Performance profile of NCAA Division I men's basketball games and training sessions

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ABSTRACT: This study aimed to analyse live and stoppage time phases, their ratio, and action played on half and full court in college basketball games. Differences were assessed for the entire games and between halves. Moreover, differences of the live/stoppage time ratio were analysed between games and game-based conditioning drills. Ten games as well as fifteen defensive, fourteen offensive and six scrimmage-type drills of the same division I men's college team (13 players) were analysed using time-motion analysis technique. Live and stoppage time were classified in five classes of duration: 1-20, 21-40, 41-60, 61-80, >80 seconds. Half court actions started and finished in the same half court. Full court actions were classified as transfer (TR) phases when at least 3 teammates crossed the mid-court line. TR phases were then classified in 5 classes of frequency: 1TR, 2TR, 3TR, 4TR, and >4TR. The results revealed no statistically significant differences between games or between halves for the considered parameters. The only significant difference was observed for live/stoppage time ratio between halves ($p < 0.001$). Furthermore, a significant difference of the live/stoppage ratio was found between games and game-based drills ($p < 0.01$). Post-hoc analysis demonstrated significant differences of scrimmage-type drills in comparison to games, and defensive and offensive drills ($p < 0.05$), whereas no differences emerged for the other pairwise comparisons. The absence of differences between games in the analysed parameters might be important to characterize the model of performance in division I men's college games. Furthermore, these results encourage coaches to use game-based conditioning drills to replicate the LT/ST ratio documented during games.

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INTRODUCTION

College basketball is highly competitive, played between teams of university students in the United States, and is regulated by the National Collegiate Athletic Association (NCAA). Athletes playing in division I college teams are very talented, and the best are drafted by teams of the National Basketball Association (NBA), which is considered the premier basketball league. NCAA basketball games are regulated by different rules compared to those organized by the NBA and the International Basketball Federation (FIBA). Specifically, NCAA basketball games are composed of two halves of 20-min duration, while NBA and FIBA games are composed of four quarters of 12- and 10-min duration, respectively [1,2]. Moreover, the number and length of time-outs are different between NCAA and the other above-mentioned basketball championships. NCAA rules permit four 75-second and two 30-second time-outs for each team per regulation time [3], while NBA rules permit a total of two 20-second time-outs per game (one for each half) and six 100-second time-outs during regulation games [2]. FIBA rules, instead, allow five 1-min time-outs for each team (two and three in the first and second half, respectively) [1]. In addition, college basketball has longer shot clock duration (35 seconds) than either the NBA or FIBA rules (24 seconds) [1-3]. Lastly, 10 seconds are allowed to advance the ball across the half-court line after a made basket, compared to 8 seconds permitted by NBA and FIBA rules [1-3]. All these differences may lead to a different performance profile of NCAA games compared to those defined for other international basketball competitions.

In general, individual and team-motion performances in basketball games have been assessed using video time-motion analysis technique, which has been shown to be a practical tool [4]. Previous investigations analysing players' movement patterns, live time and stoppage time phase durations in male, female and young players in games regulated by FIBA rules documented that basketball is an intermittent sport characterized by more than 1000 changes of movements per game [5,6] with a work to rest ratio between 1:1 and 2:1 [7,8]. However, to date no study has investigated game performance in men's college basketball. Due to its unique game structure, it is important to define the NCAA basketball profile of performance and evaluate potential differences between games in terms of live and stoppage time phases.

The characterization of NCAA basketball performance profile may be relevant for coaches to set up their training sessions. Coaches are increasingly using game-based training methods as a means of improving players' fitness and technical-tactical skills [9]. Furthermore, exercise stimuli should represent those reported during official games to increase training specificity [10]. Previous studies compared the physiological and physical demands of training sessions and competition in team sports to assess whether a drill reproduces the specificity of game performance patterns [11-15]. In basketball, Montgomery et al. [16] compared the workloads experienced during both scrimmage and games showing higher physical and physiological demands occurring in competitions. This discrepancy may depend on the use of drills with a different work to rest ratio during training sessions compared to that required by official games. In fact, it is unclear if game-based conditioning drills played during regular basketball training sessions could replicate match play demands in terms of exercise and rest time phases. Thus, the aims of this study were to: 1) characterize the NCAA division I basketball performance profile assessing potential differences between games in terms of live time (LT), stoppage time (ST) phases, their ratio, players' transfer phases (TR) and action played on half court; 2) analyse the differences of LT and ST phases, the LT/ST ratio, TR phases and action played on half court between the first and second half; 3) compare the LT/ST ratio between official games and game-based conditioning drills.

MATERIALS AND METHODS ▰▰▰▰

Subjects. The study meets the ethical standards in sports and exercise science research [17] and was approved by an institutional review board. Ten division I men's college basketball games (7 home and 3 away), 15 defensive, 14 offensive and 6 scrimmage-type drills of the same team were analysed. During official games the team won six and lost four times, respectively (score difference=13.9±7.7 points). The team was composed of 13 American and European players (mean±SD: age: 21±1 years; height: 1.96±0.09 m; body mass; 92.6±14.0 kg). American players were selected among the best high school basketball teams of the state, while all the European players were members of their respective youth national teams. Experimental approach to the problem

LT, ST, LT/ST ratio, TR, and half court actions were considered the dependent variables to verify whether differences occurred between games and between game halves. Moreover, the LT/ST ratio was used as a dependent variable to assess differences between the first and second half and between games and game-based conditioning drills. Data were collected during the 2013–2014 season between 8 November (date of the first official NCAA game) and 15 December, 2013. According to the NCAA basketball rules, the analysed games consisted of two 20-min halves separated by a 15-min break period. All games were valid to achieve the best possible ranking position in one of the NCAA competitive conferences, the winner of which receives an automatic bid to the national championship tournament. This is the season final tournament played by the best 68 teams to

determine the national NCAA winner. During the experimental period, only home training sessions were considered, and they were scheduled at the same time of day (8 a.m.). Considering that the NCAA competition schedule provides a high frequency of games in a small period and with long travels in between, players did not have a standard weekly training schedule. Typically, players undertook five 120-min training sessions and played one or two games with one mandatory rest day during the standard weekly training schedule. All of the home training sessions (n=20) performed during the experimental period were considered in this study. During each training session only 5 vs 5 drills were analysed and compared to the game situations. They were classified as: offensive, defensive and scrimmage-type drills. Offensive and defensive drills aimed to train team offensive and defensive tactics, respectively, and were played performing no more than two transfer phases. Scrimmage-type drills were played simulating game playing style. The 35-second shot clock was used in all the three drill categories, similar to what is used during official games. The coaching staff were allowed to stop and re-start each drill session as many times as necessary and for as long as they deemed necessary to make a coaching point. No time-outs were allowed during the offensive and defensive drills, while 30-second time-outs were adopted during scrimmage-type drills. Moreover, the coaching staff composed balanced teams based on players' skills and court positions and provided consistent verbal encouragement for all the 5 vs 5 drills to ensure the maintenance of consistently high work intensity.

Procedures

A video-based time-motion analysis was performed for each considered game and training session. All video recordings were collected using a fixed camera (Sony HDR-FX7E, Tokyo, Japan, 50 Hz) positioned at the midline 8–10 m away from the sideline and elevated 10–12 m. Footage was analysed by two experienced video analysts using the software Kinovea (www.kinovea.org) that has been previously adopted in video analysis studies [18,19].

LT and ST were classified in 5 classes of duration: 1-20, 21-40, 41-60, 61-80, >80 s [7] and the LT/ST ratio was calculated. An action was considered the phase included within each live time phase [7] and was coded as played on half or full court: half court actions occurred when an action started and finished in the same half court [7]; full court actions occurred when an action started in one half court and finished in the other half court, with at least 3 team members crossing the mid-court line. A single TR was counted when those players crossed the mid-court line [7]. TR phases were then classified in 5 classes of frequency: 1TR, 2TR, 3TR, 4TR, and >4TR.

Statistical analysis

Descriptive statistics (mean±SD, median and relative percentage frequency of occurrence) were calculated for the dependent variables. Normality and homogeneity of variances were assessed using the Shapiro-Wilk test. Results showed that data were not normally dis-

TABLE I. Relative frequency of occurrence (%) of live time and stoppage time in games and halves, and chi square (χ^2), p-value and effect size (Cramer's V) between 1st and 2nd half in relation to 5 time categories (1-20 s, 21-40 s, 41-60 s, 61-80 s, >80 s).

	Live Time (%)						Stoppage Time (%)					
	Game	1st half	2nd half	χ^2	p-value	Cramer's V	Game	1st half	2nd half	χ^2	p-value	Cramer's V
1-20 s	38.5	33.5	43.0				28.3	32.7	24.5			
21-40 s	26.6	28.4	24.9			0.103 (Small effect)	23.4	22.8	23.9			0.094 (No effect)
41-60 s	15.6	17.6	13.8	7.015	0.135		23.8	21.5	26.0	5.71	0.222	
61-80 s	11.2	11.2	11.2				8.3	7.6	8.8			
>80 s	8.2	9.3	7.2				16.2	15.5	16.8			

TABLE 2. Relative frequency of occurrence (%) of transfer phases (TR) in games and halves, and chi square (χ^2), p-value and effect size (Cramer's V) of 1st and 2nd half in relation to one (1TR), two (2TR), three (3TR), four (4TR) and more than four (>4TR) categories.

Transfer phases	Game (%)	1st half (%)	2nd half (%)	χ^2	p-value	Cramer's V
1TR	39.0	33.6	45.4			
2TR	24.2	26.6	22.1			
3TR	18.4	19.7	16.7	6.914	0.140	0.121 (Small effect)
4TR	7.5	7.9	5.8			
>4TR	10.9	12.2	10.0			

tributed; therefore a non-parametric statistics approach was used. Chi square (χ^2) tests of independence were used to determine whether a different distribution occurred between games and between the first and second half in LT, ST and TR phases, while a chi square goodness of fit test was applied to verify any differences in the distribution of the number of half court actions between games and between the first and second half. A Wilcoxon signed-rank test was used to assess differences in the LT/ST ratio between halves. Moreover, differences in LT/ST ratio between games and training (offensive, defensive and scrimmage game-type drills) were assessed using the Kruskal-Wallis test followed by the Mann-Whitney U test as a post-hoc test for any difference reported, and p-values were adjusted using a Bonferroni correction (adj-p). Effect sizes were calculated using Cramer's V for the chi square analyses and the r-value for Wilcoxon signed-rank and Mann-Whitney U tests [20]. Effect size values were interpreted according to Cohen's benchmarks considering 0.1, 0.3 and 0.5 as a small, medium and large effect size, respectively [21]. Relative and absolute reliability of video analysis procedures were tested using the intraclass correlation coefficient (ICC) and coefficient of variation (CV), respectively. Data were analysed using the SPSS package (version 21, IBM Corporation, Armonk, NY, USA), and the level of significance was set at p<0.05.

RESULTS

Results showed high relative (ICC=0.91–0.99) and absolute (CV=1-3%) test-retest reliability for the time-motion analysis procedures. No differences emerged between games for the frequency of occurrence of LT [χ^2=42.064, p=0.225, Cramer's V=0.126 (small effect)]

and ST [χ^2=36.442, p=0.488, Cramer's V=0.117 (small effect)] phases. The mean LT/ST ratio was 0.71±0.08 per game. On average an LT and ST phase had a mean duration of 36.6±3.8 s and 53.2±5.0 s, respectively. Moreover, no differences between games were found for TR phases [χ^2=42.646, p=0.207, Cramer's V=0.149 (small effect)] and action played on half court [χ^2=7.832, p=0.551, Cramer's V=0.109 (small effect)]. 29.2% and 70.8% of the total actions were played on half and full court, respectively.

No differences were found between halves in the distribution of LT and ST phases (table 1), while a significant difference [p=0.000, r=0.877 (large effect)] was observed for LT/ST ratio between the first (mean±SD= 0.81±0.10, median=0.83) and second half (mean±SD=0.65±0.11, median=0.62). Furthermore, half court actions [χ^2=1.543, p=0.214, Cramer's V=0.048 (no effect)] and TR phases (p=0.140) (table 2) were evenly distributed between the first and second half.

TABLE 3. Mean, standard deviation (SD) and median of LT/ST ratio in games, offensive, defensive and scrimmage-type drills.

	Mean	Median
Game	0.71 ± 0.08	0.73
Defensive drill	0.75 ± 0.23	0.65
Offensive drill	0.80 ± 0.17	0.78
Scrimmage *	1.38 ± 0.48	1.21

Note: *indicates a statistical difference compared to games [adj-p= 0.012, r= -0.789 (large effect)], defensive [adj-p= 0.024, r= -0.629 (large effect)] and offensive [p= 0.018, r= -0.664 (large effect)] drills

A significant difference in LT/ST ratio was found between games and 5 vs 5 training drills (p=0.004). Post-hoc analysis demonstrated significant differences of scrimmage-type drills in comparison to games, defensive drills and offensive drills, while no differences were found for the other pairwise comparisons (table 3).

DISCUSSION

This is the first study analysing NCAA division I men's college basketball game and training performances. The main findings were that: 1) no differences occurred in the distribution of LT, ST, TR and half court action between games; 2) no differences were found in the distribution of LT, ST, TR and half court action between the first and second half, although LT/ST ratio was higher in the first half than the second half; 3) game-based drills replicate game LT/ST ratio demand, although scrimmage-type drills showed greater values than games as well as offensive and defensive drills.

While the scientific literature has mostly focused on the assessment of game performance in European [7,22], African [5,23,24] and Australian [6,8,25,26] basketball competitions using time-motion analysis technique, no study has previously analysed American college games. In the present study, the analysis of the distribution of LT, ST, TR phases and the action played on half court revealed no statistically significant differences between games, suggesting that these data might be useful to establish a specific model of performance for NCAA college basketball. Most of the actions had a short duration and were included in the 1-20 s class, with 80% of the LT phases lasting up to 1 min. To the best of our knowledge, the study of Conte et al. [7], which evaluated the performance during elite women's FIBA games, is the only previous investigation that allows a possible comparison with the current study, since it adopted a similar time-motion analysis technique. It produced similar results to those of the current investigation, with most of the LT phases included in the 1-20s class (43.4%) and 86% of the LT phases lasting up to 1 min. Considering the ST phases, in both men's college and in elite women's games the highest frequency of occurrence was reported in the 1-20s class; however, a higher percentage was reported for elite women's games (51.1%) compared to college ones (28.3%). The reason for this difference could be the unique structure of the NCAA college games, governed by different basketball rules than those adopted by the FIBA (i.e. college games are divided into two 20-min halves, FIBA games into four 10-min quarters). Furthermore, more time-outs with a longer duration are allowed for each team in college basketball (75 s) compared to FIBA games (60 s). The reasons to call a time-out are mainly to instruct tactics, or interrupt the opponents' positive momentum and consequently gain a psychological advantage [27]. An additional reason is to allow players to recover from fatigue. Since college basketball halves are played without any standardized interruptions, while quarters are interspersed by a 2-min rest in FIBA games, coaches could call time-outs to allow players to restore their energy stores rather than for other reasons. Therefore, more frequent long interruptions were registered in college

basketball games compared to FIBA ones. Summing the frequency of occurrences in the 41-60 s, 61-80 s and >80 s classes, we observed a higher value in NCAA games (48.3%) with respect to Italian elite women's games (19.9%) [7]. These results also affect the LT/ST ratio in college games. The mean LT/ST ratio obtained in this study was 0.71, lower than the 1.08 observed in Italian elite women's games [7]. This finding could show a lower LT/ST ratio during college games. However, in both studies the pre-coded stoppage time phases (between quarters and halves) were not considered in the LT/ST ratio calculation. Therefore, it is not possible to make a real comparison, due to the absence of the pre-coded 2-min rest period of FIBA games in NCAA games. Overall, these results showed that men's college basketball is an intermittent sport characterized by short LT and ST phases. Moreover, they suggested the need for basketball athletes to have the metabolic capacity to be highly active for short periods of time (seconds to minutes) and then replenish energy stores within a short rest period.

Considering the actions played on full and half court, the results revealed that 70.8% of the actions were played on full court and that most of them involved 1TR (39%). This result is in line with that previously reported in elite women's games [7]. Moreover, Conte et al. [7] found a significant difference in the distribution of TR phases between games, while no differences were found in the present study. This difference could be explained by a more robust game sample (ten games) than the previous investigation, in which only five games were analysed and played in two different championships (Euroleague and Serie A1). Therefore, the current study allows a better generalization of the basketball game performance.

To gain a clearer picture of the college basketball performance, a comparison of LT, ST, LT/ST ratio, TR phases and half court actions was performed between halves. The results showed no statistically significant differences between the analysed parameters except for the LT/ST ratio, which was higher in the first half than the second half, with a large effect size. These data suggest a likely comparable structure of the first and second game half, while the lower LT/ST ratio observed during the second half may be caused by a fatigue effect or different tactical strategies adopted in the last part of the game. Previous studies investigating the effect of fatigue on basketball games reported different outcomes. Studies analysing players' post-game performance showed a decrease of single sprint performance and repeated sprint ability compared to pre-game performance, while no differences were reported for jump performance [28,29]. Time-motion analysis studies investigating the changes of players' high intensity efforts across the game also reported conflicting results. A reduction of the frequency of occurrence of high intensity activity (sprints, jumps, high intensity shuffles) was observed in the last quarter of the game in elite under-19-year-old basketball players [5]. Conversely, an analysis of elite female Italian senior games [7] and women's games of the British University Sport Association [22] revealed no significant differences in high-intensity activity between game quarters. However, as suggested in previous investigations, the

fatigue effect might be dependent on the number of minutes played during the game [7,22]. The fatigue effect that likely occurred in the second half in the present study may influence the low LT/ST ratio obtained, which could be related to a higher number of turnovers and committed fouls. In fact, it has been demonstrated that fatigue impairs technical skill performances in team sports [30,31,32] and specifically in basketball [33]. Therefore, future studies should assess whether a fatigue effect occurs during NCAA college basketball games. In addition, tactical strategies could influence the lower LT/ST ratio observed during the second half, since, mostly in close games, losing teams usually foul the opponents to stop the clock and recover the ball possession after free throw shots are allowed.

A novel aspect of this study was the comparison of the LT/ST ratio during game and game-based training in college basketball. Previous investigations have shown that game-based conditioning produces the most specific form of conditioning in rugby league [14] and Australian football [11], documenting a similar or greater external load in small-sided games compared to match play. However, in other team sports (hockey and soccer), game-based conditioning was unable to replicate the repeated-sprint demands and time spent at higher speeds commonly observed in match play [13,15]. In basketball, the comparison of game-based conditioning and games showed a lower physiological and physical demand in 5 vs 5 scrimmage-type drills [16]. The present study did not directly measure the workload in a basketball game and training, but we could speculate that a higher LT/ST ratio generally corresponds to a higher workload. In this study, scrimmage-type drills exceeded the LT/ST ratio observed during games, offensive drills and defensive drills, which may likely lead to a greater workload during scrimmage-type drills. This result might be explained by a shorter duration compared to match play and by the fact that they were characterized only by 30-second time-outs. Furthermore, both offensive and defensive drills showed a similar LT/ST ratio compared to games and consequently a likely similar workload. Conversely, lower physiological and physical demands were previously documented in 5 vs 5 offensive and defensive drills compared to basketball games [16]. Coaches in this study were more likely to replicate game-specific demands by using concise explanations of their offensive and defensive plays, thus keeping the LT/ST ratio at a level consistent with games.

One of the limitations of this study is the calculation of the LT/ST ratio only for the total game time and the first and second halves, while the analysis of the game time split in shorter fractions would be more meaningful to provide detailed indications for basketball coaches, scientists and practitioners. For this reason, future studies should further investigate the game performance of college basketball games and compare it with FIBA and NBA games. Moreover, the time-motion analysis performed in this study analysed only team movements, while an analysis of individual movement patterns would benefit college basketball coaches to better understand players' performance. Finally, future studies should investigate whether the LT/ST ratio values reported during game and training are related to similar physiological and physical demands using individual time-motion analysis technique or accelerometer technologies.

From a practical standpoint, the present findings suggest that basketball coaches should adopt game-based conditioning drills to replicate the game performance and that drills should be characterized by short duration and an LT/ST ratio of 1:1. To achieve this aim, coaches should provide short and concise technical-tactical directions to maintain an LT/ST ratio consistent with game sequences and to achieve an appropriate workload. In a particular period of the season, an increase of the LT or ST phases would be helpful to modify the training workload to either produce a greater physiological or physical demand or to allow more recovery time. Furthermore, to meet the game requirements, drill bout duration should last approximately 1 minute. Finally, considering the team movement patterns observed in this study, coaches should mainly set up drills with a few TR phases.

CONCLUSIONS

The absence of differences between games in the analysed parameters is important to characterize the performance profile of division I men's college games. Specifically, games are characterized by short actions with an LT/ST ratio of ~1:1. Furthermore, these results encourage coaches to use game-based conditioning drills to replicate the LT/ST ratio documented during games.

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