Not all about the effort? A comparison of playing intensities during winning and losing game quarters in basketball

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ABSTRACT

Purpose: To compare peak and average intensities encountered during winning and losing game quarters in basketball players.

Methods: Eight semi-professional, male basketball players (age: 23.1 ± 3.8 yr) were monitored during all games (N = 18) over one competitive season. The average intensities attained in each quarter were determined using microsensors and heart rate monitors to derive relative values ($\cdot min^{-1}$) for the following variables: PlayerLoad (PL), frequency of high-intensity and total accelerations, decelerations, changes of direction, jumps, and total inertial movement analysis events combined, and modified Summated-Heart-Rate-Zones (SHRZ) workload. The peak intensities reached in each quarter were determined using microsensors and reported as PL per minute ($PL\cdot min^{-1}$) over 15-s, 30-s, 1-min, 2-min, 3-min, 4-min, and 5-min sample durations. Linear mixed models and effect sizes (ES) were used to compare intensity variables between winning and losing game quarters.

Results: Non-significant (*P* >0.05), *unclear-small* differences were evident between winning and losing game quarters in all variables.

Conclusions: During winning and losing game quarters, peak and average intensities were similar. Consequently, factors other than the intensity of effort applied during games may underpin team success in individual game quarters and therefore warrant further investigation.

Key words: performance, worst case scenario, accelerometer, team sport, peak, exertion.

INTRODUCTION

Basketball is a high-intensity intermittent team sport where high-intensity movements are interspersed with low-intensity activities such as walking and standing.[1] Given the demanding nature of basketball game-play, it is important for practitioners to monitor the physical (external workload) and physiological-perceptual (internal workload) demands encountered by players to promote positive performance-related adaptations in players.[2] When monitoring basketball players to optimize performance, the external and internal exercise intensities encountered should be extensively considered as they are strongly associated with desired physical and physiological adaptations that could underpin any observed improvements in performance.[3]

In basketball, intensity is commonly calculated as the workload completed relative to total game duration ($\cdot min^{-1}$).[4] While this approach encapsulates the average intensities achieved across games, it fails to isolate the most demanding passages of play occurring across shorter epochs.[5] In this regard, recent work demonstrated that using shorter sample durations yields greater peak intensities than longer samples when applying moving averages to measure the peak workload intensities during basketball games.[5,6]

Understanding the average and peak intensities encountered by players during games permits basketball practitioners to implement training and recovery strategies that adequately prepare players for game intensities.[5] In turn, pivotal moments during games may be concomitant with peak intensities encountered and therefore the ability of players to cope with these demands may potentially influence game outcomes.[7] Past research assessing amateur, semi-professional,[8] and elite[9] basketball players revealed *small*[9,10] to *very large*[8] differences in average intensity only between games that were won and lost. However, no research has examined differences in average and peak intensities between winning and losing game quarters in basketball. Therefore, the purpose of this study was to compare the average and peak intensities between winning and losing game quarters in basketball players.

METHODS

Subjects

Eight semi-professional, male basketball players (age: 23.1 ± 3.8 yr; stature: 191 ± 8 cm; body mass: 87 ± 16 kg) volunteered to participate in this study. All players were from the same team in the Queensland Basketball League, a second-tier, state-wide Australian basketball competition. Players who were expected to receive limited playing time across the season were not routinely monitored, at the request of coaching staff, and therefore could not be considered for inclusion in this study. Players included in the study received ≥4 min playing time per game. All study procedures were approved by the Central Queensland University Human Research Ethics Committee.

Design

An observational, longitudinal study design was utilized whereby players were monitored across the entire 2018 season. Across the season, players participated in 18 games, held between Friday and Sunday each week, with 0-3 games played per week. Each game consisted of four 10-min quarters.

Methodology

Prior to study commencement, anthropometric data were collected for each player including stature using a portable stadiometer (Seca 213, Seca GMBH, Hamburg, Germany) and body mass using electronic scales (BWB-600, Tanita Corporation, Tokyo, Japan). For all games, players wore microsensor units (OptimEye s5, Catapult Innovations, Melbourne, Australia) and heart rate monitors (Polar T31, Polar Electro, Kempele, Finland) to continuously collect data.

Average intensity was captured using the microsensor unit and HR monitor. Average external intensity was reported as PlayerLoad™ per minute (AU·min^{-1}) as well as inertial movement analysis (IMA) variables per minute. IMA data collected included accelerations (-45° to 45° direction), decelerations (-135° to 135° direction), changes-of-direction ([COD], -135° to -45° direction for left and 45° to 135° direction for right), and jumps. IMA data were determined as the number of high-intensity and total accelerations, decelerations, COD, jumps, and IMA events per minute (count·min^{-1}). For accelerations, decelerations, and COD, high-intensity events were classified using proprietary cutpoints from the microsensor software as those >3.5 m·s^{2}. For jumps, high-intensity events refers to those >40 cm. A combination of PL and IMA events were used to provide insights regarding the overall intensity encountered as well as during various multidirectional and high-intensity actions (i.e. accelerations, decelerations, changes of direction and jumps).[8] PL and IMA data in combination also provide insights regarding the overall intensity encountered as well as during various multidirectional and high-intensity actions (i.e. accelerations, decelerations, changes of direction and jumps) which are important in basketball. The reliability of PL[11] and IMA events[12] has been previously reported as acceptable in team sports.

Heart rate (HR)-derived average intensity was determined using a modified Summated-Heart-Rate-Zones workload model.[13] Using this method, HR data (1-s epochs) were placed into pre-defined zones between 50-100% of HR_{max} (highest HR obtained during any training session or game),[14] with each zone increasing by 2.5%. Time (min) spent in each zone was multiplied by corresponding weightings of 1.0-5.75, increasing by 0.25 across each subsequent zone. The accumulated weightings were summed before being divided by game quarter duration (inclusive of all rest periods and substitutions)[3] to determine average intensity.

The most demanding periods of game-play (peak intensity) were captured using accelerometers within the microsensor units, sampling at 100 Hz. Data were exported as instantaneous PL, representing the square root of the change in acceleration across the x, y, and z axes, determined using proprietary software (OpenField v8, Catapult Innovations, Melbourne, Australia). Moving averages for PL were calculated consecutively over 15-s, 30-s, 1-min, 2min, 3-min, 4-min, and 5-min samples using the "zoo" package in RStudio (v3.5.3).[15] The highest value calculated for each sample duration was taken as the peak intensity for that sample duration and expressed per minute.[5]

Statistical Analysis

For all intensity variables, data are reported as mean ± standard deviation (SD) for winning quarters (individual quarters in which the team outscored the opposition [n = 119]) and losing quarters (game quarters in which the team were outscored by opposition [n = 121]). Linear mixed models with Bonferroni post hoc tests were conducted to determine differences in intensity variables between winning and losing quarters. Quarter outcome (win or loss) was entered as the fixed term and participant number was entered as the random term using IBM SPSS statistics (v25, IBM Corporation, Armonk, NY) to account for multiple observations obtained for each participant, with significance accepted where $P < 0.05$.

For all pairwise comparisons, effect sizes (ES) with 95% confidence intervals were conducted to determine the magnitude of any differences between winning and losing quarters using Microsoft Excel (v15, Microsoft Corporation, Redmond, USA). ES magnitude was interpreted as *trivial*: <0.20, *small*: 0.20-0.59, *moderate*: 0.60-1.19, *large*: 1.20-1.99, and *very large*: ≥2.00.[16] Where confidence intervals for the ES crossed ±0.2, the effect was deemed *unclear*.

RESULTS

The mean ± SD peak and average intensities attained during winning and losing game quarters for the entire team are presented in Table 1, with statistical comparisons shown in Table 2. Non-significant, *unclear-small* differences between winning and losing quarters were apparent for all variables. *Small* effects were observed between winning and losing quarters for peak intensity ($PL \cdot min^{-1}$) across 4- and 5-min sample durations and high-intensity accelerations ($count \cdot min^{-1}$), which were higher during losing quarters, and for average SHRZ workload, which was higher during winning quarters.

*****INSERT TABLE 1 AROUND HERE*****

*****INSERT TABLE 2 AROUND HERE*****

DISCUSSION

The present study is the first to compare peak and average intensities between winning and losing game quarters in basketball. Despite the lack of significant differences in intensity variables between winning and losing game quarters, it may be useful to understand findings reaching a *small* effect. Specifically, our data revealed peak intensities over longer sample durations (>3 min) and the number of high-intensity accelerations across quarters were higher (*small*) during losses compared to wins. These findings may be due to an increased game pace when attempting to maximize scoring opportunities and to minimize the score-line margin when in a losing position.[8] When considering peak intensity variables, those captured for >3 min may therefore be more useful than shorter sample durations at differentiating quarter outcome, given they represent the most demanding passages encountered across a more substantial portion of game time in each quarter. Similarly, several game scenarios promoting increased high-intensity accelerations may be encountered when teams are losing across game quarters (e.g. initiating quicker offensive schemes, adopting man-to-man defense to force turnovers). In contrast, only *trivial* differences were revealed regarding average external intensity across the entire quarter ($PL \cdot min^{-1}$). Similar average intensities between winning and losing quarters might be related to greater exposure to rest or low-intensity periods during the entire quarter (e.g. substitutions, free-throws, time-outs), which may be less important in dictating game outcomes than intense periods captured using peak intensities or high-intensity accelerations. However, sole reliance on these data to optimize performance in basketball players is not recommended given the differences in peak intensity variables between winning and losing quarters only reached a *small* magnitude.

Where internal workload was considered, SHRZ was higher during wins compared to losses. Given that SHRZ revealed different insights to external variables when comparing intensity between winning and losing quarters, it is plausible that these findings may be explained by increased psychological stress imposed during wins compared to losses, which can increase cardiovascular responses when attempting to maintain a lead during wins, irrespective of the external workloads imposed.[8] Similar to external workload variables, given only a *small* effect was observed, SHRZ intensity in isolation should not be used to anticipate performance.

In interpreting our findings, there are limitations that should be considered. Firstly, the demands encountered by players leading into games were not considered. Therefore, while game intensities may not discriminate between winning and losing quarters, the importance of periodizing training workloads surrounding games should not be discounted. Secondly, game quarter outcome was dichotomized based on win or loss; however, different insights might be revealed where other contextual factors are considered such as the opposition faced or score-line margin.[8,9] Similarly, other factors such as team tactical strategies, playing level, player experience, and player attributes (e.g. skill, anticipation ability, reaction speed, mental toughness) may also impact game outcomes, and these factors were not able to be accounted for in the present study.

PRACTICAL APPLICATIONS

Although players must be conditioned to withstand the intensities encountered during games, practitioners should not solely focus on maximizing the external and internal intensities reached during games to optimize the likelihood of team success during individual game quarters.

CONCLUSIONS

Average and peak workload intensities fail to discriminate between winning and losing quarters with only *small* differences apparent for selected variables.

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Table 1. Peak and average intensities during winning and losing game quarters in semi-professional basketball players.

Variable	**Game quarter outcome (mean (SD))**	
	Win (N = 121)	*Loss (N = 119)*
Peak intensity (PlayerLoad [AU·min^{-1}])		
15-s sample duration	23.72 (4.54)	23.34 (5.02)
30-s sample duration	19.13 (3.93)	18.94 (4.11)
1-min sample duration	15.55 (3.20)	15.46 (3.45)
2-min sample duration	12.44 (12.62)	12.59 (2.94)
3-min sample duration	11.03 (2.43)	11.20 (2.75)
4-min sample duration	10.11 (2.37)	10.44 (2.66)
5-min sample duration	9.49 (2.40)	9.86 (2.61)
Average intensity (AU·min^{-1})		
PlayerLoad	6.30 (2.06)	6.31 (2.33)
High-intensity accelerations	0.10 (0.08)	0.12 (0.10)
Total accelerations	0.79 (0.32)	0.76 (0.34)
High-intensity decelerations	0.14 (0.12)	0.13 (012)
Total decelerations	1.40 (0.61)	1.37 (0.62)
High-intensity changes of direction	0.29 (0.19)	0.28 (0.22)
Total changes of direction	4.48 (1.57)	4.53 (1.74)
High-intensity jumps	0.22 (0.17)	0.21 (0.15)
Total jumps	0.68 (0.35)	0.69 (0.33)
High-intensity IMA events	0.76 (0.41)	0.75 (0.42)
Total IMA events	9.67 (3.40)	9.60 (3.53)
Summated-Heart-Rate-Zones	3.07 (0.78)	2.96 (0.85)

Note: SD = standard deviation, AU = arbitrary units, IMA = inertial movement analysis.

Table 2. Statistical comparisons in intensity variables between winning and losing game quarters in semi-professional basketball players.

Variable	**Statistical comparisons**		
	P value	*Effect size (95% CI)*	*Effect size interpretation*
Peak intensity (PlayerLoad [AU·min^{-1}])			
15-s sample duration	0.54	0.08 (-0.17, 0.33)	*Trivial*
30-s sample duration	0.72	0.05 (-0.21, 0.30)	*Unclear*
1-min sample duration	0.84	0.03 (-0.28, 0.28)	*Unclear*
2-min sample duration	0.67	0.05 (-0.31, 0.20)	*Unclear*
3-min sample duration	0.60	0.07 (-0.32, 0.19)	*Trivial*
4-min sample duration	0.32	0.13 (-0.38, 0.12)	*Small*
5-min sample duration	0.25	0.15 (-0.40, 0.11)	*Small*
Average intensity (AU·min^{-1})			
PlayerLoad	0.98	0.01 (-0.26, 0.25)	*Unclear*
High-intensity accelerations	0.13	0.22 (-0.47, 0.03)	*Small*
Total accelerations	0.49	0.09 (-0.16, 0.34)	*Trivial*
High-intensity decelerations	0.51	0.08 (-0.17, 0.34)	*Trivial*
Total decelerations	0.67	0.05 (-0.20, 0.3)	*Trivial*
High-intensity changes of direction	0.80	0.05 (-0.20, 0.30)	*Trivial*
Total changes of direction	0.79	0.03 (-0.28, 0.22)	*Unclear*
High-intensity jumps	0.73	0.06 (-0.19, 0.31)	*Trivial*
Total jumps	0.95	0.03 (-0.28, 0.22)	*Unclear*
High-intensity IMA events	0.87	0.02 (-0.23, 0.28)	*Unclear*
Total IMA events	0.87	0.02 (-0.23, 0.27)	*Unclear*
Summated-Heart-Rate-Zones	0.28	0.13 (-0.12, 0.39)	*Small*

Note: CI = confidence interval, AU = arbitrary units, IMA = inertial movement analysis.