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Everything is not equal – comparisons in sessional training and game loads between main and bench players in a female basketball team

"No todo es igual" – comparaciones en la carga de entrenamientos y competición entre jugadoras titulares y suplentes en un equipo de baloncesto femenino

"Não é tudo igual" – comparações na carga de sessões de treino e competição entre titulares e suplentes numa equipa de basquetebol feminino.

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Abstract

Training load data should be provided to address various contextual factors such as player role; however, limited research has specifically quantified training and game demands based on player roles in female basketball players. Consequently, this study aimed to compare sessional training and game loads across a season between main (>25 min playing time in games) and bench (<25 min playing time in games), semi-professional, female basketball players (n = 12). Across all on-court team training sessions and games, players had external load measured with microsensors (PlayerLoad and inertial movement analysis variables) and internal load measured using heart rate and session-rating of perceived exertion monitoring methods. Linear mixed models revealed games imposed higher external and internal loads than training for all variables in main players (p <0.001). In contrast, training sessions induced greater external and internal intensities than games (p <0.01), while games imposed higher perceptual demands than training (p <0.01) in bench players. Main players exhibited greater external loads and heart rate demands in games than both games and training in bench players (p <0.01). The lower demands in bench players suggest they may be inadequately prepared to cope with increased loads if required to take on a main role.
Keywords: starter; demands; competition; heart rate; RPE; accelerometer.

Resumen

Se deben proporcionar datos sobre la carga de entrenamiento para abordar diversos factores contextuales, como el rol del jugador; sin embargo, una investigación limitada ha cuantificado específicamente las demandas de entrenamiento y juego basadas en los roles de las jugadoras de baloncesto. En consecuencia, este estudio tuvo como objetivo comparar el entrenamiento por sesión y las cargas de juego a lo largo de una temporada entre jugadoras de baloncesto semiprofesionales principales (>25 min de tiempo de juego en juegos) y de banco (<25 min de tiempo de juego en juegos) (n = 12). En todas las sesiones de entrenamiento y juegos del equipo en la cancha, a los jugadores se les midió la carga externa con microsensores (PlayerLoad y variables de análisis de movimiento inercial) y la carga interna se midió utilizando la frecuencia cardíaca y la calificación de la sesión de los métodos de monitoreo del esfuerzo percibido. Los modelos lineales mixtos revelaron que los juegos imponían cargas externas e internas más altas que el entrenamiento para todas las variables en los jugadores principales (p <0,001). Por el contrario, las sesiones de entrenamiento indujeron mayores intensidades externas e internas que los juegos (p <0,01), mientras que los juegos impusieron demandas perceptuales más altas que el entrenamiento (p <0,01) en los jugadores de banco. Los jugadores principales exhibieron mayores cargas externas y demandas de frecuencia cardíaca en los juegos que tanto en los juegos como en el entrenamiento en los jugadores de banco (p <0,01). Las menores exigencias de los jugadores de banco sugieren que es posible que no estén preparados adecuadamente para hacer frente a cargas mayores si se les exige que asuman un papel principal.
Palabras clave: banco; titular; exigencias; competición; frecuencia cardíaca; RPE; acelerómetro.

Introduction

Training load monitoring is commonplace in many competitive basketball teams, with practitioners using various tools to capture the external and internal loads encountered by players (Fox, Scanlan, et al., 2020; Romero-Caballero et al., 2020). The external load represents what players actually do, while the internal load indicates how players respond during training sessions and games (Jeffries et al., 2022). In this regard, external load data are useful for basketball practitioners to understand the physical demands encountered during different training and competition scenarios, which in turn can be used to inform the development or adjustment of training plans (Torres-Ronda et al., 2022). External load data offer further use in determining whether the desired physical outputs were attained when evaluating training plans (Torres-Ronda et al., 2022). Alongside individual and environmental factors, the external loads encountered will determine the internal load experienced, which strongly contributes to the physiological, psychological, and performance adaptations that ensue in players (Jeffries et al., 2022; López-Sierra et al., 2025). Accordingly, when applying load monitoring approaches for these functions, it is essential that basketball practitioners consider key contextual factors for optimal decision-making regarding player management (Torres-Ronda et al., 2022).

While training load data specific to various contextual factors have been readily quantified among different samples of basketball players (Fox, Stanton, et al., 2020; Pino-Ortega et al., 2019; Piñar et al., 2022), player role is an important factor of interest to practitioners. In this regard, identifying player roles typically involves categorizing them following a logical approach predicated on the amount of playing time they receive during games. Indeed, team sport research has identified practical value in quantifying training loads according to player role such as identifying inadequacies in loading stimuli among players who occupy roles with less game exposure (Clemente et al., 2024). Mismatched loading according to role may result in some players holding diminished fitness attributes (Caterisano et al., 1997; Scanlan et al., 2021), which can negatively impact performance (Ibáñez et al., 2023) and limit their capacity to endure increased loading should they be required to take on a different role due to player injury, suspension, or selection changes. Moreover, it is important to quantify the external and internal loads encountered across different player roles within both training and game contexts, given individualized training plans may be augmented with compensatory, top-up stimuli to counter insufficient loading during games among players who receive limited playing time (Clemente et al., 2024).

To date, limited research has directly quantified both training and game loads according to player role in basketball players (Brown et al., 2024; Conte et al., 2018; Fox et al., 2021; Kutson et al., 2024; Palmer et al., 2021; Russell, McLean, Stolp, et al., 2021). Although these studies collectively indicate that players receiving higher playing time in games (i.e., starters, high-minute players) experience higher game demands but comparable training demands than players receiving less playing time (i.e., bench, rotation, in-rotation, out-rotation, low-minute players), most have examined male players (Conte et al., 2018; Fox et al., 2021; Kutson et al., 2024; Russell, McLean, Stolp, et al., 2021) or mixed-sex samples (Palmer et al., 2021). In this regard, biological, biomechanical, and contextual (e.g., competition structure, resources) variations between male and female basketball players support the need for sex-specific load data on this topic (Power et al., 2022). Furthermore, most researchers have accumulated training and game demands across weekly (Conte et al., 2018; Russell, McLean, Stolp, et al., 2021) or monthly (Kutson et al., 2024) timeframes, which limits specificity in understanding how demands faced during individual training sessions compare to those in games. In turn, only one study (Brown et al., 2024) has examined sessional training and game loads according to player role exclusively in female players, showing high-minute players (>15 min playing time) experienced significantly greater external loads during games, but significantly lower external loads during training sessions than low-minute players (<15 min playing time). However, these data (Brown et al., 2024) are indicative of a single collegiate team (n = 13) and restricted to external load variables meaning additional research on this topic is essential to provide a more rigorous evidence base in female basketball players. In fact, only one study in the wider basketball literature has specifically analysed the weekly internal loads (using session-rating of perceived exertion [sRPE] load) encountered during training and games according to player role in a collegiate, male team

(Conte et al., 2018). Consequently, this study aimed to compare the sessional training and game loads across a season according to player role in female basketball players.

Materials and Methods

Design

A longitudinal, observational design was adopted involving a team-based approach. Players were from the same semi-professional team with load monitoring approaches utilized during all on-court team training sessions and games throughout the 2021 regular season. The team completed (mean ± standard deviation [SD]) 2 ± 1 team training sessions (19 session in total) with each lasting approximately 90 min and consisting predominantly of shooting drills, conditioning work, and game-based drills as prescribed by the coaching staff. The team also completed 1 ± 1 game per week across the 12-week season (14 games in total). Each game, consisting of four 10-min quarters, was structured the same way. Regarding game scheduling, 6 games were played at home and 8 games were played at away venues, with 3 weeks consisting of 0 games, 6 weeks consisting of a single game, 1 week consisting of 2 games, and 2 weeks consisting of 3 games. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement was followed in developing this manuscript (von Elm et al., 2007).

Participants

Semi-professional, female basketball players (*n* = 13) competing in the state-level, Australian National Basketball League One (NBL1) North competition were originally recruited; however, one player was excluded due to an injury sustained before monitoring commenced leaving 12 players in the final sample. Regarding playing position, the sample consisted of six backcourt (i.e., shooting guards and point guards) and six frontcourt (i.e., small forwards, power forwards, and centers) players as designated by coaching staff. For analyses according to role, players were evenly grouped as main players (*n* = 6; age: 23 ± 6 years; height: 175 ± 9 cm; body mass: 69 ± 9 kg) who received >25 min of playing time per game on average across the season or bench players (*n* = 6; age: 19 ± 5 years; height: 177 ± 7 cm; body mass: 69 ± 17 kg) who received <25 min of playing time per game on average. Although the criteria used to categorize players into roles varies in the literature and may be context-specific, the threshold of 25 minutes to identify main players in basketball teams has been adopted previously (Brown et al., 2024; Russell, McLean, Stolp, et al., 2021). All players and their legal guardians (if aged <18 years) were informed of the benefits and risks of participation before providing written consent (or assent) to participate. The research team instructed players to continue their normal training and recovery routines to avoid introducing any bias. The conduct of all procedures was approved by the Central Queensland University Human Research Ethics Committee (approval no. 0000023323).

Instruments

Players had their external load monitored via microsensors secured between the scapulae in vests provided by the manufacturer (OptimEye s5, Catapult Innovations, Melbourne, VIC, Australia). Relatively strong intra-device reliability (coefficient of variation [CV] = <3%; intraclass correlation coefficient [ICC] = 0.77–1.00) for acceleration and PlayerLoad variables have been reported for these devices across different movement magnitudes, with <5% variation in peak acceleration detected compared to a reference accelerometer (between 1–3 g) (Nicolella et al., 2018). Players wore the same device across all training sessions and games as recommended to avoid inter-device variability in outputs (Nicolella et al., 2018). Players also had their internal load monitored by wearing chest-based heart rate (HR) monitors (H10; Polar Electro, Kempele, Finland) at the base of the sternum and reporting their individualized sRPE using a modified 1-10 scale (Foster et al., 2001). HR responses across varied exercise intensities recorded with Polar H10 monitors have been shown to strongly correlate with those obtained with a reference electrocardiogram (R^2 = 1.00, standard error of the estimate [SEE] = 0.26 beats·min^{-1}, *p* <0.001) in men and women (Schaffarczyk et al., 2022). The validity and reliability of the sRPE method to determine training load has received wide investigation across a range of exercise and sport settings as documented in a review (Haddad et al., 2017).

Procedures

Anthropometric data were collected on each player before the monitoring period. Across the season, a microsensor and HR monitor were fitted to each player prior to each training session and game. Microsensor and HR data were downloaded following each training session and game for further analysis using proprietary software (OpenField v8; Catapult Innovations). The duration of analyses ran from the start to the end of each training session or game (excluding warm-up and cool-down activities) to capture all activity and rest periods for the main part of each session. PlayerLoad™ (PL) and inertial movement analysis (IMA) variables were measured to represent the external load. In this regard, PL is calculated within the accompanying software as the square root of the sum of the squared rate of change in acceleration across the three movement planes multiplied by 0.01 (scaling factor) to derive an output reported in arbitrary units (AU) (Fox et al., 2017). The accumulated PL (AU) and relative (to session duration) PL ($AU \cdot min^{-1}$) were determined to indicate external load volume and average intensity. IMA variables are measured based on the movement direction detected including accelerations (-45° to 45°), decelerations (-135° to 135°), and changes-of-direction (COD, -135° to -45° for left and 45° to 135° for right), as well as the movement intensity detected including low (1.5–2.5 $m \cdot s^{-2}$), medium (2.5–3.5 $m \cdot s^{-2}$), and high (>3.5 $m \cdot s^{-2}$) intensities. Jumps were detected as a further IMA variable in the vertical direction and classified as low (<20 cm), medium (20–40 cm), or high (>40cm) intensities. The count of overall and high-intensity IMA movements collectively determined across all directions (accelerations, decelerations, COD, and jumps) were taken to represent external load volume and intensity. These high-intensity IMA thresholds are consistent with the basketball literature using microsensors (Tuttle et al., 2024) and align with pre-set manufacturer settings.

All HR data were exported into Microsoft Excel for further analysis (v15; Microsoft Corp, Redmond, WA). Internal load volume was determined using a modified summated heart-rate-zones (SHRZ)-load (AU) method (Scanlan et al., 2018). This approach involved determining the time spent (min) in distinct heart-rate mediated intensity zones multiplied by a corresponding weighting, where each zone increased by 2.5% of HR_{peak} (between 50–100%) and a weighting of 0.25 (between 1.00–5.75) (Scanlan et al., 2018). In turn, HR_{peak} was determined as the highest HR obtained during any training session or game across the monitoring period (Berkelmans et al., 2018). Internal load intensity was determined as the average relative HR response ($\%HR_{peak}$) across each training session and game as a percentage of individualized HR_{peak}. Furthermore, each player reported their sRPE to the research team in the absence of peers (Minett et al., 2022) within 30 min of completing each session. The reported sRPE value was multiplied by session duration (min) to derive sRPE-load (AU) to indicate internal load volume (Foster et al., 2001).

Statistical analysis

For analyses, data were arranged according to player role (main vs. bench players) and session type (training session vs. games). All monitoring data were imported into RStudio (v4.1.3; R Core Team) from Microsoft Excel for cleaning and analyses. Data were organized in long form with rows representing separate observations and load variables arranged in columns. Linear mixed-effects models (LMM) were built to compare load variables between player roles and session types. Customized script was developed and models were built using the *lmerTest* package in RStudio (Kuznetsova et al., 2017). Player role (n = 2) and session type (n = 2) were entered into models as interacting fixed effects, while player (n = 12) was entered as a random effect given the repeated samples collected from each player. Following recommendations (Newans et al., 2022), a model with all fixed and random effects was developed, along with a second model containing an interaction between player role and session type. These models were compared to separate models developed for each player role group using the *see* (Lüdecke, Patil, et al., 2021) and *performance* (Lüdecke, Ben-Shachar, et al., 2021) packages. The full interacting model method had the lowest Akaike information criteria value, supporting its use in our analyses (Newans et al., 2022). Histograms and Q-Q plots using residual values were used to check data normality, with no statistical assumption violations detected. Tukey's Honestly Significant Difference tests were used for post hoc analyses, with pairwise comparisons compiled using the *emmeans* package (Lenth, 2023) for calculating the estimated marginal means. Effect sizes were calculated using estimated marginal means using either Hedge's g_{av} (within-group comparisons) or Cohen's *d* (between-group comparisons) (Lakens, 2013). Effect magnitudes were interpreted as: *trivial* = <0.20; *small* = 0.20–0.59; *moderate* = 0.60–203 1.19; *large* = 1.20–1.99; or *very large* = ≥2.00 (Hopkins et al., 2009). All variables were determined as estimated marginal mean (with 95% confidence limits) as well as mean ± standard deviation (SD) with an alpha level set at ≤0.05 for statistical significance.

Results

Overall, there were 62 training and 49 game data points for main players alongside 85 training and 41 game data points for bench players used in the analyses. Table 1 presents the estimated marginal means (with 95% confidence limits) for all load variables according to player role and session type. Mean ± standard deviation with individual data points for external and internal load variables are shown in Figures 1 and 2, respectively. Statistical outcomes for all pairwise comparisons in load variables are displayed in Table 2.

Table 1: Estimated marginal means (95% confidence limits) for load variables according to player role during training sessions and games throughout the regular season in semi-professional, female basketball players.

Load variable	Main players		Bench players	
	Training	*Game*	*Training*	*Game*
External load				
Accumulated PlayerLoad (AU)	414 (355, 472)	609 (549, 668)*†‡	373 (317, 431)	356 (295, 418)
Relative PlayerLoad (AU·min^{-1})	5.05 (4.37, 5.74)	6.64 (5.95, 7.34)*†‡	4.63 (3.96, 5.30)	3.88 (3.16, 4.59)‡
Total IMA events (#)	469 (325, 613)	654 (510, 799)*†	388 (245, 530)	350 (205, 496)
High-intensity IMA events (#)	25.5 (16.5, 34.5)	41.7 (32.6, 50.7)*†‡	16.5 (7.6, 25.4)	15.6 (6.4, 24.8)
Internal load				
SHRZ-load (AU)	206 (168, 245)	275 (237, 314)*	225 (187, 262)	206 (166, 245)
Relative heart rate (%HR_{peak})	67.0 (63.1, 71.0)	71.9 (67.9, 75.9)*	69.8 (65.9, 73.7)	64.8 (60.7, 68.8)‡
sRPE (AU)	3.81 (2.98, 4.64)	6.64 (5.79, 7.49)*‡	4.70 (3.91, 5.50)	7.05 (6.15, 7.94)*‡
sRPE-load (AU)	312 (239, 386)	605 (530, 681)*‡	386 (316, 455)	615 (535, 695)*‡

Abbreviations: AU, arbitrary units; IMA, inertial movement analysis; SHRZ, Summated-Heart-Rate-Zones, HR_{peak}, peak heart rate; sRPE, session-rating of perceived exertion. *Note*: * indicates significantly different to training in main players (p <0.01); † indicates significantly different to games in bench players (p <0.01); ‡ indicates significantly different to training in bench players (p <0.01).

Regarding comparisons between training sessions and games within each player role, games elicited significantly higher external and internal loads than training for all variables in main players (p <0.001, *moderate*-to-*large* effects). For bench players, training sessions yielded significantly greater relative PL (0.75 AU·min^{-1}) and %HR_{peak} (5%) than games (p <0.01, *moderate* effects), and games elicited significantly greater sRPE (2.3 AU) and sRPE-load (229 AU) than training sessions (p <0.001, *large* effects) (Table 2). For comparisons between player roles within each session type, main players experienced significantly greater external loads across all variables in games than bench players (p <0.05, *very large* effects). Although not reaching statistical significance (p >0.05), main players also experienced higher SHRZ-load (69 AU) and %HR_{peak} (7%) than bench players in games (*large* effects), and more total IMA events (81) and high-intensity IMA events (9) than bench players in training sessions (*moderate* effects) (Table 2). It should also be noted that non-significant (p = 0.095–1.000) differences were evident between training sessions in main players and games in bench players for all load variables except sRPE (3.2 AU) and sRPE-load (220 AU), which were significantly (p <0.001) higher in games for bench players. In contrast, all load variables were significantly (p = <0.001–0.015) higher in games for main players than training sessions in bench players, except total IMA events (p = 0.061), $\%HR_{peak}$ (p = 0.845), and SHRZ-load (p = 0.224).

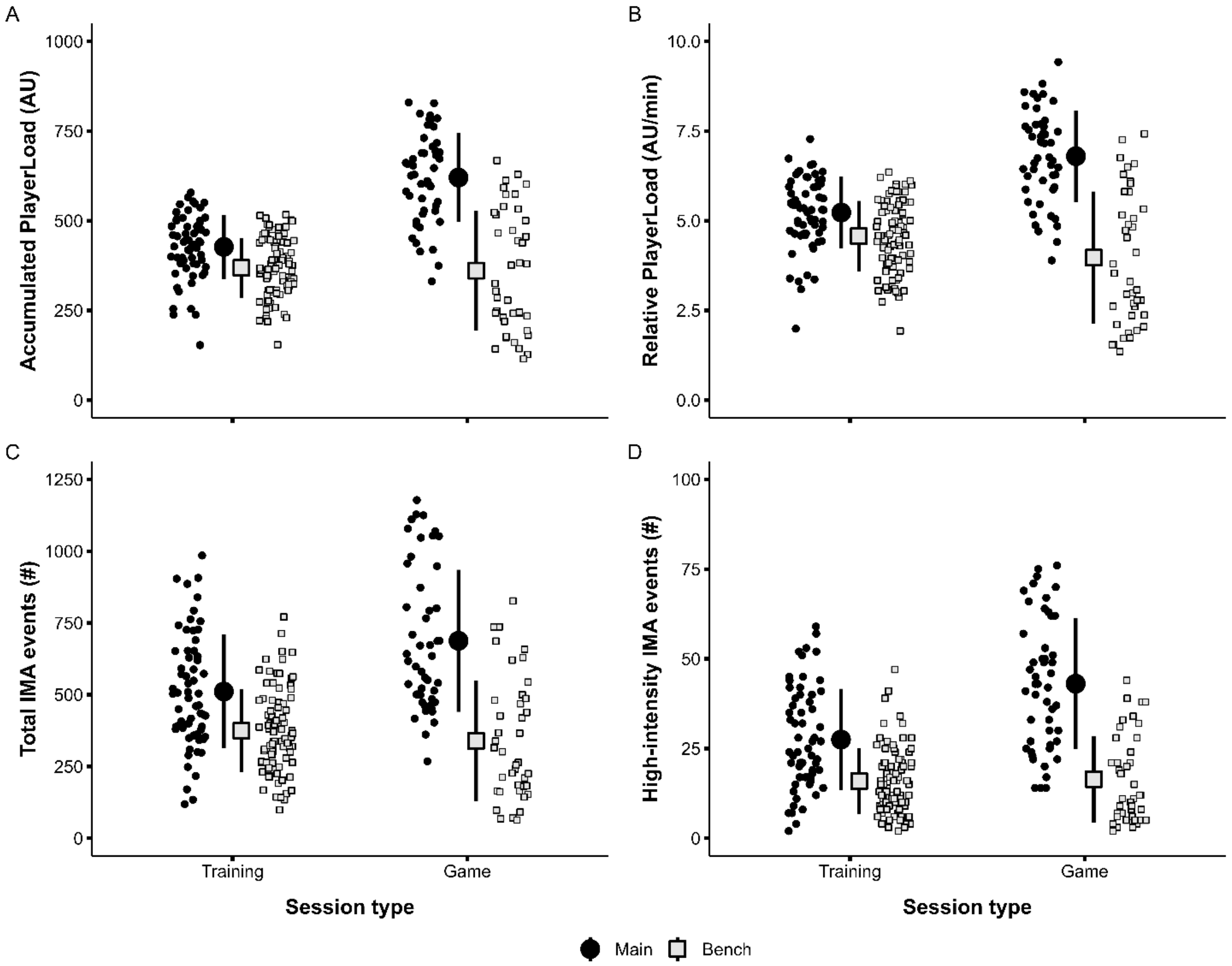

Figure 1. Mean ± standard deviation (bolded dots and lines) alongside individual data points (non-bolded dots) for external load variables according to player role during training sessions and games including (A) accumulated PlayerLoad (PL), (B) relative PlayerLoad, (C) total inertial movement analysis (IMA) events, and (D) high-intensity IMA events. *Note*: AU, arbitrary units.

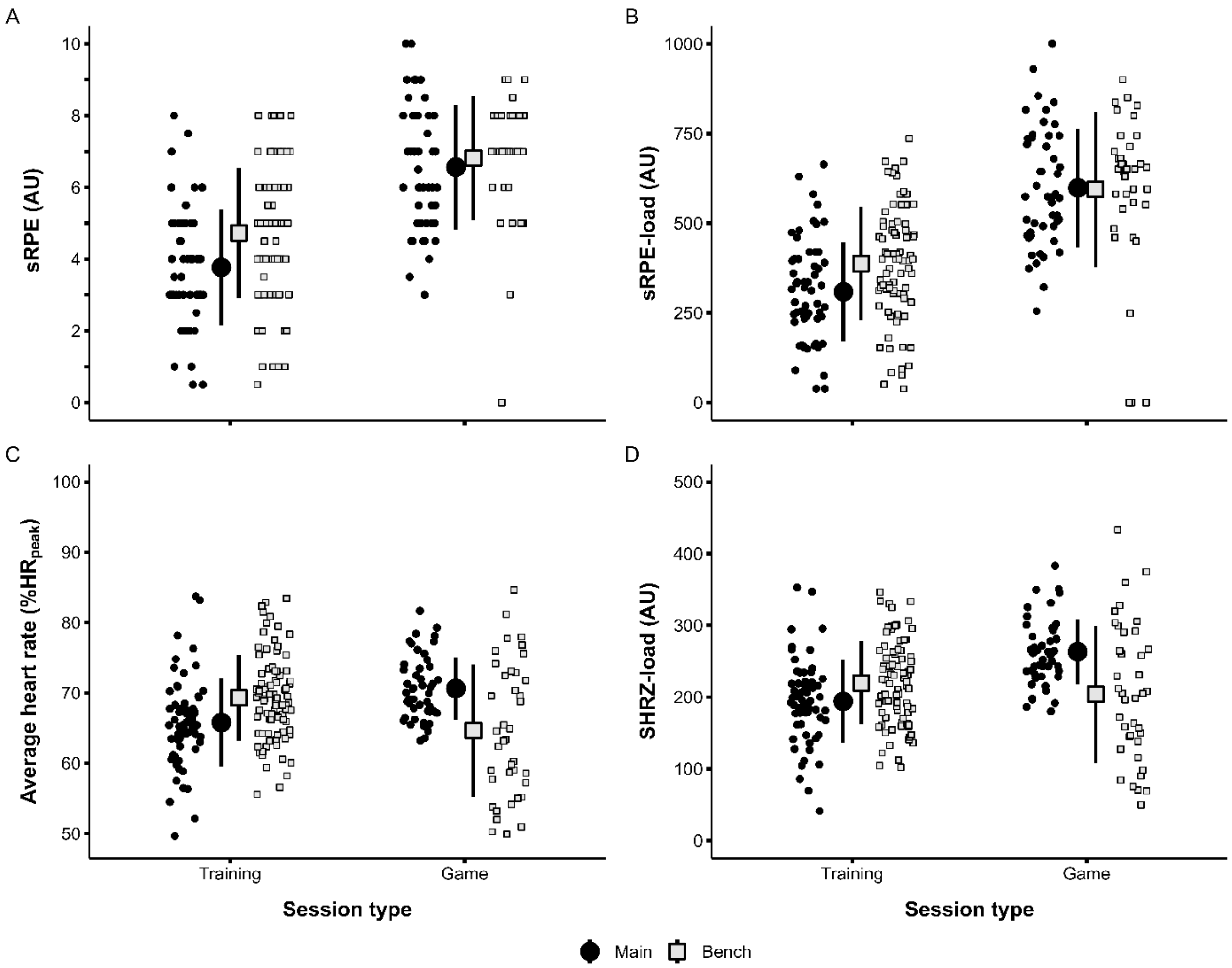

Figure 2. Mean ± standard deviation (bolded dots and lines) alongside individual data points (non-bolded dots) for internal load variables according to player role during training sessions and games including (A) session-rating of perceived exertion (sRPE), (B) session-rating of perceived exertion load (sRPE-load), (C) average relative heart rate, and (D) summated heart-rate-zones-load (SHRZ-load). *Note*: AU, arbitrary units; %HR_{peak}, percentage of peak heart rate obtained during the monitoring period.

Table 2: Statistical pairwise comparisons (*p*-values and effect sizes with 95% confidence intervals) in load variables between player roles and session types in semi-professional, female basketball players.

Load variable	Training sessions vs. games		Main players vs. bench players	
	Main	*Bench*	*Training*	*Game*
External load				
Accumulated PlayerLoad (AU)	***p* <0.001** g_{av} = -1.98 (-2.35, -1.60)#	*p* = 0.806 g_{av} = 0.18 (-0.21, 0.58)	*p* = 0.722 *d* = 0.40 (-0.43, 1.24)	***p* <0.001** *d* = 2.57 (1.66, 3.49)#
Relative PlayerLoad (AU·min^{-1})	***p* <0.001** g_{av} = -1.50 (-1.87, -1.12)#	***p* = 0.003** g_{av} = 0.71 (0.31, 1.11)	*p* = 0.768 *d* = 0.40 (-0.51, 1.31)	***p* <0.001** *d* = 2.62 (1.64, 3.60)#
Total IMA events (count)	***p* <0.001** g_{av} = -1.52 (-1.90, -1.15)#	*p* = 0.436 g_{av} = 0.31 (-0.09, 0.70)	*p* = 0.811 *d* = 0.67 (-1.01, 2.35)#	***p* = 0.032** *d* = 2.51 (0.80, 4.23)#
High-intensity IMA events (count)	***p* <0.001** g_{av} = -1.68 (-2.06, -1.31)#	*p* = 0.969 g_{av} = 0.09 (-0.31, 0.49)	*p* = 0.434 *d* = 0.94 (-0.39, 2.28)#	***p* = 0.004** *d* = 2.73 (1.35, 4.11)#
Internal load				
SHRZ-load (AU)	***p* <0.001** g_{av} = -1.30 (-1.67, -0.93)#	*p* = 0.312 g_{av} = 0.35 (-0.05, 0.75)	*p* = 0.465 *d* = -0.35 (-1.37, 0.67)	*p* = 0.074 *d* = 1.31 (0.26, 2.37)#
Relative heart rate (%HR_{peak})	***p* <0.001** g_{av} = -0.88 (-1.25, -0.51)#	***p* <0.001** g_{av} = 0.91 (0.51, 1.31)#	*p* = 0.698 *d* = -0.50 (-1.52, 0.51)	*p* = 0.077 *d* = 1.30 (0.25, 2.35)#
sRPE (AU)	***p* <0.001** g_{av} = -1.79 (-2.17, -1.42)#	***p* <0.001** g_{av} = -1.49 (-1.90, -1.07)#	*p* = 0.363 *d* = -0.57 (-1.31, 0.16)	*p* = 0.895 *d* = -0.26 (-1.05, 0.52)
sRPE-load (AU)	***p* <0.001** g_{av} = -1.89 (-2.26, -1.52)#	***p* <0.001** g_{av} = -1.48 (-1.89, -1.07)#	*p* = 0.424 *d* = -0.48 (-1.13, 0.18)	*p* = 0.998 *d* = -0.06 (-0.78, 0.65)

Abbreviations: AU, arbitrary units; IMA, inertial movement analysis; SHRZ, Summated-Heart-Rate-Zones, HR_{peak}, peak heart rate; sRPE, session-rating of perceived exertion. *Note*: Effect sizes are presented as Hedge's g_{av} for within-group comparisons and Cohen's *d* for between-group comparisons where a negative effect size indicates training sessions were lower than games or main players were lower than bench players; bolded p-values indicates a statistically significant difference (*p* <0.05); # indicates a *moderate*-to-*very large* effect was detected.

Discussion

This study adds to the limited evidence base concerning the role-specific demands encountered during training and games in female basketball players, providing some novel insights specific to main and bench players in a semi-professional, female basketball team. The main findings we observed included: (1) main players encountered significantly higher external and internal loads during games than training sessions; (2) bench players experienced significantly higher external and internal intensities during training sessions than games; (3) bench players exhibited significantly lower loads across multiple variables during training sessions and games than games in main players; and (4) bench players exhibited significantly higher perceptual demands during games than training sessions. These outcomes provide useful evidence that could inform loading strategies across female basketball teams for end-users.

The greater loading apparent during games compared training sessions in main players suggests the average physical, physiological, and perceptual training stimuli administered in individual sessions across the season do not replicate the demands experienced during individual games. This trend in loading indicates that on-court team training sessions are likely periodized in main players to allow for maintenance of physical and skill attributes combined with optimal readiness to perform in weekly competition (where 1–3 games are typically played each week). Indeed, while training load distribution and magnitude across individual sessions likely varies according to context among basketball teams (e.g., competitive level, game schedule) (Conte et al., 2018; Manzi et al., 2010), most individual training sessions across typical weekly microcycles are prescribed to elicit loads lower than or comparable to those anticipated for games on a team level in basketball settings, with care recommended to ensure players with high game exposure are not overloaded (Vretaros, 2024). This approach may have certainly been the case in our study, especially given the trend we observed aligns with previous research showing main players (starters or high-minute players) encounter significantly higher external load (PL) peak intensities (Fox et al., 2021) and external load volumes and average intensities (PL and IMA variables) (Brown et al.,

2024) during games than training sessions among basketball players. As a novel point, we also showed that physiological and perceptual demands encountered in games were significantly higher than those experienced in training, suggesting competition scenarios may be the prominent stimuli driving adaptative responses (Fox et al., 2017) in players across the season.

In opposition to main players, mixed trends for comparisons in loads between training sessions and games were observed for bench players. Specifically, the significantly higher external and internal intensities evident during training sessions compared to games contrast the findings in main players, suggesting training demands provide the greatest stimuli to players in bench roles. Further to this point, the training (all load variables) and game (external load and HR-based variables) demands encountered in bench players were lower than those observed in main players during games. Collectively, these results indicate training sessions may be appropriately prescribed to prepare bench players for the likely game demands that will be encountered in the bench role; however, bench players appear inadequately prepared for game demands should they be required to take on a main role (e.g., due to injury or suspension of a main player, or team rotation changes by coaching staff). Indeed, it has been suggested that supplementary loads are essential to administer in players with less game exposure to avoid pronounced differences in physical and physiological status according to player role (Vretaros, 2024). While the inclusion of supplementary training (also called top-up or compensatory training) for bench players has been noted as part of the training plan in some basketball research (Russell, McLean, Stolp, et al., 2021), little evidence on the prescription of supplementary training strategies is documented in the wider basketball literature. In this way, research has regularly highlighted the importance of supplementary training, including different strategic approaches, among other team sports (Büchel et al., 2024; Clemente et al., 2024; Díaz-Serradilla et al., 2023). Similar to our findings, significantly greater sessional external load intensities and volumes have been observed during games in high-minute players compared to training sessions and games in low-minute players within a collegiate, female basketball team (Brown et al., 2024). Likewise, starters have been observed to accumulate greater overall weekly loads (training and games combined) than bench or out-rotation players among collegiate (using sRPE-load) (Conte et al., 2018) and professional (external load volume) (Russell, McLean, Stolp, et al., 2021), male basketball teams. Consequently, the potential inadequate preparedness of bench players to meet increased load requirements indicative of starters may be a pertinent issue for many basketball teams.

In opposition to the findings for other load variables, bench players demonstrated significantly greater perceptual load intensities and volumes during games than training sessions. While this finding may be counterintuitive given perceptual demands may be expected to align with the greater physical and physiological loads observed in training sessions compared to games for bench players, it is likely attributed to the multifaceted span of factors that may influence RPE differently between contexts. In this regard, game situations may exacerbate RPE compared to training settings given the inherent psychological stimuli encountered. For instance, environmental distractions in the form of spectators and opponents during games may induce more of an external attentional focus, and holding a lower “status” in the team may reduce self-efficacy in competition among bench players, both of which can increase RPE (Hutchinson, 2021). Moreover, collective game stressors such as the importance of winning, coach and teammate expectations, and scoreline may introduce added pressure on players that is not present during training, which can elevate RPE in players less psychologically resistant to them (Coquart et al., 2012). Moreover, bench players likely held a lower fitness status than main players (Scanlan et al., 2021) due to their reduced loading across the season, which could have exacerbated their perceptual demands to a given external load as documented in wider team sport literature (Malone et al., 2020). While previous basketball research has shown starters accumulate greater total weekly sRPE-loads (training and games combined) than bench players among collegiate, males (Conte et al., 2018) and greater total weekly game sRPE-loads than bench players in elite, females (Paulauskas et al., 2019), sessional data comparing sRPE-loads between training and games have not been reported in basketball players, prohibiting comparisons with existing evidence. Nevertheless, our data are highly relevant for basketball coaches and performance staff given RPE-monitoring is the most readily used training load method adopted among them (Romero-Caballero et al., 2020). In this regard, the unique findings for perceptual load we observed suggest basketball coaches and performance staff may need to use a range of objective and subjective external and internal load monitoring tools (Torres-Ronda et al., 2022) to capture the complete scope of demands faced by players according to their needs as they appear to provide different trends.

While our findings provide useful new insight regarding load monitoring in female basketball players according to role, some notable limitations should be considered when interpreting them. Firstly, we adopted a sessional focus on loading; however, the accumulated loads experienced across training throughout longer timeframes, such as weekly or monthly cycles, have shown training demands exceed those that are accumulated across games in the same timeframe among male basketball players (Conte et al., 2018; Fox et al., 2018; Kutson et al., 2024; Russell, McLean, Stolp, et al., 2021). Further research is therefore encouraged to assess how training stimuli compare to game stimuli accumulated across timeframes beyond a sessional level specifically in female players to elucidate the nuances regarding loading patterns across the season according to player role. Secondly, we assessed a single semi-professional, female basketball team that typically completed two on-court team training sessions per week. Consequently, the findings we observed may not be translatable to other teams or competitive levels given coaches may adopt different load prescription strategies (Salazar et al.) and undergo more rigorous training schedules each week (Iglesias-Torres et al., 2024; Manzi et al., 2010; Vretaros, 2024). Thirdly, we categorized players as main and bench players based on average playing time in games across the season to maximize the sample size for each role. In turn, other basketball research has categorized players more precisely across three categories (starter, in-rotation bench, and out-rotation bench players or starter, rotation, and bench players) (Palmer et al., 2021; Russell, McLean, Stolp, et al., 2021), yielding varied differences in loads between roles. Consequently, further research recruiting a larger sample of players may expand on our research and explore this topic across varied role category methods in female basketball players. Finally, we did not account for individual training sessions performed by players on their own given they were undertaken sporadically based on personal preference rather than coach prescription, some sessions were conducted at light intensities for relatively short durations (e.g., shooting sessions), or loads could not be adequately monitored with the available equipment (e.g., resistance training).

Conclusions

Our results indicated that sessional training and game demands vary considerably within and between main and bench players in a semi-professional, female basketball team setting. In this regard, main players encountered significantly higher external and internal loads during games than training sessions. In turn, bench players exhibited significantly higher demands in many load variables during training sessions than games, and significantly lower loads during training sessions and games compared to those experienced by main players in games. In contrast to these findings, comparable training demands were observed between player roles, with bench players also experiencing significantly higher perceptual demands in games than training. These findings add to the scarce available evidence regarding load data specific to player role among female basketball players.

Practical applications

Given load monitoring is the leading area in which sports coaches use research evidence to inform, plan, deliver, or reflect on their practice (Schwarz et al., 2021), our observations provide useful insight for basketball practitioners particularly as most plan training using microcycle models (Romero-Caballero et al., 2020). In this regard, reporting load data across all players within basketball teams according to their role has been advocated as an essential practice for individualized management of players in high-performance sport (Russell, McLean, Impellizzeri, et al., 2021). The loading pattern in main players we observed suggests they were exposed to training plans considering their readiness for games and to avoid overloading. However, a team-based approach seemed to be administered whereby bench players received relatively similar training demands without the added loading provided by game exposure. Consequently, bench players appear ill-prepared for increased game demands resembling those in main players based on their training exposure across individual sessions. In scenarios where main roles become available like injuries and suspension or changes in team selection and tactics, bench players may not be able to perform optimally due to a lack of readiness to undertake the required loads from inadequate fitness (Castillo et al., 2021; Ryan et al., 2017), also potentially carrying a heightened risk in sustaining an injury (Meeuwisse et al., 2007; West et al., 2021). In turn, supplementary training strategies may be a solution to circumnavigate this issue among basketball teams. In this way, further research is needed to understand the considerations and approaches of coaches and performance staff in managing player loads according to their role in basketball teams, including the adoption of supplementary training. In turn, experimental research is also required exploring the effects of different practical supplementary training strategies, such as manipulating different games-based drills to impose varied demands on players according to their role (O'Grady et al., 2020), to optimize loading across the entire team throughout the season.

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