Changes in External Load When Modifying Rules of 5-on-5 Scrimmage Situations in Elite Basketball

Jairo Vazquez-Guerrero,[1] Xavi Reche,[1] Francesc Cos,[1] David Casamichana,[2] and Jaime Sampaio[3]

[1]*Sport Performance Department, FC Barcelona Sports, Barcelona, Spain;* [2]*European Atlantic University, Santander, Spain; and* [3]*CreativeLab Research Community, Research Center in Sports Sciences, Health Sciences and Human Development, CIDESD, Portugal*

Abstract

Vazquez-Guerrero, J, Reche, X, Cos, F, Casamichana, D, and Sampaio, J. Changes in external load when modifying rules of 5-on- 5 scrimmage situations in elite basketball. *J Strength Cond Res* XX(X): 000–000, 2018—Constraining tasks are very frequent during the team sports training process; however, most of the effects of these coaching decisions are unknown, which leads to less controlled performing environments, with less chances to promote improvements. The aim of this study was to determine the effects of modifying rules of 5-a-side scrimmage on the physical performance of professional basketball players. Data were collected from 12 elite male players (age, 29.6 ± 4.5 years; height, 1.99 ± 9.6 cm; body mass, 92.1 ± 11.9 kg) from the Spanish first Division of Basketball during thirty-three 5-on-5 scrimmage situations over a 18-week period. Physical demands were assessed using WIMU PRO Local Positioning System (Realtrack Systems, Almeria, Spain) and included total and speed-ranged distance covered, player load, peak speed, number of high-intensity actions, number of total and high-intensity accelerations and decelerations, and peak acceleration. A repeated-measures analysis of variance was used to test the differences in all variables, considering playing in half-court (HALF), half-court and transition (HTRAN), and full-court (FULL) conditions for the 5-on-5 scrimmage drill. Results showed that during the HALF condition, there was less distance covered (effect size [ES] = 3.55), lower peak speeds (ES = 3.00), less player load (ES = 2.79), lesser number of high-intensity actions (ES = 1.45), and lesser number of high-intensity accelerations (ES = 1.44) and decelerations (ES = 1.31) than in FULL. In HTRAN, players covered more distance (ES = 2.42), presented higher player load (ES = 1.88), higher intensity actions (ES = 1.02), and peak speed (ES = 4.22) than in HALF. In conclusion, physical demands can be modulated changing the rules and court size using 5-on-5 scrimmage situations, and this factor should be taken into account when designing training drills and when fine-tuning periodization.

Key Words monitoring, training load, local positioning measurement, team sports

Address correspondence to Jairo Vazquez-Guerrero, jairo.vazquez@fcbarcelona.cat.

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Introduction

Basketball is a very complex and dynamic team sport where the decision-making process (2) is combined with intermittent and multidirectional explosive actions, such as sprints, changes of direction, jumps, accelerations, and decelerations (5). In fact, basketball has substantial physiological and neuromuscular demands (27), comprising around 1,000 actions (5) of which 11.5% require maximum intensity (6). The duration of high-intensity actions ranges between 2 and 5 seconds (18), with a mean work-to-rest ratio of 1:10 when considering maximum effort actions (6,18,27). Understanding of these physical and physiological demands encountered during basketball competition has allowed to improve player preparation.

Time-motion analysis in basketball has been almost exclusively performed with research purposes, using video-based methodologies that are really time consuming. In the past years, outdoor team sports, like soccer and rugby, have advanced in the topic of describing competition and training demands because of the massive usage of global positioning systems (GPS) systems (35) that enable researchers and coaches to collect high volumes of data. Thus, there were substantial progresses under the topic of identifying the physical and physiological performances demanded either by the game or by any specific training drills (9,16).

In indoor sports like basketball, the performances under these constraint-imposed changes during ball drills are scarcely known, probably because of the lack of monitoring devices capable of providing valid and reliable data. However, recent technological advances have provided the possibility to track players indoor using local positioning systems, most of them providing higher validity and reliability than standard GPS units (15,22,29). Having these possibilities, current hot topics in research are focused in better understanding the physical and physiological demands during the most frequently used training tasks (33). In fact, game-based conditioning, such as ball drills or small-sided games, are often considered as an appropriate training methodology (16), as they combine specific technical, tactical, cognitive, and physical demands into the same performing environment. In fact, basketball coaching staffs can modulate the physiological and technical demands of ball drills, for example, by changing different variables such as the number of players (8,11,12,23), specific rules (11), court dimensions (1,20), and number and duration of task repetitions (11,20).

Available research using local positioning measurement technology has identified the effects of defensive pressure on technical actions and time-motion variables in basketball. The time-motion analysis presented similar results between defensive conditions (full-court, half-court, and quarter court), showing a total distance covered of around 90 $m \cdot min^{-1}$. There was more distance covered while jogging in the offensive court (38.15 ± 12.17 $m \cdot min^{-1}$ offensive court vs. 32.94 ± 10.84 $m \cdot min^{-1}$ defensive court) and more distance covered while running in the defensive court (16.41 ± 10.27 $m \cdot min^{-1}$ offensive court vs. 19.56 ± 10.29 $m \cdot min^{-1}$ defensive court) (31). There was another study using these procedures to provide evidence on how changing the level of defensive pressure promotes different collective behaviors (21). Although these studies present novel information, they are limited to the usage of nonprofessional players. In fact, the difficulties in congregating access to high-precision measuring equipment with the availability of high-level players are still evident, and this probably explains the scarcity of research using professionals.

For example, in professional players, a 5-on-5 scrimmage basketball training drill in different court sizes is considered to mimic game performance requirements and, therefore, appropriate to improve these aspects of performance. Unfortunately, all available information about these situations is anecdotal, and there is no research available that describes the demands of these spatial task constraints in professional male basketball players. Therefore, the aim of this study was to determine whether the rules during 5-on-5 scrimmage basketball drills had any effect on players' physical responses. Knowing these results will probably be a contribution to better understand the dose-response mechanism of these training tasks in a way to allow fine-tuning periodization according to the level of congested fixtures calendars.

Methods

Experimental Approach to the Problem

The 5-on-5 scrimmage was used to examine the between-formats differences in 3 conditions: half-court (HALF), half-court and transition (HTRAN), and full-court (FULL). A nonexperimental, descriptive, comparative design was used to examine the differences between formats and to determine physical demands on the players. Comparisons were performed examining male professional basketball players during the competitive season (2016–2017), collecting data from a Spanish basketball team over a 18-week period. The players' physical demands were assessed using WIMU PRO Local Positioning System (Realtrack Systems, Almeria, Spain).

Subjects

The subjects were part of one professional men's basketball team ($n = 12$) competing in the Spanish First Division (ACB) (age, 29.6 ± 4.5 years; height, 1.99 ± 9.6 cm; weight, 92.1 ± 11.9 kg, all measurements in $\pm SD$; playing positions, guards: $n = 3$; forwards: $n = 6$; and centers: $n = 3$). The team roster had 8 international players from different countries. At the time of the study (October to December), player training was ~6 hours of basketball practice (skill and tactical team sessions), ~1 hour of physical conditioning (strength training sessions in the weight room), plus competing per week in 2–3 games and traveling ~7 hours. All of the players and coaches were informed about the research protocol, requirements, benefits, and risks, and their written consent was obtained before the study began. Approval for the study was provided by the Committee of Ethics of Clinical Investigations of the Sports Administration of Catalonia Barcelona, Spain.

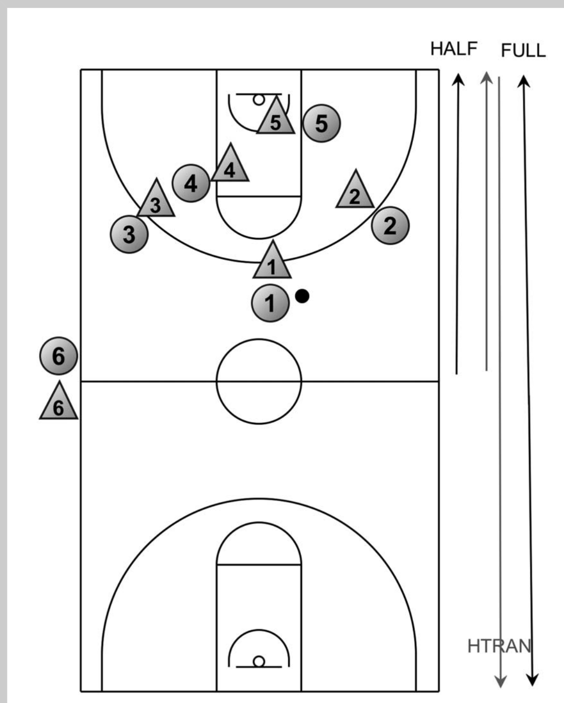

Figure 1. The 5-on-5 scrimmage situations considering the 3 situations of varied rules.

Procedures

All training sessions started with a 10-minute standardized warm-up based on ball dribbling, shooting, specific mobility, and dynamic stretching exercises. All training sessions were performed on the same court in similar environmental conditions. Players performed 3 different 5-on-5 scrimmage as follows (Figure 1):

- HALF, the 5-on-5 game was played in the same HALF. The attack was restarted in the middle of the court by the point guard. Ball possession switched team every time, independently of scoring.
- HTRAN, the 5-on-5 game begun with one team attacking and the opponents defending on half-court. Then, the opponents attacked on transition with the team defending, the transition finishes when an opponent turnover ball or score. The attack restarted in the court where the opponent transition finished.
- FULL, the 5-on-5 scrimmage was played under formal game rules.

A total of 33 drills with different rules and in different court sizes (HALF = 14; HTRAN = 15; FULL = 4) were evaluated during training sessions over a 18-week period during the in-season. Drills performed on the day before and the day after the competition were not included in this study. The 5-on-5 scrimmage is a commonly used training drill to mimic competition and practice strategic plays. During each drill, the 12 players were continuously monitored, with 10 players performing simultaneously and 2 players resting. Given that the substitutions during the drills are unpredictable, and this is common practice in sports training, the average for the 12 players measured was used for the analysis. Only the training situations that respected this criterion of participation of 12 players were included in the analysis. The mean duration of the 5-on-5 scrimmage was 8.7 ± 3.1 minutes, with unclear differences between times (HALF = 8.0 ± 2.3; HTRAN = 9.3 ± 2.8; FULL = 8.4 ± 6.3). The differences in time duration among sessions and games format were included in the study to keep the ecological validity from the situations. During these team-training sessions, offensive and defensive teammates varied randomly. The 5-on-5 scrimmage were designed and supervised by the coaching staff. Players were able to replace water loss by drinking liquid ad libitum during recovery periods.

Physical Profile. Players' movements during testing situations were measured using a portable local positioning system (WIMU PRO; Realtrack Systems SL). These devices (85 × 48 × 15 mm, 65 g) were fitted to the upper back of each player using adjustable harnesses (Rasán, Valencia, Spain). The WIMU PRO units integrate different sensors registering at different sample frequencies. Sampling frequency for 3-axis accelerometer, gyroscope, and magnetometer was 100 Hz and 120 kPa for the barometer. The system has 4 ultra-wideband antennas placed 5 m outside the corners of the court, and the sampling frequency for positioning data was 20 Hz. The system operates using triangulations between the antennas and the units, and the 4 antennas send a signal to the units every 50 milliseconds. Then, the device calculates the time required to receive the signal and derives the unit

Table 1. Means (±*SD*s), 95% CIs (in parentheses) and coefficient of variation for the studied variables collected in the different 5-on-5 scrimmage situations.*

	Half court	Half court and transition	Full court
Distance covered (m)	43.9 ± 5.1 (40.9–46.9)	56.6 ± 3.7 (54.6–58.6)	63.4 ± 3.6 (57.6–69.2)
%CV (average)	27%	23%	39%
Player load (arbitrary units)	0.7 ± 0.1 (0.7–0.8)	0.9 ± 0.0 (0.8–0.9)	1.0 ± 0.1 (0.8–1.2)
%CV (average)	31%	27%	44%
Peak speed ($km \cdot h^{-1}$)	15.2 ± 0.8 (14.7–15.6)	20.0 ± 1.4 (19.2–20.7)	18.0 ± 1.1 (16.5–20.1)
%CV (average)	18%	14%	32%
High-intensity actions (counts)	3.5 ± 0.7 (3.0–3.9)	4.1 ± 0.5 (3.9–4.4)	4.9 ± 0.9 (3.3–6.3)
%CV (average)	53%	42%	55%
Accelerations (counts)	18.0 ± 2.4 (16.6–19.4)	18.3 ± 2.8 (16.7–19.8)	16.9 ± 0.4 (16.2–17.6)
%CV (average)	20%	16%	33%
Decelerations (counts)	17.6 ± 2.2 (16.3–18.9)	17.9 ± 2.6 (16.4–19.3)	16.4 ± 0.5 (15.6–17.2)
%CV (average)	20%	17%	35%
High-intensity accelerations (counts)	1.4 ± 0.3 (1.2–1.6)	1.6 ± 0.2 (1.5–1.7)	1.9 ± 0.4 (1.3–2.6)
%CV (average)	52%	37%	55%
High-intensity decelerations (counts)	1.1 ± 0.3 (1.0–1.3)	1.4 ± 0.2 (1.3–1.5)	1.6 ± 0.3 (1.1–2.1)
%CV (average)	55%	42%	58%
Peak acceleration ($m \cdot s^{-2}$)	3.4 ± 0.5 (3.2–3.7)	3.8 ± 0.4 (3.6–4.0)	3.3 ± 0.4 (2.7–3.9)
%CV (average)	21%	21%	28%

*HALF = half-court; HTRAN = half-court and transition; FULL = full-court; %CV = percentages of coefficient of variation.

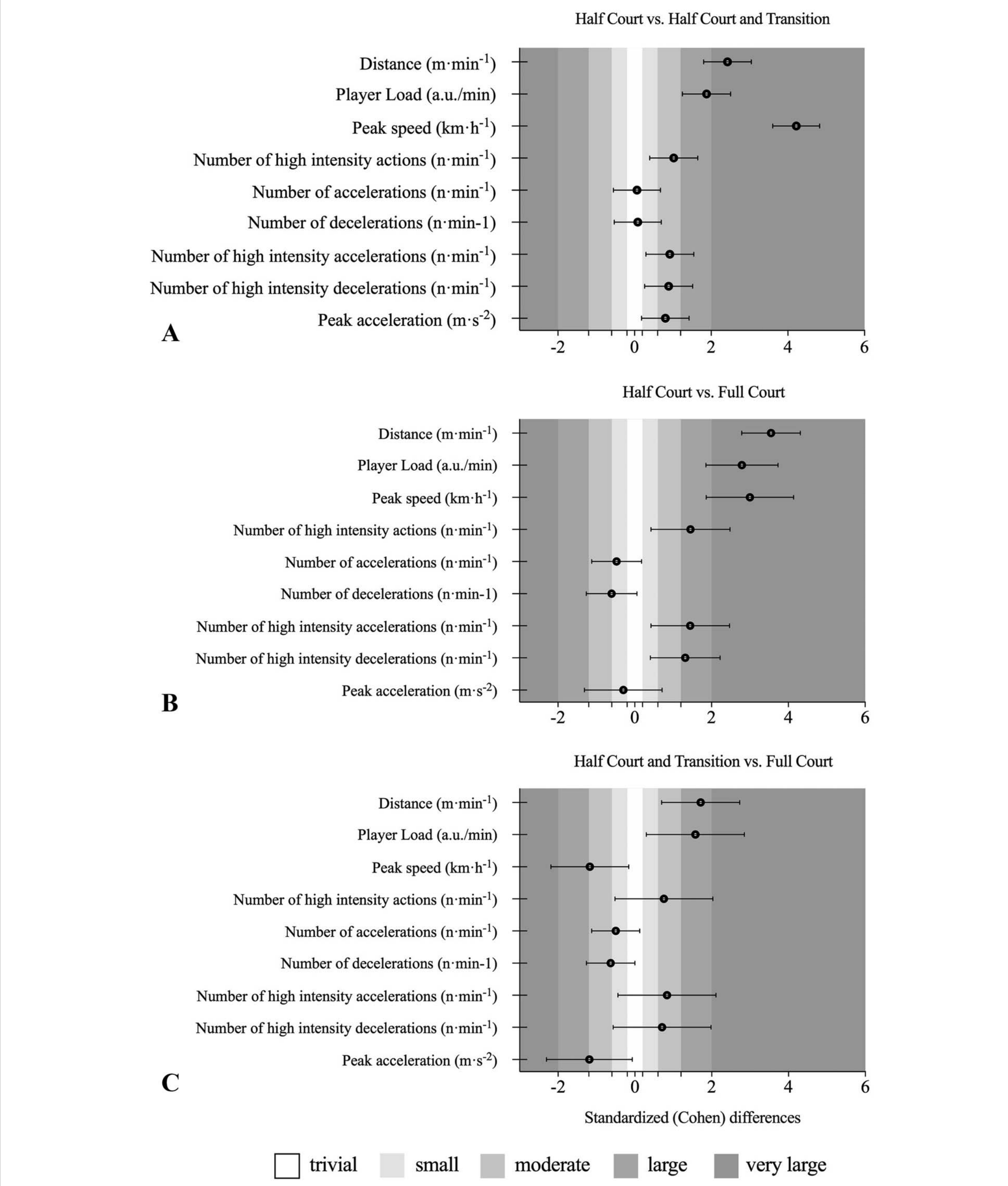

Figure 2. Standardized differences (Cohen's *d*) in variables according to the 3 conditions. Error bars indicate uncertainty in the true mean changes with 90% CI.

position (coordinates X and Y), using one of the antennas as a reference. Data were analyzed using the system-specific software (WIMU Software; Realtrack Systems SL).

To compare the different training exercises, the following variables were calculated per minute: (a) distance covered and (b) distance covered in established speed zones: stationary per walking (<6.0 km·h^{-1}), jogging (6.0–12.0 km·h^{-1}), running (12.1–18.0 km·h^{-1}), high-intensity running (18.1–24.0 km·h^{-1}), and sprinting (>24.1 km·h^{-1}). These speed and movement zones are similar to those used in other basketball studies (27,30); (c) player load, vector magnitude expressed as the square root of the sum of the squared instantaneous rates of change in acceleration in each of the 3 planes divided by 100 (3,14); (d) peak speed (km·h^{-1}) and peak acceleration (m·s^2), as the highest value obtained during the situation; (e) the number of total accelerations and total decelerations; and (f) the number of high-intensity actions, the number of jumps and impacts that exceed 5 G's forces, measured with the inertial accelerometer in the z, x, and y axes, respectively, high-intensity accelerations (>2 m·s^{-2}) and decelerations (<-2 m·s^{-2}).

The WIMU PRO system showed acceptable accuracy for measures of speed and mean acceleration and deceleration for intermittent activities (37). Unpublished studies report an error of less than 2% in linear runs at different speeds over distances of 14 and 28 m. More recently, the WIMU PRO system showed better accuracy (bias: 0.57–5.85%), test-retest reliability (% technical error of measurement [%TEM]: 1.19), and interunit reliability (bias: 0.18) in determining distance covered than the GPS technology (bias: 0.69–6.05%; % TEM: 1.47; bias: 0.25) overall (4). Also, it showed better results (bias: 0.09; intraclass correlation [ICC] = 0.979; bias: 0.01) for mean velocity measurement than GPS (bias: 0.18; ICC = 0.951; bias: 0.03) (4). Nevertheless, to confirm calibration and prevent any errors because of the excessive usage, the reliability of the system was reinspected during the study period using line and v-cut movements while walking, jogging, running, and sprinting. The average values of the ICC between obtained distances and real distances were very high (ICC = 0.973, 95% confidence interval [CI] ranged between 0.964 and 0.980), and the coefficient of variation from these differences was low (CV = 1.3%).

Statistical Analyses

The data for the 12 basketball players are presented using the mean and the standard deviations (±*SD*). Magnitude-based inferences and precision of estimation were used to analyze the data (2). Before the comparisons, all processed variables were log-transformed to reduce the nonuniformity of error. Differences between subgroups (HALF, HTRAN, and FULL) were assessed via standardized mean differences (Cohen's *d*) and respective 90% confidence limits. Thresholds for effect size (ES) statistics were 0.2, trivial; 0.6, small; 1.2, moderate; 2.0, large; and >2.0, very large (19).

Results

The selected physical variables were reported as mean ± SD (95% CI) in Table 1, whereas the magnitude-based inferences analysis can be found in Figure 2. In addition, Table 1 presents the average coefficients of variation in each of the 3 drills.

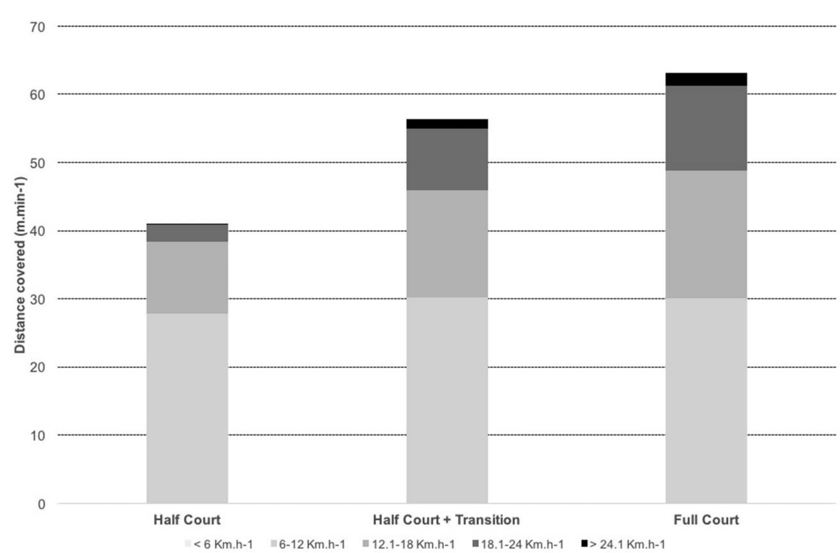

Figure 3. Distance covered per minute during the 5-on-5 scrimmages performed on half-court, half-court and transition, and full-court at different speed zones.

In HALF, the temporary game patterns were 17.7 ± 4.6 seconds of work time (play time without interruptions) and resting time was 19.2 ± 12.5 seconds. In HTRAN situations, the work time was 17.4 ± 7.9 seconds and resting time was 20.8 ± 9.5 seconds. Finally, in FULL, the work time was 31.4 ± 27.5 seconds and resting time was 17.9 ± 10.3 seconds.

Players in HALF covered less distance (ES = 3.55), had lower peak speeds (ES = 3.00), lower player load (ES = 2.79), lesser number of high-intensity actions (ES = 1.45), lesser number of high-intensity accelerations (ES = 1.44) and decelerations (ES = 1.31) than in FULL. Players in HTRAN presented less distance covered (ES = 1.71) than in FULL. In HTRAN, players covered more distance (ES = 2.42), presented higher player load (ES = 1.88), higher high-intensity actions (ES = 1.02), and higher peak speed (ES = 4.22) than in HALF. There were no substantial effects between conditions in the number of accelerations, decelerations, and peak acceleration.

The total distance covered was distributed across 5 zones at different speeds (Figure 3). Distance covered was higher in FULL than in HALF in 6–12 $km \cdot h^{-1}$ (ES = 3.10), 12–18 $km \cdot h^{-1}$ (ES = 4.90), 18–21 $km \cdot ^{-1}$ (ES = 3.20), and >21 $km \cdot h^{-1}$ (ES = 6.50). In HTRAN, the distance covered was higher than in HALF in 12–18 $km \cdot h^{-1}$ (ES = 3.76), 18–21 $km \cdot h^{-1}$ (ES = 3.67), and >21 $km \cdot h^{-1}$ (ES = 4.32). There were no substantial effects between FULL and HTRAN.

Discussion

The aim of this study was to determine whether modifying rules during 5-on-5 scrimmage had any effect on the physical responses of professional basketball players. The main findings seem to suggest that the greater the court dimensions, the higher the physical load (distance covered, player load, and peak speed), also with a strong effect being identified on high-intensity actions, high-intensity accelerations, and high-intensity decelerations.

In accordance with other team sport studies (8,24,27), it was found that an increase in the court dimensions led to a concomitant increase in the physical load. However, basketball player responses during both FULL and HTRAN were similar, with both showing differences when compared with HALF situations. The results obtained in this study are barely comparable with those obtained in the previous works (28,39), mainly because of the use of different measuring instruments, as well as differences in the research designs. Main differences among games can be justified because of different task design. Concretely, HTRAN and FULL allow at least a second action (fast break, transition, or positional attack), and for these actions, the court size is larger. Training both situations could promote fast break or fast transitions (e.g., playing pick and roll during the first 6–8 seconds) in offense and full-court press or sprint back in defense. Therefore, if in a team, offensive playing style is based on fast break and transitions, coaches can select primarily HTRAN and FULL situations, to elicit higher workload. In addition to the physical demands of each game, the design of the games can lead to different temporary patterns (work time and resting time), which could emphasize different utilizations of the energy systems, for example, produce a higher cardiovascular demand during FULL situations.

The distance covered at high speed and the player's sprint and peak speed are key determinants of team sport performances (38). A recent report in Gaelic footballers postulated that a high-speed training habits (chronic load), running at high speeds, and reaching peak velocities, close to the maximum for each player (25), has a protective effect, decreasing the likelihood of injury. Specifically, in high-level basketball, research has shown that lateral ankle sprains, patellofemoral inflammations, lumbar strains, and hamstring strains are common injuries that need to be seriously considered (13). In this sense, it might be possible that a reduced training time using FULL situations does not allow the players to reach high movement speeds and, ultimately, may interfere in this possible protective effect.

There were no differences in the total number of accelerations and decelerations between the 3 situations. However, in FULL, the high accelerations and high decelerations were more frequent than in HALF. These results do not match with results previously obtained with soccer players (17), where a smaller number of high-intensity accelerations and decelerations was identified when the dimensions of the playing court were reduced. This result must be taken into account because a reduction in court dimensions is usually associated with an optimization of the strength capacity (33). However, our results indicate that when court dimensions are reduced, high-intensity accelerations and decelerations appear less frequently. Therefore, it is likely that court length helps determining the intensity of the accelerations and decelerations. In this sense, and although it has not been taken into account in the present study, the initial and final acceleration and deceleration velocities can provide more information regarding these types of actions in training situations with different court sizes (36). It is likely that in larger courts, the final velocity could be higher, which may be necessary for high-intensity deceleration actions (26). Finally, it could also be interesting to distinguish acceleration and deceleration profiles while playing in offense or in defense in a way to have evidence-based standpoints to fine-tune the workload.

In conclusion, physical demands can be modulated changing the rules and court size using 5-on-5 scrimmage situations, and this factor can be taken into account when designing training drills and when fine-tuning periodization, especially with regard to high-velocity actions. The limitations of the present study concern the lack of the real requirements for a player who does not rest any time because the 12 players were continuously monitored, although 2 players were resting. Also, not all the participants played the same amount of time and not all the games lasted the same time. Nevertheless, this is the design that best replicates the training situation dynamics and, therefore, respects ecological validity. In addition, internal and technical loading measures were not accounted during this study. Previous studies (10,28,39) indicate that cardiovascular impact is reduced when court size is reduced. Moreover, based on the high correlations obtained between external and internal load measures in basketball players (32) and in other team sports (7,34), it is likely that the internal load imposed on the player increases as the size of the playing court increases.

Practical Applications

The main practical application for coaches and strength conditioning professionals is that rules modulate physical load, especially with regard to high-intensity actions. Particularly, when court dimensions are reduced, the physical load imposed on basketball players is also reduced. Furthermore, half-court and transition and full-court situations could be specially related with some tactical purposes, such as fast break or transition. This could also be interesting for warm-ups, recovery sessions, and sessions immediately before the next match. However, training harder and including high-intensity movements seems mandatory for playing on a full-court; therefore, this study seem to stresses the importance of using full-court situations in a way to reach higher levels of exertion. Also, results show higher percentages of coefficient of variation for the full-court situations. These results help understanding that basketball game demands cannot be well replicated using half-court situations.

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