attributed these differences to the superior fitness of the international players, demonstrated by a significant relationship ($R = 0.56$, $p \leq 0.05$) between estimated $\dot{V}O_2max$ and time spent performing high-intensity activity (3). Furthermore, the international players also spent longer durations engaged in recovery (low-intensity activity), which has been shown to promote enhanced high-intensity activity performance in basketball players (11). Although physiological fitness characteristics cannot be discounted as contributing factors in our study as they were not investigated, the availability of passive recovery opportunities to players provides some direct insight.

The lower interquarter activity fluctuations in semiprofessional players are also likely to be associated with other game-related factors, namely stoppage duration. The intermittent, high-intensity, and total activity demands during semiprofessional game play were significantly related ($R =$ 0.63–0.73) to stoppage duration. In contrast, professional players exhibited nonsignificant trivial-to-small ($R = -0.03$ to 0.14) relationships between stoppage duration and total activity demands. In past research, similar stoppage durations across game quarters have been reported across international and national playing levels in junior male basketball (3). Conversely, we observed nonsignificant very large decreases in stoppage duration in professional players and a nonsignificant large increase in semiprofessional players with game progression. Both tactical and competition factors likely contributed to these variations, including the use of time-outs and incidence of player fouls. Given game stoppages involve players sitting or standing with limited motion, the increased opportunity for passive recovery in semiprofessional players is likely to have promoted enhanced restoration of phosphocreatine and ATP stores, resulting in improved ability to maintain high-intensity intermittent workloads across games (16). This type of recovery has been shown to offer the greatest benefit in reducing fatigue and improving repeated high-intensity performance in basketball players, possibly because of the reduced oxygen availability from oxidative metabolic recruitment during active forms of recovery and game play (11,34). These findings indicate that stoppage duration primarily influences the ability of players to maintain basketball-specific intermittent work rates at lower playing levels.

In addition to stoppage duration, further game-related tactical factors have been proposed to influence game activity demands relative to playing level in various team sports (1,3,33). Specifically, during basketball game play, it has been suggested that teams attempt to control the ball toward the end of competition, which limits the opportunity of high-intensity play transitions and decreases the overall pace of the game (7). This tactical strategy might have been used by the professional players in this study as there were nonsignificant trends for increases in dribbling duration and significantly reduced dribbling and overall activity velocities with game progression. A greater duration of dribbling activity suggests that ball possession was less distributed among players, whereas lower dribbling and overall velocities might infer that ball transition and player movement were slowed during later game quarters. These data suggest that the professional players adopted a slower offensive tactical approach, and these offensive tactics have been previously associated with higher levels of competitive basketball (i.e., professional), primarily because of teams exerting greater ball control during later game stages (18). However, a combination of activity demands and tactical/statistical data (e.g., ball possessions, offensive plays) should be measured during basketball game play to directly assess the influence of offensive tactics and ball control on player activity.

Some limitations of this study should be acknowledged. First, player activity was not described with the direction of movement, which has been suggested to produce varied physiological and metabolic demands (28). Second, velocity ranges for each activity category were based on previous generalized values described in court-based team sports (2). A more specific, individualized approach to activity velocity categorization should be addressed in future basketball TMA research. Third, the current results are indicative only of the teams investigated, and player responses will vary in other teams and competitions because of differences in player fitness and skills, game score and importance, opponent ability, and tactical strategies. Fourth, because of practical and infrastructure restrictions, only 2 and 3 games were analyzed for the professional and semiprofessional players, respectively. The small number of analyzed games likely contributed to the frequent appearance of large-to-very large effect sizes for interquarter comparisons with limited statistically significant differences. Furthermore, the varied dispersion of analyzed games for each playing level might have differently influenced the cumulative fatigue and thus activity outputs for professional and semiprofessional players across the season. Future investigations should include a matched sample size across playing levels and a greater quantity of games evenly dispersed throughout the competitive season to gather a more definitive representation of game demands. Finally, this study did not provide position-specific data for activity fluctuations across games but instead reported group results across the 5 on-court playing positions. Further research should quantify the fluctuations in activity demands across playing periods relative to playing position to precisely identify game-related responses in guards, forwards, and centers.

This study is the first to quantify game activity demands relative to playing period and compare game activity fluctuations between playing levels in adult male basketball. The professional basketball players experienced significant declines in dribbling and total activity velocities with game progression. Although nonsignificant, effect size analyses also showed trends for greater decreases in high-intensity movements and shuffling activity across games in professional players than semiprofessional players. The observed trends relative to playing level were possibly attributed to physiological fatigue-related mechanisms, tactical factors, and game-related aspects. In particular, stoppage duration appeared to significantly influence the maintenance of activity work rate in the semiprofessional players.

Practical Applications

This study offers important practical value to basketball players, coaches, and conditioning professionals. First, the provided data permit more precise approaches to player conditioning in adult male basketball players. The present quantification of fluctuations in game activity demands helps identify deficits across games, which allows conditioning professionals to optimally configure training movements, intensities, and durations in the annual conditioning plan to enhance the preparedness of players for the demands of competition across game quarters. For example, the nonsignificant but large-to-very large declines in shuffling activity could provide important insight for the development of shuffling-specific endurance drills, so players are better able to maintain this type of activity across games. Second, comparisons between playing levels help establish benchmark performance indicators. Our findings can be used by semiprofessional coaches to implement training plans and game tactics to elevate player and team performance closer to the professional level. Third, the present data assist coaches in strategically developing player recovery and substitution strategies. Nonsignificant large and very large reductions in activity intensity were evident across the third and fourth quarters, indicating coaches should explore half-time interventions and second-half substitution patterns to assist player recovery and maintenance of activity intensity. Fourth, the significant large-to-very large correlations between stoppage durations and player activity during semiprofessional games indicate that basketball coaches at this level can strategically use player fouls and time-outs to manipulate passive recovery opportunity for players and promote better maintenance activity outputs at key stages of games.

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