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Human Kinetics
BRIEF REPORT

Not All About the Effort? A Comparison of Playing Intensities During Winning and Losing Game Quarters in Basketball

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Purpose: To compare peak and average intensities encountered during winning and losing game quarters in basketball players. ***Methods:*** Eight semiprofessional male basketball players (age = 23.1 [3.8] y) were monitored during all games (N = 18) over 1 competitive season. The average intensities attained in each quarter were determined using microsensors and heart-rate monitors to derive relative values (per minute) for the following variables: PlayerLoad, frequency of high-intensity and total accelerations, decelerations, changes of direction, jumps, and total inertial movement analysis events combined, as well as modified summated-heart-rate-zones workload. The peak intensities reached in each quarter were determined using microsensors and reported as PlayerLoad per minute over 15-second, 30-second, 1-minute, 2-minute, 3-minute, 4-minute, and 5-minute sample durations. Linear mixed models and effect sizes were used to compare intensity variables between winning and losing game quarters. ***Results:*** Nonsignificant ($P > .05$), *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.

Keywords: worst-case scenario, accelerometer, team sport, peak, exertion

Basketball is an 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.[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, the intensity is commonly calculated as the workload completed relative to total game duration (per minute).[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, semiprofessional,[8] and elite[9] basketball players revealed *small*[9,10] to *very large*[8] differences in average intensity 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 encountered by basketball players during winning and losing game quarters.

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Methods

Subjects

Eight semiprofessional, male basketball players (age = 23.1 [3.8] y; 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. The players included in the study received ≥4 minutes of 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 to 3 games played per week. Each game consisted of four 10-minute quarters.

Methodology

Prior to the 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, the players wore microsensor units (OptimEye s5; Catapult Innovations, Melbourne, Australia) and heart rate (HR) 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 (in arbitrary units per minute) as well as inertial movement analysis (IMA) variables per minute. The 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. The IMA data were determined as the number of high-intensity and total accelerations, decelerations, COD, jumps, and IMA events per minute (counts per minute). For accelerations, decelerations, and COD, high-intensity events were classified using proprietary cut points from the microsensor software as those >3.5 $m \cdot s^2$. 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 (ie, accelerations, decelerations, COD, and jumps).[8] The reliability of PL[11] and IMA events[12] has been previously reported as acceptable in team sports.

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

The most demanding periods of gameplay (peak intensity) were captured using accelerometers within the microsensor units, sampling at 100 Hz. The 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 version 8; Catapult Innovations, Melbourne, VIC, Australia). Moving averages for PL were calculated consecutively over 15-second, 30-second, 1-minute, 2-minute, 3-minute, 4-minute, and 5-minute samples using the "zoo" package in RStudio (version 3.5.3).[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, the data are reported as mean (SD) for the winning quarters (individual quarters in which the team outscored the opposition [n = 119]) and losing quarters (game quarters in which the team was outscored by the opposition [n = 121]). Linear mixed models with Bonferroni post hoc tests were conducted to determine differences in intensity variables between the 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 (version 25.0; IBM Corp, Armonk, NY) to account for multiple observations obtained for each participant, with significance accepted where $P < .05$.

For all pairwise comparisons, effect sizes with 95% confidence intervals (CIs) were conducted to determine the magnitude of any differences between the winning and losing quarters using Microsoft Excel (version 15.0; Microsoft Corporation, Redmond, WA). The effect size magnitude was interpreted as *trivial*: <0.20, *small*: 0.20 to 0.59, *moderat*e: 0.60 to 1.19, *large*: 1.20 to 1.99, and *very large*: ≥2.00.[16] Where CIs for the effect size 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. Nonsignificant, *unclear–small* differences between the winning and losing quarters were apparent for all variables. *Small* effects were observed between the winning and losing quarters for peak intensity (PlayerLoad per minute) across 4- and 5-minute sample durations and high-intensity accelerations (counts per minute), which were higher during losing quarters, and for average SHRZ workload, which was higher during winning quarters.

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 the winning and losing game quarters, it may be useful to understand the findings reaching a *small* effect. Specifically, our data revealed peak intensities over longer sample durations

Table 1 Peak and Average Intensities During Winning and Losing Game Quarters in Semiprofessional Basketball Players

Variable	Game quarter outcome (mean [SD]) Win (N = 121)	Loss (N = 119)
Peak intensity (PlayerLoad, $AU \cdot min^{-1}$)		
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, $AU \cdot min^{-1}$		
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)

Abbreviations: AU, arbitrary units; IMA, inertial movement analysis.

Table 2 Statistical Comparisons in Intensity Variables Between Winning and Losing Game Quarters in Semiprofessional Basketball Players

Variable	*P*	ES (95% CI)	ES interpretation
Peak intensity (PlayerLoad, AU·min^{-1})			
15-s sample duration	.54	0.08 (−0.17 to 0.33)	Trivial
30-s sample duration	.72	0.05 (−0.21 to 0.30)	Unclear
1-min sample duration	.84	0.03 (−0.28 to 0.28)	Unclear
2-min sample duration	.67	0.05 (−0.31 to 0.20)	Unclear
3-min sample duration	.60	0.07 (−0.32 to 0.19)	Trivial
4-min sample duration	.32	0.13 (−0.38 to 0.12)	Small
5-min sample duration	.25	0.15 (−0.40 to 0.11)	Small
Average intensity, AU·min^{-1}			
PlayerLoad	.98	0.01 (−0.26 to 0.25)	Unclear
High-intensity accelerations	.13	0.22 (−0.47 to 0.03)	Small
Total accelerations	.49	0.09 (−0.16 to 0.34)	Trivial
High-intensity decelerations	.51	0.08 (−0.17 to 0.34)	Trivial
Total decelerations	.67	0.05 (−0.20 to 0.3)	Trivial
High-intensity changes of direction	.80	0.05 (−0.20 to 0.30)	Trivial
Total changes of direction	.79	0.03 (−0.28 to 0.22)	Unclear
High-intensity jumps	.73	0.06 (−0.19 to 0.31)	Trivial
Total jumps	.95	0.03 (−0.28 to 0.22)	Unclear
High-intensity IMA events	.87	0.02 (−0.23 to 0.28)	Unclear
Total IMA events	.87	0.02 (−0.23 to 0.27)	Unclear
Summated heart-rate zones	.28	0.13 (−0.12 to 0.39)	Small

Note: AU, arbitrary units; CI, confidence interval; ES, effect size; IMA, inertial movement analysis.

(>3 min), and the number of high-intensity accelerations across quarters were higher (*small*) during losses compared with 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 minutes 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 (eg, 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 (PlayerLoad per minute). Similar average intensities between winning and losing quarters might be related to greater exposure to rest or low-intensity periods during the entire quarter (eg, substitutions, free throws, and 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 that 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 with losses. Given that SHRZ revealed different insights to external variables when comparing intensity between the winning and losing quarters, it is plausible that these findings may be explained by increased psychological stress imposed during wins compared with 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 that 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. First, 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. Second, 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 (eg, skill, anticipation ability, reaction speed, and 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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References

1. Scanlan A, Dascombe B, Reaburn P. A comparison of the activity demands of elite and sub-elite Australian men's basketball competition. *J Sport Sci*. 2011;29(11):1153–1160. doi:10.1080/02640414.2011.582509
2. Sansone P, Tschan H, Foster C, Tessitore A. Monitoring training load and perceived recovery in female basketball: implications for training design. *J Strength Cond Res*. 2020; 34(10):2929–2936. doi:10.1519/JSC.0000000000002971
3. Vetter RE, Yu H, Foose AK. Effects of moderators on physical training programs: a Bayesian approach. *J Strength Cond Res*. 2017; 31(7):1868–1878. doi:10.1519/JSC.0000000000001585
4. Fox JL, Stanton R, Scanlan AT. A comparison of training and competition demands in semiprofessional male basketball players. *Res Q Exerc Sport*. 2018;89(1):103–111. doi:10.1080/02701367.2017.1410693
5. Fox JL, Conte D, Stanton R, McLean B, Scanlan AT. The application of accelerometer-derived moving averages to quantify peak demands in basketball: a comparison of sample duration, playing role, and session type [published online ahead of print February 14, 2020]. *J Strength Cond Res*. doi:10.1519/JSC.0000000000003486
6. Alonso E, Miranda N, Zhang S, Sosa C, Trapero J, Lorenzo J, Lorenzo A. Peak match demands in young basketball players: approach and applications. *Int J Env Res Pub Health*. 2020;17(7): 2256. doi:10.3390/ijerph17072256
7. Tierney P, Tobin DP, Blake C, Delahunt E. Attacking 22 entries in rugby union: running demands and differences between successful and unsuccessful entries. *Scan J Med Sci Sports*. 2017;27(12):1934–1941. doi:10.1111/sms.12816
8. Fox JL, Stanton R, Sargent C, O'Grady CJ, Scanlan AT. The impact of contextual factors on game demands in starting, semi-professional, male basketball players. *Int J Sports Physiol Perform*. 2019;15(4): 450–456. doi:10.1123/ijspp.2019-0203
9. Zhang S, Lorenzo A, Gomez M, Liu H, Goncalves B, Sampaio J. Players' technical and physical performance profiles and game-to-game variation in NBA. *Int J Perform Anal Sport*. 2017;17(4): 466–483. doi:10.1080/24748668.2017.1352432
10. Fernández-Leo A, Gomez-Carmona CD, Garcia-Rubio J, Ibanez SJ. Influence of contextual variables on physical and technical performance in male amateur basketball: a case study. *Int J Env Res Pub Health*. 2020;17(4):1193. doi:10.3390/ijerph17041193
11. Barrett S, Midgley A, Lovell R. PlayerLoad™: reliability, convergent validity, and influence of unit position during treadmill running. *Int J Sports Physiol Perform*. 2014;9(6):945–952. doi:10.1123/ijspp.2013-0418
12. Lutebegert LS, Holme BR, Spencer M. Reliability of wearable inertial measurement units to measure physical activity in team handball. *Int J Sports Physiol Perform*. 2017;13:467–476.
13. Scanlan AT, Fox JL, Poole JL, et al. A comparison of traditional and modified Summated-Heart-Rate-Zones models to measure internal training load in basketball players. *Meas Phys Educ Exerc Sci*. 2018; 22(4):303–309. doi:10.1080/1091367X.2018.1445089
14. Berkelmans DM, Dalbo VJ, Fox JL, et al. Influence of different methods to determine maximum heart rate on training load outcomes in basketball players. *J Strength Cond Res*. 2018;32(11):3177–3185. doi:10.1519/JSC.0000000000002291
15. Salazar H, Castellano J. Most demanding passages in Basketball: a preliminary study. *Sport Perform Sci*. 2019. https://sportperfsci.com/wp-content/uploads/2019/08/SPSR73_Salazar_190807_final.pdf.
16. Hopkins WA. A scale of magnitudes for Effect Statistics. *SportSci*. 2006. http://www.sportsci.org/resource/stats/index.html.