Manuscript title: The most demanding scenarios of 5-on-5 modified scrimmage situations in elite basketball

Running title: The most demanding scenarios of 5-on-5 in basketball

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ABSTRACT

BACKGROUND: The most demanding scenarios and physical demands of elite basketball 5-on-5 scrimmages are unknown to trainers, although recent advances in microtechnology allows the gaps in this research to be filled. The purpose of this study was to describe and compare the physical demands, through the most demanding scenarios and traditional average measures, of two different 5-on-5 scrimmage situations executed during training sessions in elite male basketball players.

METHODS: Physical demand measures (i.e., total distance covered, high-speed running distance, number of high-intensity accelerations actions, number of high-intensity decelerations actions) were collected from 12 players from the Spanish first Division using a Local Positioning System.

Measures were compared via a Bayesian inference analysis, considering playing in half-court (HALF) and half-court and transition (HTRAN) conditions for the 5-on-5 scrimmage.

RESULTS: This study showed that, irrespective of the approach used to quantify the physical demands (traditional [average measures per minute] and novel rolling average time epoch [most demanding scenarios]), during the HALF condition players covered less and performed a lower number of high-intensity accelerations and decelerations than in HTRAN (Bayesian factor > 10 and standardized effect size > 0.6). Furthermore, players´ physical demands during 5-on-5 scrimmage situations, independently of the court size, were underestimated consistently by the traditional approach.

CONCLUSIONS: Quantifying players´ physical demands through the rolling approach may provide a more accurate measure of the most intense periods of activity. Based on the physical demands described, HTRAN may be used to help train players to perform optimally during the most physically-stressful scenarios of match-play whereas HALF may be more suitable to be included in warm- ups, recovery sessions and sessions immediately before a match.

Key words: Monitoring, training load, local positioning measurement, team sports

Introduction

Technological advances allow sports scientists to accurately track intermittent team sport athletes indoors (e.g., basketball, futsal and handball players) using local positioning systems (LPS) [1,2]. Determining athletes' physical demands, using variables such as distance covered at different speeds (walking and jogging, high-speed running, sprinting) and the number of high-intensity actions executed (accelerations and decelerations) during the most frequently used training drills, can aid to improve the decision-making process for designing and implementing effective training sessions in order to develop, maintain and recover physiological parameters related to performance [3,4]. Small-sided games (i.e. 1-on-1 up to 4-on-4 scrimmage situations) and game simulations modifying rules (i.e. 5-on-5 scrimmage situations) are very popular training drills in basketball [5–8]. These constraints-based drills are used to master individual technical skills as well as to develop teams' tactical proficiency and specific basketball physical fitness [9]. In particular, 5-on-5 scrimmage situations are usually performed in basketball training as it has been suggested (based on anecdotical evidence) that this drill may replicate match-play performance and, therefore, assist in ensuring players are prepared to perform effectively during physically-demanding scenarios of competitive match-play [5,10].

Some studies using microtechnology have analysed and compared the average per minute physical demands of 5-on-5 scrimmage situations with different court sizes (half-court vs. full-court) and rules (no-stop game vs. regular-stop game) [5,6,10]. The main findings of these studies seem to suggest that the greatest physical demands of the 5-on-5 scrimmage situations are demonstrated when playing non-stop and on full-court [6,10]. Furthermore, these studies also indicate that 5-on-5 scrimmage situations may elicit similar, and even higher when playing non-stop, averaged (per minute) physical demands than during competitive basketball match-play [5]. Although these studies present novel information [5,6,10], the use of this traditional approach based on average scores to calculate players′ physical demands during the 5-on-5 scrimmage situations may provide an underestimation of the peak demands (i.e. the most demanding scenarios of the drill) due to its inability to capture fluctuations in physical demands [11]. In particular, this traditional approach quantifies for each physical demand measure selected the number of repetitions performed (e.g. 10 high-intensity accelerations) or distance covered in a specific speed zone (e.g.: 50 m at high-speed running) by a single player during the total drill duration (e.g. five min) [7]. These absolute scores are normally averaged per minute (e.g.: two high-intensity accelerations per minute or 10 m covered at high-speed running per minute) and presented as players´ averaged physical demands [7]. Therefore, this traditional approach does not consider the existence of scenarios or passages during drills in which players have to face peaks in the physical demands (e.g.: the period of time that comprises the minutes 2.5 and 3.5, four [out of 10] high-intensity accelerations might have been registered) [12].

Recently, the use of a novel approach has been suggested as alternative to the traditional one to describe the most demanding scenarios of match-play, training sessions or drills through the use of the "peak scores" [13]. This novel approach takes the most relevant (in terms of sport performance) physical demand measures, after having examined the data second by second, and using all of this data to determine rolling average time duration or epochs (e.g., 0–3, 1–4, 2–5 min). This new rolling average time epoch approach (ROLLING) has been recently used to describe the most demanding scenarios of competitive basketball match-play, showing that the activity profile described is much more demanding than that reported in previous studies where traditional average measures have been employed [4,12,14]. The use of this novel ROLLING approach to quantify the most demanding scenarios of the most frequently used basketball drills (such as 5-on-5 scrimmage situations) may provide a more comprehensive estimation of the external workload imposed on players [15]. However, no studies are available in the literature (to the authors´ knowledge) describing the physical demands of popular training drills in basketball using this novel ROLLING approach.

Therefore, the main purpose of this study was to describe and compare the physical demands, quantified simultaneously through the novel ROLLING (most demanding scenarios) and traditional (average measures per minute) approaches, of two different 5-on-5 scrimmage situations executed during in-season training sessions in professional male basketball players.

Materials and methods

Experimental Approach to the Problem

A nonexperimental, descriptive and comparative design was used to address the purpose of this study. This study was conducted during the competitive season 2018–2019. A total of twenty 5-on-5 scrimmage situations (figure 1) performed for 5 minutes with two different court sizes during training sessions were monitored over a 10-week period:

- Half-court (HALF): the 5-on-5 scrimmage was played in the same half court. The attack was re-started in the centre court by the point guard. Ball possession switched team every re-start, independent of scoring.
- Half court and two transitions (HTRAN): the 5-on-5 scrimmage started with one team attacking and the opponents defending on half-court. Then, the opponents attacked on transition (full court) with the team defending, the transition finished when an opponent turned over the ball or a basket was scored. Finally, the first offensive team performed another transition attack while the opposition team defended. The attack restarted at the point on the court where the drill begun.

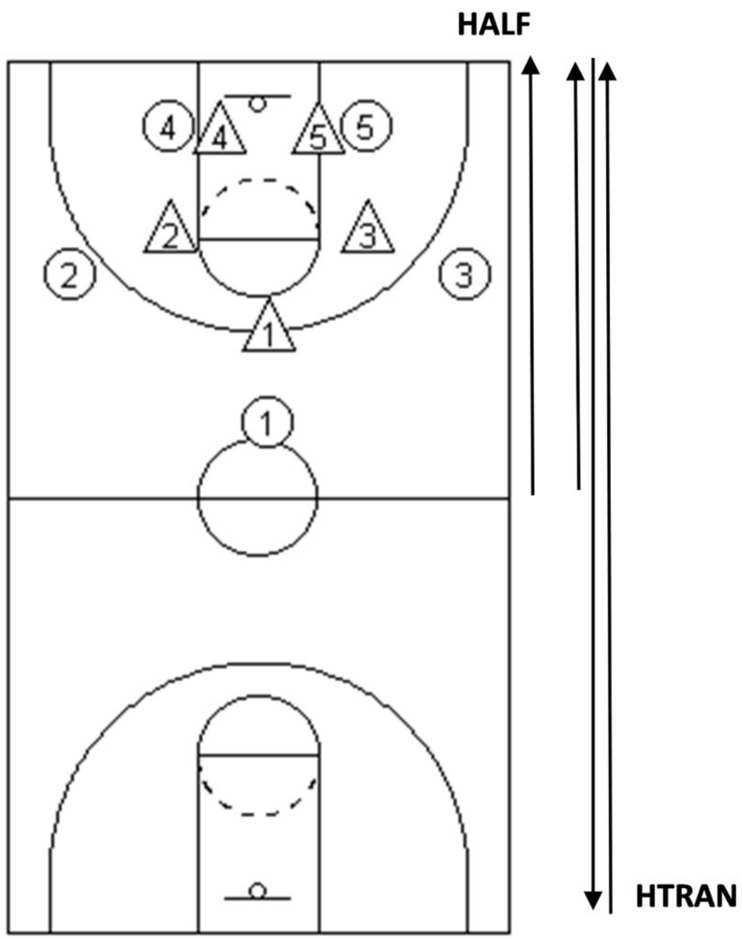

Figure 1 The 5-on-5 scrimmage situations considering the 2 situations of varied rules.

Data collection occurred in training sessions carried out from 24 to 12 hours prior to and at least 48 hours after a competitive match play or long travel, as players were supposed to be recovery from previous efforts and ready to play near the level of their maximum basketball performance. Each 5-on-5 scrimmage situation was always carried out at the beginning of the training sessions (after the warm-up). All training sessions were performed on the same court in similar environmental conditions and started with a 12-minute standardized warm-up based on specific mobility, dynamic stretching exercises, shooting and ball dribbling. During both situations, the 12 players were continuously monitored, with 10 players performing on the court and two players resting in a bench. Given that the changes during the 5-on-5 scrimmage situations were random, which is regular practice in basketball training, the average for the 12 players studied was used for the analysis. Only the training sessions that respected this criterion of participation were included in the study. During these training sessions, defensive and offensive teammates varied randomly. The 5-on-5 scrimmage were prescribed and supervised by the coaching staff. All players were able to replace water loss by drinking ad libitum once the 5-on-5 scrimmage situation was fully completed. Those players who were substituted during the 5-on-5 scrimmage situations sat on a bench placed 2 meters apart from the side court line to passively recovery (no other recovery strategies [e.g. stretching, light running] were permitted) and they were also allowed to replace fluid losses. Food consumption during the training sessions was not permitted.

Subjects

A convenience sample of 12 professional male basketball players belonging to a team competing in the Spanish First Division (ACB) and the Euroleague (age: 29.6 ±4.5 years; stature: 199 ±9.6 cm; body mass: 92.1 ±11.9 kg; playing positions: three guards, six forwards and three centers) took part in this study. The team roster had nine international players from different countries. At the time of the study (April to June), player training was: six hours of basketball practice (skill and tactical team sessions), an hour of physical conditioning (strength training sessions in the weight room), plus competing in 2–3 matches per week and traveling approximately seven hours. All of the players and coaches provided written informed consent and were informed about the research protocol, requirements, anticipated benefits (e.g. to provide a more comprehensive estimation of the external workload imposed on players during two common 5-on-5 scrimmage situations that may help coaching staff better manage training loads and design more effective recovery strategies), and potential risks (e.g. increased potential of physical fatigue from completing the 5-on-5 scrimmage situations, that without appropriate recovery measures might cause increased risk of suffering an muscular injury during the subsequent training sessions). The following exclusion criterion was utilised: players who sustained an injury during the data collection phase of the study that forced them to refrain from participation in training for at least three consecutive or six non-consecutive days. None of the players recruited were excluded. The experimental procedures used in this study were in accordance with the Declaration of Helsinki [16] and no ethics committee approval was needed as the data were routinely obtained during the player's training sessions [17].

Procedures

Players' movements were measured using a portable local positioning system (LPS) (WIMU PRO, Realtrack Systems SL, Almería, Spain) during drills. Devices (81 mm × 45 mm × 15 mm, 70 g) were fitted to the upper back of each player using an adjustable harness (Rasán, Valencia, Spain). The WIMU PRO units integrate different sensors recording at different sample frequencies. Sampling frequency for a three-axis accelerometer, gyroscope, and magnetometer was 100 Hz and 120 kPa for the barometer. The system has six ultra-wide-band antennas with no metallic materials placed around, four placed 3 m outside the corners of the court and two placed 3 m outside half-court; the sampling frequency for positioning data was 20 Hz. The system operates using triangulations between the antennas and the units; the six antennas send a signal to the units every 50 ms. Then, the device calculates the time required to receive the signal and derives the unit position (coordinates x and y), using one of the antennas as a reference. The system used time difference of arrival (TDOA) that is one of the widely used localization schemes that records the arriving time of the source signal.

WIMU PRO software was used to computate both the most demanding scenarios (ROLLING approach) and average scores (traditional approach) of each physical demand measure using 60 s as the time epoch. With the aim of providing a more comprehensive comparison of the peak physical demands elicited by the 5-on-5 scrimmage situations selected in the current study with those recently described in basketball match-play, two extra rolling average time epochs were analysed: 30 and 180s. For the ROLLING approach, the maximum value of each physical demand measure analysed for each time epoch was recorded. For example, for a 60 s rolling average time epoch with a sampling of 20 Hz, the software identified 1,200 consecutive data points (i.e., 20 samples/s for 60 s). For a 120 s rolling average time epoch, 2,400 samples were used, and so on. Thus, for the 60 s rolling epoch, algorithm values were calculated using the current and the 1,199 preceding samples.

In each epoch-length, the peak values of the physical demands selected were recorded independently so that it is very likely that they came from different data points. The traditional approach, the averaged per 60 s physical demand value relative to the total time the player was competing on the court was recorded.

For both 5-on-5 scrimmage situations, the following physical demands were calculated: a) total distance covered, b) high-speed running distance (>18 $km \cdot min^{-1}$), c) the number of high-intensity accelerations actions (>2 $m \cdot s^{-2}$) and d) the number of high-intensity decelerations actions (<-2 $m \cdot s^{-2}$).

The LPS has demonstrated acceptable accuracy for measures of speed and mean acceleration and deceleration for intermittent activities [18]. Furthermore, Bastida-Castillo et al. [19] reported that the WIMU PRO system demonstrated better accuracy (bias: 0.57–5.85%), test–retest reliability (%TEM: 1.2) and inter-unit reliability (bias: 0.18) in determining distance covered compared to GPS technology (bias: 0.69–6.05%; %TEM: 1.47; bias: 0.25) when both devices were worn by the same athlete [19]. In particular, the WIMU PRO system showed a mean absolute error of 5.2 ± 3.1 cm for the x-position and 5.8 ± 2.3 cm for the y-position, which represented percentage of differences of 0.9 ± 1% for the x-coordinate and 0.9 ± 1.1% for the y-coordinate [20]. Bastida-Castilla et al. [19] also found that the inter-unit reliability showed a large ICC for the x-coordinate (0.65) and a very large ICC for the y-coordinate (0.88), and a good %TEM (2%) was reported for the error agreement between the two devices assessed.

Statistical analysis

Statistical analyses were performed using JASP (Amsterdam, Netherland) software version 0.10. A descriptive statistic (mean and 95% credible intervals) was calculated for each physical performance measure. The distribution of raw data sets was checked for homogeneity and skewness using the Shapiro-Wilk expanded test.

The current study used the novel Bayesian method (based on the quantification of the relative degree of evidence for supporting two rival hypotheses, null hypothesis [H_0 = no significant differences or effects] vs. alternative hypothesis [H_1 = significant differences or effects], by means of the Bayesian factor [BF_{10}] [21-23] for hypothesis testing. The BF_{10} is interpreted using the evidence categories suggested by Lee & Wagenmakers [24]: < 1/100 = extreme evidence for H_0, from 1/100 to < 1/30 = very strong evidence for H_0, from 1/30 to < 1/10= strong evidence for H_0, from 1/10 to < 1/3 = moderate evidence for H_0, from 1/3 to <1 anecdotical evidence for H_0, from 1 to 3 = anecdotical evidence for H_1, from >3 to 10 = moderate evidence for H_1, from >10 to 30 = strong evidence for H_1, from > 30 to 100 = very strong evidence for H_1, > 100 extreme evidence for H_1.

In order to analyse the possible effects of the three rolling average time epochs selected (30, 60 and 180 s) on the most demanding passages (number of high-intensity accelerations and decelerations, total distance covered and distance covered at high-intensity running) of the 5-on-5 scrimmages situations (HALF and HTRAN), separate ANOVAs were conducted using a Bayesian statistical approach. Individual "player code" was treated as a random factor for all analyses to account for the multiple observations collected for each individual. Only those Bayesian ANOVAs that showed at least a strong (ten times higher) evidence for supporting H_1 ($BF_{10} > 10$) and a percental error < 0.001 (which indicates great stability of the numerical algorithm that was used to obtain the result) were considered robust enough to identify true inter time epochs differences and posterior post hoc analyses were then carried out.

For both the ROLLING and traditional approaches, separate Bayesian paired samples t-tests (for normally distributed variables) or Bayesian Wilcoxon tests (for non-normally distributed variables) were conducted to explore differences between the two different 5-on-5 scrimmages situations (HALF and HTRAN) in the physical demand measures calculated at each time epoch (inter scrimmage situations differences). Inter-approaches differences (ROLLING vs. traditional) in the physical demand measures recorded during the two different 5-on-5 scrimmages situations (HALF and HTRAN) using a 60 s time epoch were also explore through separate Bayesian paired samples t-tests (for normally distributed variables) or Bayesian Wilcoxon tests (for non-normally distributed variables). As stated before, a $BF_{10} > 10$ was needed to consider a difference in any paired-comparison as significant.

The median and the 95% central credible interval of the posterior distribution of the standardized effect size (δ) (i.e. the population version of Cohen's d) was also calculated for each of the paired-comparisons carried out. Magnitudes of the posterior distribution of the standardized effect size were classified as: trivial (<0.2), small (>0.2 – 0.6), moderate (>0.6 –1.2), large (>1.2 – 2.0) and very large (>2.0 – 4.0) [25].

Results

Tables 1 and 2 display descriptive statistics of the most demanding passages for each rolling average time epoch of the 5-on-5 scrimmages performed on HALF and HTRAN, respectively.

Table 1 The most demanding passages of *5*-on-*5* scrimmage situations performed on *half-court* for three different rolling average time epochs (mean and 95% credible intervals)

Variable	**Time epochs**					
	30 s		**60 s**		**180 s**	
Accelerations (counts)*	3.3	(3.1 - 3.6) [**b,c**]	4.6	(4.2 - 4.9) [**a,c**]	8.0	(7.3 - 8.8) [**a,b**]
Decelerations (counts)*	3.0	(2.8 - 3.3) [**b,c**]	4.0	(3.7 - 4.4) [**a,c**]	7.0	(6.3 - 7.7) [**a,b**]
Total distance covered (m)*	45.7	(42.7 - 48.7) [**b,c**]	75.6	(70.2 - 80.9) [**a,c**]	171.8	(158.0 - 185.6) [**a,b**]
Distance covered at high-intensity running (m)	4.3	(2.7 - 5.9)	5.1	(2.0 - 8.1)	6.3	(1.6 - 11.0)

*: The Bayesian ANOVA reported that there was at least a strong evidence (Bayes factor [BF_{10}] > 10 and percental error < 0.001) to support the alternative hypothesis (H_1).
Post hoc analysis: super-indices indicate that there was at least strong evidence to support the presence of differences (BF_{10} > 10) between [a]: 30 s time epoch, [b]: 60 s time epoch and [c]: 180 s time epoch. In bold are those sub-indices whose magnitude of the differences observed were at least moderate ($\delta > 0.6$). m: meters

Table 2 The most demanding passages of *5*-on-*5* scrimmages performed on *half-court and transition* for three different time epochs (mean and 95% credible intervals)

Variable	**Time epochs**					
	30 s		**60 s**		**180 s**	
Accelerations (counts)*	4.4	(4.2 - 4.6) [**b,c**]	6.1	(5.8 - 6.3) [**a,c**]	11.5	(10.8 - 12.1) [**a,b**]
Decelerations (counts)*	4.1	(3.9 - 4.3) [**b,c**]	5.5	(5.3 - 5.8) [**a,c**]	10.2	(9.6 - 10.8) [**a,b**]
Total distance covered (m)*	68.0	(65.8 - 70.3) [**b,c**]	108.6	(105.2 - 112.1) [**a,c**]	250.5	(239.6 - 261.5) [**a,b**]
Distance covered at high-intensity running (m)	14.8	(13.7 - 15.9) [b,c]	18.4	(16.9 – 20.0) [a,c]	27.4	(24.7 - 30.1) [**a,b**]

*: The Bayesian ANOVA reported that there was at least strong evidence (Bayes factor [BF_{10}] > 10 and percental error < 0.001) to support the alternative hypothesis (H_1).
Post hoc analysis: super-indices indicate that there was at least a strong evidence to support the presence of differences (BF_{10} > 10) between [a]: 30 s time epoch, [b]: 60 s time epoch and [c]: 180 s time epoch. In bold are those sub-indices whose magnitude of the differences observed were at least moderate ($\delta > 0.6$). m: meters

In both 5-on-5 scrimmage situations, the Bayesian ANOVAs conducted with the time epoch as the fixed factor demonstrated extreme evidence (BF_{10} > 100 and percentage error

< 0.001) that supports the existence of a main effect of time epoch for all physical demand variables. The subsequent post hoc analysis revealed substantial differences ($BF_{10} > 10$ and $\delta > 0.6$) in peak values for each physical demand measure across all time epochs.

Table 3 shows the average scores (traditional approach) and their 95% credible intervals of the four physical demand measures collected for the two different *5*-on-*5* scrimmage situations using 60 s as time epoch.

Table 3 Averaged values of the four physical demand measures collected during two different *5*-on-*5* scrimmage situations (half court [HALF] vs. half court and transition [HTRAN]) using a 60 s time epoch.

Variable	**5-on-5 scrimmage situations**			
	HALF		**HTRAN**	
Accelerations (counts)*	1.6	(1.4 - 1.7)	2.2	(2.0 - 2.3)
Decelerations (counts)*	1.3	(1.2 - 1.5)	1.9	(1.8 - 2.1)
Total distance covered (m)*†	38.5	(34.8 - 42.2)	57.7	(54.1 - 61.2)
Distance covered at high-speed running (m)*†	0.1	(0.03 - 0.16)	3.8	(3.3 - 4.2)

m: meters.

*: The Bayesian inference for inter-scrimmages situations comparisons reported that there was at least strong evidence (Bayes factor [BF_{10}] > 10 and percental error < 0.001) to support the alternative hypothesis (H_1).

†: The magnitude of the differences observed were at least moderate ($\delta > 0.6$).

For both ROLLING (table 4) and traditional (table 3) approaches, Bayesian paired comparisons showed substantial differences between both scrimmage situations on all physical demand measures whereby players in HALF covered less total distance and distance at high-speed running as well as performing fewer numbers of high-intensity accelerations and decelerations than in FULL.

There was extreme evidence ($BF_{10} > 10$ and $\delta > 0.6$) that the physical demand measures described in both 5-on-5 scrimmage situations using the ROLLING approach were much higher than those determined using the traditional approach.

Discussion

The current study describes the most demanding scenarios of 5-on-5 scrimmage situations with two different court sizes (HALF vs. HTRAN) from a professional basketball team through four physical demand measures using three rolling average time epochs: 30,

Table 4 Differences between two different *5*-on-*5* scrimmages situations (half court vs. half court and transition) in the most demanding passages calculated for three different time epochs.

Variable	Difference		Bayesian factor (BF_{10})		Effect size (δ)	
			Value	Qualitative interpretation	Mean and 95% CI	Qualitative interpretation
Accelerations (counts)						
• 30 s	-1.1	(-1.4 to -0.7)	>100	Extreme evidence for H_1	-0.59 (-0.81 to -0.37)	Small
• 60 s	-1.5	(-1.9 to -1.0)	>100	Extreme evidence for H_1	-0.61 (-0.83 to -0.38)	Moderate
• 180 s	-3.5	(-4.4 to -2.5)	>100	Extreme evidence for H_1	-0.67 (-0.89 to -0.42)	Moderate
Decelerations (counts)						
• 30 s	-1.1	(-1.4 to -0.8)	>100	Extreme evidence for H_1	-0.77 (-0.99 to -0.54)	Moderate
• 60 s	-1.5	(-1.9 to -1.1)	>100	Extreme evidence for H_1	-0.84 (-1.09 to -0.59)	Moderate
• 180 s	-3.2	(-4.1 to -2.3)	>100	Extreme evidence for H_1	-0.73 (-0.96 to -0.50)	Moderate
Total distance covered (m)						
• 30 s	-22.4	(-26.0 to -18.7)	>100	Extreme evidence for H_1	-1.23 (-1.45 to -0.98)	Large
• 60 s	-33.1	(-39.1 to -27.0)	>100	Extreme evidence for H_1	-0.68 (-0.89 to -0.46)	Moderate
• 180 s	-78.7	(-96.1 to -61.3)	>100	Extreme evidence for H_1	-1.06 (-1.33 to -0.82)	Moderate
Distance covered at high-intensity running (m)						
• 30 s	-10.5	(-14.0 to -7.0)	>100	Extreme evidence for H_1	-1.89 (-2.94 to -1.12)	Large
• 60 s	-13.5	(-18.5 to -8.5)	>100	Extreme evidence for H_1	-1.46 (-2.41 to -0-68)	Large
• 180 s	-21.2	(-29.9 to -12.6)	>100	Extreme evidence for H_1	-1.54 (-2.67 to -0.73)	Large

60 and 180 s. For example, for the 30 s time epoch, players performed 4.4 and 4.1 high-intensity accelerations and decelerations for a total covered distance of 68 m when performing HTRAN. It should be highlighted that the physical demands (with the exception of the distance covered at high speed running) in the two types of 5-on-5 scrimmage situations significantly increased across the time epochs. The results also indicate that the greater the court dimensions, the higher the distance covered (total and at high-speed running) and a greater number of high-intensity accelerations and decelerations are performed by players, independently of the time epoch (30, 60 and 180s) and approach used to quantify them (ROLLING and traditional). Thus, for the 180 s time epoch, players covered 20 m more at high-speed running and performed three more high-intensity accelerations and decelerations during HTRAN than during HALF. An explanation for the higher players´ peak physical demands observed in HTRAN in comparison with HALF may be based on the fact that HTRAN, unlike HALF, allows always two more actions (fast break, transition or positional attack) and for the action, the court size is larger. Therefore, court size appears to be a variable that may help to modulate the intensity of the game simulations

(including 5-on-5 scrimmage situations) carried out during training sessions in intermittent team sports.

To the best of the authors´ knowledge, only Vazquez-Guerrero et al. [14] have described the most demanding scenarios (in terms of physical demands) during basketball match-play from professional male players. These authors used the same ROLLING approach and locomotive measures that in the current study and hence, direct comparisons with the physical demands found for the training drills in the current study can be made. In this sense, it can be observed that during HTRAN players performed a slightly lower number of high-intensity accelerations (8.8 [match-play] vs. 6.1 [HTRAN] for 60 s time epoch) and decelerations (8.2 [match-play] vs. 5.5 [HTRAN] for 60 s time epoch) to those performed during a basketball match-play. Similarly, players seem to cover lower total distance (141.3 m [match-play] vs. 108.6 m [HTRAN] for 60 s time epoch) and distance at high-speed running (25.4 m [match-play] vs. 18.4 m [HTRAN] for 60 s time epoch) during HTRAN than during match-play. In term of practical applications, HTRAN may be considered as a type of 5-on-5 scrimmage situation that could help coaches and strength and conditioning specialists to progressively prepare players to perform optimally during the most physically-stressful scenarios of match-play. In this sense, and based on the physical demands elicited by HTRAN, these 5-on-5 scrimmage situations should be prescribed in training sessions performed at least 36-48 hours before the next match. However, prescribing training drills with similar and even slightly higher peak physical demands that the ones players must encounter during match-play may be beneficial to maintain and promote better performance as well as to decrease injury risk [11]. In this regard, more studies are warranted to identify basketball-specific drills which provide physical demands similar and above the competition´s most demanding scenarios. Likewise, in rehabilitation programs, HTRAN may be also used in the phase previous to the return to play because it may help restore players' specific fitness and locomotor performance in relation to match physical demands. In this sense, one of the main purposes of the last phase of any injury rehabilitation process is to prepare players for a safe return to re-perform [26]. In order to successfully address this purpose, players should be exposed (with adequate rest) at the end of the rehabilitation process to training drills whose technical, tactical and physical demands progressively reflect the worst-case scenarios of play [26]. Therefore, within a progression of game simulation drills aimed at improving injured professional basketball players´ ability to tolerate the most demanding scenarios of competition, the HTRAN 5-on-5 scrimmage may be positioned in the latest places, just before those scrimmage situations that replicate match-play performance. The most demanding scenarios documented for HALF are lower than the ones found for HTRAN, and thus this training drill may be used for external load prescription and periodization in order to optimally prepare players for competition by progressively decreasing the physical demands over the days prior to the game. Furthermore, HALF could be performed in warm- ups, recovery sessions and sessions immediately before the next match.

A second purpose of this study was to compare players´ physical demands during 5-on-5 scrimmage situations with different court sizes in professional basketball quantified through two different methodological approaches (ROLLING vs. traditional) using 60 s as the time epoch. In this regard, the findings of this study clearly demonstrate that players´ physical demands during 5-on-5 scrimmage situations, independently of the court size, were significantly lower when the traditional approach based on whole average scores was used for their quantification. For example, during HTRAN, the most demanding scenarios quantify through the ROLLING approach indicated that players covered a total distance of 109 $m \cdot min^{-1}$ and 18 $m \cdot min^{-1}$ at high-speed running whereas the traditional approach reported 58 $m \cdot min^{-1}$ and 4 $m \cdot min^{-1}$ respectively. The same situation was documented for the number of high-intensity accelerations and decelerations, whereby 6 accelerations and 5.5 decelerations were quantified by the ROLLING approach and only 2.2 and 2 were recorded by the traditional approach. Similar findings have been reported by previous studies that compared these two approaches when assessing the physical demands during competition and training drills in other team sports, such as rugby [12,27] and soccer [15]. Therefore, the use of the previous traditional approaches to describe players peak physical demands during competition and training drills may have clouded our understanding of the physical demands of basketball because they led to a dramatically underestimation of the most demanding scenarios. On the contrary, quantifying players´ physical demands through the ROLLING approach may provide a more accurate measure of the most intense periods of activity performed by players.

The present study provides important insight for basketball practitioners; however, in applying these findings, some limitations should be acknowledged. Data were collected in a single professional, male basketball team. As such, the players´ physical demands encountered during the 5-on-5 scrimmage situations may not reflect those of other teams at different levels of competition, in different age categories, or in female teams where workloads may vary [28]. In addition, other factors such as sport-specific training background [29] and playing position [3] may impact the peak physical demands encountered by players and therefore warrants investigation. This research is also limited because not all the participants played the same amount of time. Nevertheless, this is the model that best reproduces the training situation dynamics and, therefore, respects ecological validity. In addition, technical and internal loading measures were not accounted during this study. Furthermore, due to technical reasons, this study was not able to determine the effect of ball possession (or not) (i.e. offensive game actions vs defensive). Finally, the analysis of the most demanding scenarios for each specific position may also help to provide a better understanding of elite game physical demands. Future research to address these issues are therefore warranted.

Conclusions

The current study provides novel results based on the most demanding scenarios that may help coaches and strength and conditioning specialists to better understand the physical demands of two different 5-on-5 scrimmage situations in basketball training and, thus, improve evidence-based approaches when selecting training drills and periodization of practices in professional basketball. In particular, the findings of this study confirm that the court size may be a variable that modulate the physical demands of 5-on-5 scrimmage using the most demanding scenarios so that the greater the court dimensions, the higher the distance covered and the number of accelerations and decelerations executed by players. Furthermore, half-court and transition situations seem to approach competition demands and hence, may be used, in sessions separate at least 36-48 hours to the next competition or in the last phase of a rehabilitation program previous to the return to play, to help train players to perform optimally during the most physically-stressful scenarios of match-play. On the contrary, half court situations may be more suitable to be included n warm- ups, recovery sessions and sessions immediately before the next match. Finally, the findings of this study promote the use of the novel rolling approach to describe the most demanding scenarios of basketball play because the traditionally used approach based on average values appear to dramatically underestimate peak physical demands.

Notes

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