SCIENTIFIC JOURNAL OF SPORT AND PERFORMANCE

ORIGINAL ARTICLE

Player role-specific workload profiles and the internal-external load relationship in semi-professional basketball: A two-season longitudinal study

Hoani K. Smith . *Department of Tourism, Sport and Society. Lincoln University. Christchurch, New Zealand.*
Stephen P. Bird. *School of Health, Psychological and Medical Sciences. University of Southern Queensland. Queensland, Australia.*
Peter D. Olsen. *Department of Applied Sciences and Social Practice. Ara Institute of Canterbury. Christchurch, New Zealand.*
Thomas Kavanagh. *Department of Tourism, Sport and Society. Lincoln University. Christchurch, New Zealand.*
Michael J. Hamlin. *Department of Tourism, Sport and Society. Lincoln University. Christchurch, New Zealand.*

ABSTRACT

Understanding how internal and external loads interact is critical for optimising basketball performance. This two-season study quantified internal (session-RPE, wellness) and external (IMU-derived accelerations, decelerations, distance, sprints, heart rate, and jumps) demands across 36 games, 292 trainings, and 74 skill sessions in 18 players (20.6 ± 1.3 years, 191.9 ± 6.5 cm, 87.3 ± 7.2 kg). Players were classified as starters (>24 min/game-1), rotation (10-24 min-1), or bench (< 10 min-1). Starters accumulated greater game loads (ES = 1.65) and high intensity sprints (ES = 1.32) than rotation and bench players ($p < .05$). Trainings produced higher total volume but lower intensity, while games elicited more accelerations and decelerations (Zone 2 accelerations = 142 ± 38 and 27 ± 10; Zone 3 = 75 ± 44 and 67 ± 20, respectively). Game sRPE correlated with accelerations (Zone 2: r = .70; Zone 3: r = .54) and decelerations (Zone 2: r = .68; Zone 3: r = .52), indicating that sRPE reflects high-intensity demand. Integrating internal and external measures clarifies workload. Practically, bench and rotation players may benefit from high-intensity exposure, whereas moderating volume around MD + 2 may support recovery. Findings show role-specific patterns guiding evidence-based load management.

Keywords: Performance analysis, Load monitoring, Inertial measurement, Session-RPE, Training microcycle, Acceleration–deceleration, Team sport.

Cite this article as:
Smith, H. K., Bird, S. P., Olsen, P. D., Kavanagh, T., & Hamlin, M. J. (2026). Player role-specific workload profiles and the internal-external load relationship in semi-professional basketball: A two-season longitudinal study. *Scientific Journal of Sport and Performance*, *5*(3), 410-423. https://doi.org/10.55860/QDNS6807

Corresponding author. *Department of Tourism, Sport and Society, Lincoln University. PO Box 85084. Lincoln 7647. New Zealand.*
E-mail: hoani.Smith2@lincoln.ac.nz
Submitted for publication January 23, 2026.
Accepted for publication February 25, 2026.
Published March 19, 2026.
Scientific Journal of Sport and Performance. ISSN 2794-0586.

doi: https://doi.org/10.55860/QDNS6807

INTRODUCTION

Basketball is a dynamic, high-intensity team sport characterised by intermittent bursts of physical activity, requiring athletes to perform repeated high-speed movements, accelerations, decelerations, and changes of direction (Ferreira et al., 2021). To meet these demands, players must be physically and psychologically prepared, with effective load monitoring essential for optimising performance while supporting readiness and recovery across congested competitive schedules (Edwards et al., 2018; Petway, Freitas, Calleja-González, Medina Leal, & Alcaraz, 2020). Monitoring load allows coaches to assess demands, track responses, and adjust workloads to support readiness and recovery (Gamonales, Hernández-Beltrán, Escudero-Tena, & Ibáñez, 2023).

Player monitoring typically involves assessing two primary dimensions: 1) external load; and 2) internal load (Foster, 1998). External load represents the mechanical work measured by metrics such as total distance, sprints, accelerations, and decelerations using Global Positioning System (GPS) or inertial movement units (IMU), summarising the volume and intensity of training and competition (Halson, 2014). These external load metrics provide insights into the volume and intensity of demands in both training and games (Stojanović et al., 2018). In basketball, external load variables such as accelerations (>2 m.s^{-2}), decelerations (>2 m.s^{-2}), and high-speed running (>18 km.h^{-1}) are considered key indicators of workload, particularly during high-intensity match scenarios (Vázquez-Guerrero, Suarez-Arrones, Casamichana Gómez, & Rodas, 2018). Conversely, internal load reflects a player's psychobiological response to external stress. It is typically assessed through heart rate monitoring or subjective scales like the session Rating of Perceived Exertion (sRPE) (Haddad, Stylianides, Djaoui, Dellal, & Chamari, 2017). Monitoring internal load is essential for understanding how athletes cope with training demands and identified individual variability in fatigue, recovery, and readiness (Petway et al., 2020).

Understanding the relationship between external and internal load is crucial for delivering appropriate physical training to induce the desired adaptations (Fox, O'Grady & Scanlan, 2020). Integrating both measures allows practitioners to contextualise mechanical demands against individual psychophysiological responses, facilitating informed decisions regarding training prescription and recovery strategies (Fox et al., 2020). By tailoring loads to individual needs, coaches can balance stress and recovery to enhance outcomes. This is particularly relevant in basketball, where training and games differ markedly in physical and cognitive demands. Despite its practical value, limited research has examined these relationships in basketball across multiple contexts and extended timeframes (Fox, Power & Scanlan, 2020; Scanlan et al., 2014; Svilar et al., 2018).

Scanlan et al., (2014) examined relationships between accelerometer-derived workload and internal measures, such as summated-heart-rate-zones (SHRZ), training impulse (TRIMP), and session-rating of perceived exertion (sRPE), during pre-season training (Scanlan et al., 2014). They found significant correlations, with accumulated load showing a stronger correlation with SHRZ ($r = .61$), compared to moderate correlations between external workload and sRPE ($r = .49$) or TRIMPs ($r = .38$). Accumulated load, typically calculated as player load, provides a composite measure of total movement intensity and volume (Li et al., 2024). Player load is computed by summing the rate of change in acceleration across three movement planes, giving a widely used proxy for overall demand (Li et al., 2024). SHRZ appeared to better reflect physiological intensity, while sRPE captured subjective effort. Interestingly, accelerations correlated only moderately with sRPE ($r = .49$), whereas decelerations showed a stronger association ($r = .61$), suggesting movement types contribute unevenly to internal responses.

Svilar et al., (2018) extended this work by exploring accelerometer-derived external loads, IMU variables, and sRPE, in professional basketball players (Svilar & Jukic, 2018). They reported strong correlations between accumulated external workload and sRPE, (r = .84), especially for decelerations, (r = .83), and changes of direction (r = .84), while number of jumps showed lower correlations (r = .49 - .55). In contrast, IMU-derived accelerations (r = .65) and high-intensity accelerations (r = .53) were less strongly associated with sRPE (Svilar & Jukic, 2018). Together, these findings indicate that specific movement types, particularly decelerations and changes of direction, exert stronger influences on perceived exertion than accelerations or jumps.

While previous research highlights the importance of selecting appropriate monitoring variables, most studies have focused on short-term training periods or isolated session types, limiting their applicability to long-term load management. In particular, few studies have simultaneously examined internal and external load relationships across training and competitive games, over multiple seasons, and between player roles. Given the substantial differences in exposure experienced by starters, rotation, and bench players, a more comprehensive, longitudinal approach is required to inform applied load management strategies.

Therefore, the primary aim of this study was to quantify and compare internal and external load demands across two competitive seasons in semi-professional basketball players. A secondary aim was to examine differences between session types (team training, skill training, and games) and player roles (starter, rotation, bench). It was hypothesised that (1) starters would accumulate greater total and high intensity loads than rotation and bench players, and (2), games would elicit higher internal and external loads compared with training and skill sessions.

MATERIALS AND METHODS

Participants

Eighteen semi-professional, male basketball players volunteered to participate in this study (Table 1). Players belonged to the same team, a premier basketball club in the Canterbury region of New Zealand. Ten players participated in both seasons, while eight contributed data for a single season. All participants gave written informed consent (Declaration of Helsinki), with approval from an institutional human ethics committee (HEC2022-25).

Table 1. Physical characteristics of year 1 and year 2 players.

Characteristic	Year 1, 2022 (n = 14)	Year 2, 2023 (n = 10)
Age (yr)	20.3 ± 1.3	20.8 ± 1.3
Height (cm)	191.9 ± 6.5	191.8 ± 6.1
Body Mass (kg)	88.9 ± 7.5	85.6 ± 6.9
Sum of 8 Skinfolds (mm)	78.9 ± 27.6	66.6 ± 18.1
Years Playing Basketball (yrs)	7.4 ± 2.2 years	8.5 ± 2.5 years

Note. Data are mean ± SD. Sum of 8 skinfolds included triceps, subscapular, biceps, iliac crest, supraspinale, abdominal, front thigh and medial calf.

Design

A longitudinal, observational design was employed where internal and external training loads were collected during all training sessions and games over the combined 2022 and 2023 seasons. A total of 36 competitive games were played across two 18-week in-season phases. Overall, 292 IMU samples from team trainings, 74 for skill trainings, and 229 samples from games were included for analysis. Additionally, 252 days of internal load data covering the same training period (Health and Sport Technologies, Ltd., trading as Metrifit, Millgrange, Greenore, Co., Louth, Ireland) were analysed. No experimental manipulation of training load was undertaken.

METHODS

All practices and games were included and assigned to the following activity categories: Team training, competitive games, strength training, and skill training (i.e. drills with limited contact focused on skill development e.g., spot shooting, ball handling). Team training sessions were on Monday and Thursday nights, strength training occurred on Monday, Tuesday, and Thursday mornings, and individual skill work was scheduled for Wednesday afternoons. Games were held on Saturday afternoons (Figure 1). Participants were separated by role, only in the game context, with starters playing more than 24 minutes, rotation players completing 10-24 minutes, and bench players playing fewer than 10 minutes per game (Palmer, Wundersitz, Bini, & Kingsley, 2021).

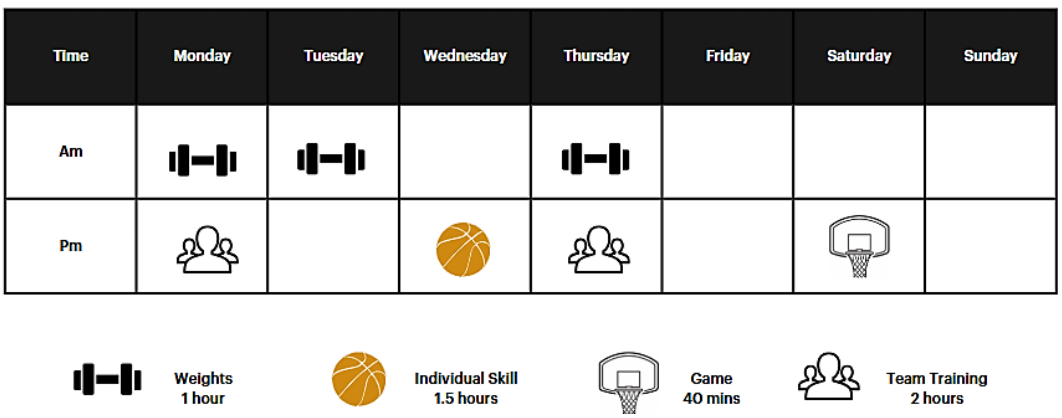

Figure 1. Weekly practice schedule for male basketball players.

Table 2. General goals and specific training contents across the structured microcycle in basketball.

Session	Goals	Contents
MD +1	Recovery	Passive recovery, or very light individual work to facilitate recovery
MD +2	Strength Training	Ideal day for heavier loads and more challenging resistance work.
	Team Training	To accumulate the highest weekly basketball-specific load and optimise the team's playing model. Simulated 5-on-5 competition.
MD -4	Strength Training	Moderate to high-intensity strength training. Tapering down from MD+2 but still ensuring maintenance of strength gains.
MD -3	Individual Training	To develop player's basic skills
		Structural
		Individual skills
MD -2	Strength Training	Low to moderate volume with high intensity strength / speed work. Emphasis is on maintenance, avoiding excessive fatigue while keeping muscle activation high.
	Team Training	Tactical drills, focusing on upcoming match strategies, working on team patterns, and how to adapt to the opponent.
MD	Game Day Performance	

Note. MD+1 is match day plus 1. MD+2, match day plus 2. MD-4, match day minus 4. MD-3, match day minus three. MD-2, match day minus two. MD, match day.

Training periodisation

Across both competitive seasons, training was organised into macrocycles reflecting the preparatory, competitive, and taper phases. The preparatory phase-built capacity, the competitive phase balanced training and recovery, and tapering reduced load while maintaining intensity. These phases provided the framework for the weekly microcycle. The structured microcycle formed the foundation of each training week, aimed at optimising player performance. While literature outlines general frameworks, the current study's microcycle (i.e., MD+2, MD-4, etc) was adapted to team scheduling, player availability, and coaching constraints-(Vretaros, 2024). This approach integrated physical, technical, and tactical elements across sessions, as outlined in Table 2.

External workload

External load was monitored using accelerometer, gyroscope and magnetometer sensors included in the VXSport Omni devices (VXSport, New Zealand) to capture all on-court activities. The device was worn in a fitted garment between the scapulae, sampling at 100 Hz. Each player used the same device throughout the study for consistency. After all training sessions and games, data was downloaded using the manufacturer software package and exported for integration (VXSport, New Zealand). These devices have been found to be reliable for measuring external load in basketball, particularly for tracking movement patterns such as speed and directional changes (Smith, Bird, Olsen, Kavanagh, & Hamlin, 2024).

Variables analysed included total duration (min), duration of high-intensity heart rate (min: sec, over 180 bpm), total distance covered (m), distance rate covered (m.min^{-1}), high-intensity distance rate (m, over 15 km.h^{-1}), maximal speed (km.h^{-1}), sprints total (number), high-intensity sprints (number, over 18 km.h^{-1}), HR average (bpm), HR max total (bpm), acceleration (zone 1, 0 – 2 m.s^{-2}, zone 2, 2.1 – 4 m.s^{-2}, zone 3, 4.1 – 10 m.s^{-2}), deceleration (zone 1, 0 – 2 m.s^{-2}, zone 2, 2.1 – 4 m.s^{-2}, zone 3, 4.1 – 10 m.s^{-2}), max jump height (cm), jump count (number), body impacts (number), distance speed very high (m, >20 km.h^{-1}), distance speed (m) (zone 1, 0 – 6 km.h^{-1}, zone 2, 6 – 12 km.h^{-1}, zone 3, 12.1 - 18 km.h^{-1} , zone 4, 18.1, 24 km.h^{-1}, zone 5, >24.1 km.h^{-1}), accelerations total (number) and decelerations total (number). To ensure accuracy in measuring distance indoors, each player completed a one-time calibration session using the VXSport Omni system, as described by Smith, Bird, Olsen & Hamlin (2024).

Table 3. Daily wellness internal load monitoring likert scale.

Measure	1	2	3	4	5
Mood	Very stressed	Quite stressed	Slightly stressed	Little stress	No stress
Sleep Quality	Poor	Below average	Normal	Good	Very good
Energy Levels	Extremely low	Very low	Low	Normal	High/Excellent
Muscle Soreness	Extremely sore	Very sore	Quite sore	Mild soreness	No soreness
Academic Pressure	Academic pressure high	Academic pressure building	Heavy academic day	Normal academic pressure	No academic pressure
Diet Yesterday	Poor	Fair	Good	Very good	Excellent
Health	So sick I have to stay in bed	Feeling well below par	Just ok	Feeling healthy/normal	Never better

Internal workload

Each day, player well-being was evaluated upon waking via the administration of questionnaires on a phone app (Health and Sport Technologies Ltd., trading as Metrifit, Milgrange, Greenore, Co. Louth, Ireland). The questions used a five-point Likert scale to record athletes' subjective ratings (Table 3). This approach has been validated in previous research, showing that athlete self-reported measures using an app, help effectively track training loads, wellness, and injury risk (Hamlin, Wilkes, Elliot, Lizamore & Kathiravel, 2019). Participants also recorded daily session-RPE using a modified 10-point scale factor (Foster et al., 2001), a reliable indicator of exercise intensity (Eston & Williams, 1988; Gabbett & Domrow, 2007; Hamlin & Hellemans, 2007; Impellizzeri, Rampinini, Coutts, Sassi, & Marcora, 2004).

Statistical analysis

Changes in the mean of the variables and standard deviations representing the between-and within-subject variability were estimated using a mixed modelling procedure (Proc Mixed) in the Statistical Analysis System (Version 9.4, SAS Institute, Cary, NC, United States). Chances that the true effects were substantial were estimated when a value for the smallest worthwhile effect was entered into the calculation. We chose 0.20 standardised units (representing change in mean divided by the between-subject SD at baseline) as the smallest worthwhile change (Cohen, 1988). To make inferences about the true (population) uncertainties in estimate of change were presented as 95% confidence intervals and as likelihoods that the effect was increased, decreased, or was trivial. Additionally, *p*-values were reported, with statistical significance set at ≤.05. Effect size (ES) were defined as <0.20, trivial; 0.20–0.59, small; 0.60–1.19, moderate; 1.20–1.99, large; and >2.0, very large (Hopkins, Marshall, Batterham & Hanin, 2009).

For external load variables, accelerometer-derived data (i.e. total distance, sprints, accelerations and decelerations) were recorded only on training/game days using VXSport Omni devices (VX Log VX105, Firmware V7.0.21.0, December 20, 2023, VXSport, New Zealand). These variables were summed to weekly totals, allowing the analysis of both short-term (weekly) and long-term (seasonal) workload fluctuations. Internal load data were collected daily using subjective ratings (RPE, sleep quality, energy levels, and muscle soreness). For analysis, the mean of each wellness variable was calculated per week, while RPE values were multiplied by session duration to calculate session-RPE, which was then summed weekly to quantify overall training load. This process produced weekly external and internal load values that were used to examine correlations between the two domains.

Session duration was recorded for training (start to end, including rest) and games (on-court minutes only). RPE was reported after every session and multiplied by session duration to calculate session-RPE. These values were summed daily and across the week to determine weekly training load. Weekly training loads were also categorised by player role (starter, rotation, or bench player), and separate analyses were conducted to assess differences between groups. Associations between selected external and internal variables were calculated using Pearson correlation coefficients (PROC CORR) in SAS.

RESULTS

External game load

The external training loads for the players over two seasons are shown in Table 4. Starters recorded the highest total game load (242.1 ± 40.4, au), covering the most distance (4944.7 ± 1033.3 m), and performing the most total sprints (177.6 ± 53.7). Starters also had the most high-intensity sprints (78.2 ± 37.5), the longest time spent at a high-intensity heart rate (17.5 ± 14.4 min), and highest distance covered per minute (61.3 ± 9.3 $m.min^{-1}$). Additionally, starters showed the highest number of Zone 2 accelerations (142.2 ± 37.7) and Zone 3 decelerations (67.4. ± 19.5), along with the highest mean (151.8 ± 18.5 bpm) and maximum heart rates (192.9 ± 19.0 bpm).

Table 4. Average game load data per game over two seasons combined, separated into starter, rotation, and bench players.

Variable	Starter	Rotation	Bench	All
Minutes Played (min)	31.6 ± 4.4 a, b	20.5 ± 4.5 c	7.0 ± 4.0	21.5 ± 11.3
Game Duration (min)	81.0 ± 13.1	79.0 ± 10.9	82.3 ± 13.6	80.9 ± 12.8
Game RPE	7.6 ± 0.5 a, b	7.0 ± 1.0 c	5.9 ± 1.5	7.0 ± 1.3
Total Game Load (au)	242.1 ± 40.4 a, b	146.1 ± 42.5 c	45.7 ± 30.3	159.7 ± 91.6
Duration HR Hi-Int (min: sec)	17.5 ± 14.4 b	16.6 ± 17.5 c	8.7 ± 10.1	15.2 ± 14.8
Game Load per min (au)	7.6 ± 0.5 a, b	7.0 ± 1.0 c	6.0 ± 1.4	7.0 ± 1.2
Distance Total (m)	4944.7 ± 1033.3 a, b	3384.8 ± 900.5 c	1437.5 ± 779.2	3486.5 ± 1755.2
Distance Rate ($m.min^{-1}$)	61.3 ± 9.3 a, b	43.7 ± 9.2 c	18.0 ± 10.8	43.6 ± 20.9
Distance Speed Hi-Int (m)	723.6 ± 343.4 a, b	488.4 ± 228.7 c	222.7 ± 136.1	516.2 ± 341.4
Speed Max ($km.h^{-1}$)	26.2 ± 3.7 a, b	24.3 ± 4.2	23.6 ± 4.9	24.9 ± 4.4
Sprints Total (num)	177.6 ± 53.7 a, b	120.2 ± 34.8 c	48.8 ± 27.8	124.0 ± 69.4
Sprints Hi-Int (num)	78.2 ± 37.5 a, b	49.7 ± 25.2 c	21.5 ± 12.7	54.2 ± 37.7
HR Average Total (bpm)	151.8 ± 18.5 a, b	140.5 ± 19.3 c	125.4 ± 20.4	141.5 ± 22.1
HR Max Total (bpm)	192.9 ± 19.0 b	188.4 ± 24.7	181.3 ± 26.1	188.5 ± 23.1
Acceleration Zone 1 (num)	19.1 ± 11.8 b	16.0 ± 9.4 c	6.9 ± 4.9	14.7 ± 10.9
Acceleration Zone 2 (num)	142.2 ± 37.7 a, b	102.3 ± 26.2 c	40.5 ± 23.1	101.08 ± 53.2
Acceleration Zone 3 (num)	74.9 ± 43.7 a, b	45.8 ± 26.9 c	20.7 ± 11.7	52.0 ± 40.2
Deceleration Zone 1 (num)	74.9 ± 37.8 a, b	47.0 ± 22.8 c	20.6 ± 12.3	51.7 ± 36.7
Deceleration Zone 2 (num)	26.9 ± 9.7 a, b	20.7 ± 7.5 c	9.9 ± 5.2	20.3 ± 10.9
Deceleration Zone 3 (num)	67.4 ± 19.5 a, b	50.2 ± 15.8 c	19.8 ± 11.9	48.8 ± 26.0
Acceleration Zone 1 (min)	43.5 ± 27.2 a, b	25.8 ± 15.8 c	11.8 ± 7.5	29.8 ± 24.4
Acceleration Zone 2 (min)	0.6 ± 0.4 b	0.8 ± 0.4	1.2 ± 1.5	0.8 ± 0.9
Acceleration Zone 3 (min)	4.5 ± 1.0 b	5.0 ± 0.9	6.5 ± 4.0	5.2 ± 2.5
Deceleration Zone 1 (min)	2.3 ± 1.3	2.2 ± 1.2	3.1 ± 1.4	2.5 ± 1.3
Deceleration Zone 2 (min)	0.9 ± 0.3 b	1.0 ± 0.3	1.4 ± 1.0	1.0 ± 0.6
Deceleration Zone 3 (min)	2.1 ± 0.5 b	2.4 ± 1.2	3.0 ± 1.9	2.5 ± 1.2
Max Jump Height (cm)	55.3 ± 11.1 a, b	47.6 ± 10.6	44.3 ± 16.4	50.4 ± 13.4
Jump Count (num)	35.3 ± 31.0 a, b	21.0 ± 11.6 c	9.7 ± 6.9	24.9 ± 25.0
Body Impacts (num)	1.6 ± 1.2	1.4 ± 0.5	1.1 ± 0.3	1.5 ± 1.0
Distance Speed Very-High (m)	82.6 ± 58.9 a, b	52.0 ± 40.8 c	27.7 ± 23.9	58.3 ± 51.8
Distance Zone 1 0-6 $km.h^{-1}$ (m)	1655.5 ± 368.5 a, b	1154.5 ± 346.5 c	517.4 ± 268.8	1177.8 ± 589.3
Distance Zone 2 6.1-12 $km.h^{-1}$ (m)	2040.5 ± 431.5 a, b	1438.4 ± 338.3 c	585.7 ± 344.5	1443.3 ± 729.3
Distance Zone 3 12.1-18 $km.h^{-1}$ (m)	1066.0 ± 351.7 a, b	723.1 ± 246.1 c	284.1 ± 183.3	744.3 ± 436.6
Distance Zone 4 18.1-24 $km.h^{-1}$ (m)	163.7 ± 109.0 a, b	95.4 ± 67.4 c	46.1 ± 39.2	111.4 ± 94.2
Distance Zone 5 24.1+ $km.h^{-1}$ (m)	15.6 ± 13.3 a, b	7.7 ± 7.0	8.3 ± 8.3	12.1 ± 11.7
Accelerations Total (num)	237.4 ± 70.0 a, b	163.3 ± 46.1 c	64.7 ± 37.4	165.8 ± 92.4
Decelerations Total (num)	138.2 ± 40.3 a, b	95.9 ± 28.5 c	38.7 ± 22.6	97.3 ± 53.6

Note. Data are mean ± SD, au, arbitrary unit; RPE, rate of perceived exertion; Min: sec, minutes: seconds; Acceleration Zone 1, 0 – 2 m.s-2; Acceleration Zone 2, 2.1 – 4 m.s-2; Acceleration Zone 3, 4.1 – 10 m.s-2; Deceleration Zone 1, 0 – 2 m.s-2; Deceleration Zone 2, 2.1 – 4 m.s-2; Deceleration Zone 3, 4.1 – 10 m.s-2; [a] significant difference between starter and rotation (p < .05); [b] significant difference between starter and bench (p < .05); [c] significant difference between rotation and bench (p < .05).

Team training and skill training external load

Team training sessions showed significantly higher physical demands than skill training, including greater total load (645.9 ± 152.5 au), total distance (4941.1 ± 1230.5 m, $p < .05$), high-intensity distance (544.8 ± 333.9 m, $p < .05$), sprints (157.0 ± 55.1), and high-intensity sprints (56.7 ± 32.7, $p < .05$). Heart-rate responses were also highest in team sessions (max 185.6 ± 22.5 bpm; mean 141.6 ± 18.3 bpm). Team training showed significantly more Zone 3 accelerations (67.3 ± 38.8, $p < .05$) and Zone 3 decelerations (58.1

± 22.1, $p < .05$) compared to skill training. Skill training recorded higher jump-related outputs, including maximal jump height (59.1 ± 10.7 cm) and total jump count (103.8 ± 57.3).

External game load versus team training load

When comparing external load, team training was significantly higher for all roles (645.9 ± 152.6 au, vs. starters 242.1 ± 40.4 au; rotation 146.1 ± 42.5 au; bench 45.7 ± 30.3 au; $p < .05$) (Tables 5 and 4, respectively). Distance rate tended to be higher in team training (52.5 ± 10.2 $m.min^{-1}$) than games (43.6 $m.min^{-1}$), though it was not statistically significant (Table 5). Despite the overall greater number of acceleration and deceleration zones during team training, games showed higher per-minute averages, particularly for starters and rotation players in zones 2 and 3 (Tables 5 and 4, respectively).

Table 5. Average external training load data from two seasons of team and skill training sessions.

Variable	Team trainings	Skill trainings	All games
Training Duration (min)	93.2 ± 16.3 *	78.7 ± 10.3	21.5 ± 11.3
Training RPE	6.9 ± 0.8	6.8 ± 1.2	80.9 ± 12.8
Total Training Load (au)	645.9 ± 152.6 *	532.7 ± 123.8	7.0 ± 1.3
Duration HR Hi-Int (min: sec)	12.2 ± 13.8 *	9.6 ± 10.9	159.7 ± 91.6
Distance Total (m)	4941.1 ± 1230.5 *	3582.2 ± 1170.5	3486.5 ± 1755.2
Distance Rate ($m.min^{-1}$)	52.5 ± 10.2	46.0 ± 12.4	43.6 ± 20.9
Distance Speed Hi-Int (m)	544.8 ± 333.9 *	149.5 ± 131.0	516.2 ± 341.4
Speed Max ($km.h^{-1}$)	24.9 ± 3.8 *	21.6 ± 4.2	24.9 ± 4.4
Sprints Total (num)	157.0 ± 55.1 *	89.2 ± 47.5	124.0 ± 69.4
Sprints Hi-Int (num)	56.7 ± 32.7 *	18.9 ± 15.6	54.2 ± 37.7
HR Average Total (bpm)	141.6 ± 18.3	136.1 ± 18.5	141.5 ± 22.1
HR Max Total (bpm)	185.8 ± 22.5 *	174.9 ± 20.0	188.5 ± 23.1
Acceleration Zone 1 (num)	18.3 ± 15.7 *	11.0 ± 6.6	14.7 ± 10.9
Acceleration Zone 2 (num)	134.1 ± 42.9 *	83.6 ± 38.3	101.08 ± 53.2
Acceleration Zone 3 (num)	67.3 ± 38.8 *	40.9 ± 29.8	52.0 ± 40.2
Deceleration Zone 1 (num)	59.4 ± 32.2 *	23.6 ± 17.1	51.7 ± 36.7
Deceleration Zone 2 (num)	27.1 ± 11.3 *	19.3 ± 8.4	20.3 ± 10.9
Deceleration Zone 3 (num)	58.1 ± 22.1 *	27.8 ± 13.4	48.8 ± 26.0
Acceleration Zone 1 (min)	34.5 ± 21.8 *	14.0 ± 11.1	29.8 ± 24.4
Acceleration Zone 2 (min)	0.2 ± 0.2	-	0.8 ± 0.9
Acceleration Zone 3 (min)	0.2 ± 0.2	-	5.2 ± 2.5
Deceleration Zone 1 (min)	0.7 ± 0.4	-	2.5 ± 1.3
Deceleration Zone 2 (min)	0.3 ± 0.1	-	1.0 ± 0.6
Deceleration Zone 3 (min)	0.6 ± 0.2	-	2.5 ± 1.2
Max Jump Height (cm)	54.0 ± 11.3	59.1 ± 10.7	50.4 ± 13.4
Jump Count (num)	60.3 ± 39.0 *	103.8 ± 57.3	24.9 ± 25.0
Body Impacts (num)	1.2 ± 1.1 *	2.3 ± 2.7	1.5 ± 1.0
Distance Speed Very-High (m)	68.6 ± 61.6	20.4 ± 22.9	58.3 ± 51.8
Distance Zone 1 0-6 $km.h^{-1}$ (m)	2057.3 ± 545.1	2049.5 ± 722.2	1177.8 ± 589.3
Distance Zone 2 6.1-12 $km.h^{-1}$ (m)	1909.7 ± 538.5 *	1213.7 ± 481.3	1443.3 ± 729.3
Distance Zone 3 12.1-18 $km.h^{-1}$ (m)	805.0 ± 372.3 *	267.9 ± 209.1	744.3 ± 436.6
Distance Zone 4 18.1-24 $km.h^{-1}$ (m)	118.6 ± 98.6 *	26.4 ± 22.7	111.4 ± 94.2
Distance Zone 5 24.1+ $km.h^{-1}$ (m)	12.5 ± 12.6	11.9 ± 12.1	12.1 ± 11.7
Accelerations Total (num)	218.8 ± 73.5 *	135.2 ± 64.5	165.8 ± 92.4
Decelerations Total (num)	119.1 ± 41.6 *	59.4 ± 27.2	97.3 ± 53.6

*Note. Data are mean ± SD, au, arbitrary unit; RPE, rate of perceived exertion; Min: sec, minutes: seconds; Acceleration Zone 1 ,0 – 2 m.s-2; Acceleration Zone 2, 2.1 – 4 m.s-2; Acceleration Zone 3, 4.1 – 10 m.s-2; Deceleration Zone 1, 0 – 2 m.s-2; Deceleration Zone 2,- 2.1 – 4 m.s-2; Deceleration Zone 3, 4.1 – 10 m.s-2; *significant difference between team trainings and skill trainings (p < .05).*

Table 6. Selected demanding external variables for starters, rotation and bench players.

External variable		MD+2		MD-3		MD-2		MD
	Role	Mean ± SD	% Diff	Means ± SD	% Diff	Means ± SD	% Diff	Means ± SD
Duration HR Hi-Int (min: sec) > 180 bpm	Starter	3.3 ± 1.82	- 82%	18.2 ± 15.9	+ 1%	18.1 ± 16.1	+ 1%	18.0 ± 14.4
	Rotation	22.7 ± 23.8	+ 59%	-		3.2 ± 2.5	- 78%	14.3 ± 14.5
	Bench	-	-	4.8 ± 5.9	- 47%	4.7 ± 4.3	- 48%	9.1 ± 10.4
	All	11.7 ± 15.5	- 22%	12.1 ± 15.3	- 19%	12.7 ± 12.7	- 15%	15.0 ± 14.0
Distance Total (m)	Starter	4622.7 ± 1125.6	- 8%	4510.0 ± 1197.8	- 11%	4737.5 ± 809.5	- 6%	5042.9 ± 1003.8 [1, 2]
	Rotation	3571.2 ± 1301.8	+ 4%	3382.5 ± 958.9	- 1%	3508.2 ± 833.5	+ 2%	3432.9 ± 919.3 [3]
	Bench	-	-	3816.0 ± 3160.8	+ 164%	2825.7 ± 3080.0	+ 96%	1444.4 ± 794.4
	All	4822.4 ± 1388.9 [a, b]	+ 39%	3666.7 ± 1212.7 [c]	+ 5%	4871.7 ± 1216.1 [e]	+ 40%	3479.2 ± 1805
Distance Speed Hi-Int (m) > 15km.h^{-1}	Starter	732.2 ± 394 ± 7	- 1%	639.8 ± 471 ±6	- 14%	603.7 ± 154.4	- 19%	742.1 ± 355.5 [1, 2]
	Rotation	334.5 ± 207.8	- 34%	573.0 ± 398 ± 4	+ 14%	435.6 ± 107.0	- 14%	503.7 ± 211.2 [3]
	Bench	-	-	460.0 ± 203.6	+ 107%	324.3 ± 274.5	+ 46%	222.1 ± 137.4
	All	528.3 ± 356.0 [a]	+ 2%	222.5 ± 263.6 [c, d]	- 57%	548.0 ± 309.1	+ 6%	519.2 ± 340.8
Sprints Hi-Int (num) > 18 km.h^{-1}	Starter	71.0 ± 26.7	- 11%	68.8 ± 47.1	- 14%	71.5 ± 16.3	- 11%	79.9 ± 37.3 [1, 2]
	Rotation	36.8 ± 21.0	- 28%	61.2 ± 44.9	+ 20%	45.2 ± 13.9	- 12%	51.1 ± 23.3 [3]
	Bench	-	-	47.0 ± 26.9	+ 118%	30.7 ± 30.2	+ 42%	21.6 ± 12.8
	All	55.2 ± 34.1 [a]	+ 1%	26.4 ± 28.3 [c, d]	- 51%	57.1 ± 31.3	+ 5%	54.4 ± 37.8
Acceleration Zone 1 (num) 0 – 2 m.s^{-2}	Starter	16.2 ± 5.9	- 17%	16.0 ± 9.1	- 18%	14.2 ± 2.1	- 28%	19.6 ± 12.3 [2]
	Rotation	21.2 ± 7.6	+ 33%	6.7 ± 1.5	- 58%	16.0 ± 14.7	0%	16.0 ± 9.0 [3]
	Bench	-	-	15.0 ± 14.1	+ 114%	8.0 ± 7.0	+ 14%	7.0 ± 5.0
	All	17.9 ± 19.9	+ 22%	11.5 ±7.1 [c]	- 22%	18.3 ± 10.5	+ 24%	14.7 ± 11.1
Acceleration Zone 2 (num) 2.1 – 4 m.s^{-2}	Starter	136.2 ± 37.7	- 7%	109.0 ± 59.0	- 25%	139.0 ± 27.1	- 5%	145.8 ± 33.7 [1, 2]
	Rotation	105.8 ± 45.9	+ 2%	113.0 ± 34.6	+ 8%	105.4 ± 37.3	+ 1%	104.2 ± 25.0 [3]
	Bench	-	-	132.5 ± 108.2	+ 229%	76.3 ± 83.4	+ 89%	40.3 ± 23.3
	All	132.3 ± 47.1 [a, b]	+ 31%	87.3 ± 40.9 [c]	- 14%	132.1 ± 41.2 [e]	+ 30%	101.3 ± 53.9
Acceleration Zone 3 (num) 4.1 – 10 m.s^{-2}	Starter	79.5 ± 25.1	+ 3%	53.0 ± 39.8	- 31%	68.7 ± 26.9	- 11%	77.3 ± 44.6 [1, 2]
	Rotation	37.0 ± 22.1	- 21%	62.2 ± 27.9	+ 32%	60.2 ± 48.3	+ 28%	47.0 ± 27.2 [3]
	Bench	-	-	62.5 ± 50.2	+ 202%	37.0 ± 43.3	+ 79%	20.7 ± 11.9
	All	67.3 ± 40.6 [a]	+ 28%	42.8 ± 30.7 [c]	- 19%	65.2 ± 37.4	+ 24%	52.7 ± 41.3
Deceleration Zone 1 (num) 1 – 0 – 2 m.s^{-2}	Starter	23.7 ± 7.4	- 15%	20.2 ± 8.1	- 27%	28.2 ± 3.0	+ 1%	27.8 ± 9.7 [1, 2]
	Rotation	24.3 ± 5.4	+ 15%	13.0 ± 4.9	- 38%	19.4 ± 12.6	- 8%	21.1 ± 7.4 [3]
	Bench	-	-	22.5 ± 20.5	+ 137%	13.3 ± 15.5	+ 40%	9.5 ± 5.2
	All	25.9 ± 11.2 [a, b]	+ 26%	19.2 ± 8.6 [c]	- 7%	27.3 ± 11.3 [e]	+ 33%	20.6 ± 11.2
Deceleration Zone 2 (num) 2.1 – 4 m.s^{-2}	Starter	56.5 ± 11.5	- 19%	54.3 ± 34.8	- 22%	53.5 ± 10.3	- 23%	69.4 ± 17.1 [f, g]
	Rotation	46.0 ± 15.0	- 9%	58.7 ± 14.0	+ 16%	44.4 ± 15.0	- 13%	50.6 ± 16.1 [3]
	Bench	-	-	46.5 ± 33.2	+ 135%	36.3 ± 39.7	+ 83%	19.8 ± 12.0
	All	56.3 ± 24.1 [a]	+ 15%	31.9 ± 19.2 [c, d]	- 35%	58.3 ± 20.3	+ 19%	48.9 ± 26.4
Deceleration Zone 3 (num) 4.1 – 10 m.s^{-2}	Starter	44.2 ± 21.4	- 1%	31.1 ± 27.1	- 30%	46.0 ± 17.5	+ 3%	44.7 ± 27.4 [f, g]
	Rotation	19.7 ± 10.8	- 26%	36.0 ± 20.0	+ 35%	21.8 ± 13.8	- 18%	26.6 ± 15.5 [3]
	Bench	-	-	35.0 ± 25.5	+ 197%	17.3 ± 16.6	+ 47%	11.8 ± 7.6
	All	34.4 ± 22.8 [a]	+ 14%	16.9 ± 15.3 [c, d]	- 44%	33.8 ± 21.1	+ 12%	30.2 ± 24.7

Note. Data are mean ± SD; % Diff shows the percentage difference between training and game values; MD+2, match day plus two; MD-3, match day minus three; MD-2,match day minus two; MD, match day; [a] significant difference between all MD+2 and MD-3; [b] significant difference between all MD+2 and MD; [c] significant difference between all MD-3 and MD-2; [d] significant difference between all MD-3 and MD; [e] significant difference between all MD-2 and MD; 1significant difference between starter and rotation on MD; 2significant difference between starter and bench on MD; 3significant difference between rotation and bench on MD; Where n ≤ 3 data was not presented.

External game load versus team trainings most demanding variables

The total distance was significantly lower on match days (MD) compared to other days (4822.4 ± 1388.9 m on MD+2 and 3479 ± 1805 m on MD; *p* < .05, ES = 0.32, Table 6). In contrast, high-intensity distance covered was greater on MD, with significant differences between MD+2 and MD-3 (528.3 ± 356.0 vs 222.5 ± 263.6, *p* < .05, ES = 0.81). Sprint efforts were also higher on match days, with starters completing 79.9 ± 37.3 sprints compared to 26.4 ± 28.3 on MD-3 (*p* < .05, ES = 0.70). Acceleration demands in zone 2 showed small to moderate differences, between MD+2 and MD (132.3 ± 47.1 vs. 101.3 ± 53.9, *p* < .05, ES = 0.26). Deceleration demands were similarly varied, with the highest values seen on MD+2 (56.3 ± 24.1) and lower values on MD (31.9 ± 19.2, *p* < .05, ES = 0.55). Significant differences were also found between starters and bench players on match day, with starters covering more distance (5042.9 ± 1003 vs. 1444.4 ± 794.4, *p* < .05, ES = 1.1).

Internal workload

The average daily internal load was similar across player roles, with no significant differences observed between Starters, Rotation, and Bench Players (Table 7). Small variations were observed in health status, diet, and mood, however, overall patterns remained consistent across groups.

Table 7. Internal daily load averages measured over two seasons.

Variable	Starter	Rotation	Bench	All
Mood state	3.5 ± 0.7	3.7 ± 0.6	3.6 ± 0.5	3.6 ± 0.6
Sleep quality	3.4 ± 0.9	3.4 ± 0.9	3.4 ± 0.8	3.5 ± 0.8
Energy levels	3.5 ± 0.7	3.6 ± 0.5	3.6 ± 0.6	3.6 ± 0.6
Muscle readiness	3.5 ± 0.6	3.7 ± 0.7	3.8 ± 0.6	3.6 ± 0.6
Academic pressure	3.8 ± 0.8	3.8 ± 0.8	3.8 ± 1.0	3.8 ± 0.8
Diet yesterday	3.4 ± 0.7	3.3 ± 0.7	3.4 ± 0.9	3.4 ± 0.8
Sleep duration (hours)	7.7 ± 1.2	7.7 ± 1.1	8.2 ± 1.3	8.0 ± 1.1
Health	3.5 ± 0.7	3.6 ± 0.8	3.6 ±0.7	3.6 ± 0.7

Note. Data are mean ± SD.

Internal versus external associations

Large correlations were observed between game sRPE and accelerations in (r = .70, *p* < .001), and zone 3 (r = .54, *p* < .001), with smaller associations observed for Zone 1 accelerations (r = .31, *p* < .001). Moderate to large correlations were also identified between game sRPE and decelerations (Zone 1: r = .49; Zone 2: r = .68; Zone 3: r = .52; all *p* < .001). Game sRPE demonstrated a large correlation with total game load (r = .70, *p* < .001). No meaningful associations were observed between wellness variables and acceleration or deceleration metrics.

DISCUSSION

This study investigated internal and external load demands in semi-professional male basketball players across two competitive seasons, including games, team training, and skill sessions. The primary finding was that RPE strongly correlated with high-intensity external metrics (accelerations, decelerations, and overall game load) confirming its value as an indicator of peak physical demands. Role related differences were also evident, with starters consistently exposed to higher total and high-intensity efforts than rotation and bench players. Analysis of session type revealed clear contrasts: team trainings accumulated the greatest total volume, games imposed the highest per-minute intensities, and skill sessions emphasised jumping outputs. Collectively, these results highlight the importance of monitoring both internal and external variables to guide role-specific and context specific load management strategies.

A key finding was the strong relationship between RPE and high-intensity load metrics. Zone 3 decelerations (r = .52) and Zone 3 accelerations (r = .5) demonstrated stronger correlations with RPE than lower-intensity zones, suggesting that perceived exertion is closely linked to the most physically demanding actions of the game. These findings align with Scanlan et al. (2014), who reported moderate correlations between sRPE and accelerometer derived loads in basketball players (r = .49), and Svilar & Jukic (2018) who found significant correlations between player load and sRPE (r = .84) (Scanlan et al., 2014; Svilar & Jukic, 2018). Collectively, this evidence supports the use of sRPE as a practical indicator of high-intensity workload in applied basketball settings.

Although training sessions produced greater overall volume at lower intensities, games consistently imposed greater demands at higher intensities across measures such as RPE, time spent in high-intensity heart rate zones, accelerations and decelerations, and high intensity sprints. This pattern was mirrored in decelerations, particularly in zone 3 (4.1 – 10 $m.s^{-2}$), where games placed the highest demands on players. This was also observed in a systematic review by Stojanovic, (2018) where players performed more frequent accelerations and decelerations during games, with 2.2 to 4.3 accelerations per min in games versus 1.2 to 2.5 per min in trainings (Stojanović et al., 2018). These findings emphasise the importance of appropriately exposing players to high-intensity demands during training. However, skill training, while lower in overall intensity, had the most jumps relative to both games and team training sessions, likely due to the specific nature of skill work, where repetitive actions such as shooting, lay-ups, and rebounding drills, are emphasised more frequently. This suggests that skill sessions many contribute uniquely to jump exposure within the weekly training structure.

While per-minute ratios provide useful context, examining peak-demand external variables is also essential, as these highlight the accelerations, decelerations, and high-speed efforts that games demand most. Incorporating these findings into training design helps ensure sessions replicate the highest match-play intensities across starter, rotation, and bench roles. As shown in Table 6, starters covered significantly more distance at high intensities compared to rotational and bench players. The greatest difference was observed in zone 2 decelerations, where starters exhibited a considerably higher number of decelerations than both rotational and bench players. These findings echo Garcia et al. (2022), who reported that while training occasionally surpassed match play in high-speed running (>18 $km.h^{-1}$) it did not replicate the broader intensity demands of competition (García et al., 2022). Similarly, García et al. (2022) reported that starters experienced higher values for both external and internal loads than rotation players, reinforcing that role-based differences extend beyond external measures. The present findings extend this work by demonstrating that these role-based differences persist across multiple seasons and session contexts.

This study has several limitations. The sample size prevented positional analysis (e.g., guards vs. forwards, front court vs. backcourt), which may have revealed role-specific differences. Strength training data were limited to a general overview, without details on repetitions, sets, and resistance loads, restricting insight into concurrent strength adaptions. Additionally, IMUs could not filter out low-intensity movements during stoppages (e.g., fouls), likely inflating low-intensity workload values and underrepresenting actual on-court demands. Future studies should incorporate positional analyses, detailed strength-training data, and advanced IMU filtering to refine accuracy.

CONCLUSION

The findings from this study provide valuable insights into the internal and external workload demands of semi-professional basketball players across two competitive seasons. Clear role-specific differences were observed, with starters consistently exposed to higher total and high-intensity loads than rotation and bench players. Games imposed the greatest high intensity demands, particularly accelerations, decelerations, and time spent in elevated heart rate zones, while team trainings accumulated larger overall volumes and skill sessions placed unique emphasis on jumps. Taken together, these results show that internal and external load measures do not always align, with external metrics highlighting role and session-based differences, while internal measures such as RPE confirmed that starters also perceived greater exertion than the other roles. This demonstrates that combining internal and external metrics provides the clearest picture of how demands differ across games, team trainings, and skill sessions. These findings have practical implications for how training exposure is distributed across player roles. Differences observed across the weekly microcycle further highlight the importance of considering both volume and intensity when planning training around competition. By incorporating both IMU-derived metrics and subjective measures such as RPE, this study expands on previous research, offering a comprehensive approach to monitoring basketball workloads. Future research should build on these findings by including positional analysis and refining load management strategies tailored to individual player roles. Such work will support more informed and individualised approaches to performance monitoring in basketball.

AUTHOR CONTRIBUTIONS

The study was designed by HS and MH. HS, MS and PO were responsible for data collection. HS conducted the data analysis, with MH contributing to data interpretation. HS drafted the manuscript. MH, SB, PO, and TK critically reviewed the manuscript and contributed important intellectual content. All authors have read and approved the final version of the manuscript.

SUPPORTING AGENCIES

No funding agencies were reported by the authors.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

REFERENCES

Cohen, J. (1988). Statistical Power Analysis for Behavioural Sciences. New York: Routledge.

Edwards, T., Spiteri, T., Piggott, B., Bonhotal, J., Haff, G. G., & Joyce, C. (2018). Monitoring and Managing Fatigue in Basketball. Sports, 6(1), 19. https://doi.org/10.3390/sports6010019

Eston, R. G., & Williams, J. G. (1988). Reliability of ratings of perceived effort regulation of exercise intensity. British Journal of Sports Medicine, 22(4), 153-155. https://doi.org/10.1136/bjsm.22.4.153

Ferreira, M., Camões, M., Lima, R. F., Silva, R., Castro, H. d. O., Mendes, B., . . . Clemente, F. M. (2021). Variations of workload and well-being measures across a professional basketball season. Revista Brasileira de Cineantropometria & Desempenho Humano, 23. https://doi.org/10.1590/1980-0037.2021v23e75863

Foster, C. (1998). Monitoring training in athletes with reference to overtraining syndrome. Medicine and science in sports and exercise, 30(7), 1164-1168. https://doi.org/10.1097/00005768-199807000-00023

Foster, C., Florhaug, J. A., Franklin, J., Gottschall, L., Hrovatin, L. A., Parker, S., . . . Dodge, C. (2001). A new approach to monitoring exercise training. Journal of strength and conditioning research, 15(1), 109-115. https://doi.org/10.1519/00124278-200102000-00019

Fox, J. L., O'Grady, C. J., & Scanlan, A. T. (2020). The Relationships Between External and Internal Workloads During Basketball Training and Games. International Journal of Sports Physiology and Performance, 15(8), 1081-1086. https://doi.org/10.1123/ijspp.2019-0722

Gabbett, T. J., & Domrow, N. (2007). Relationships between training load, injury, and fitness in sub-elite collision sport athletes. Journal of Sports Sciences, 25(13), 1507-1519. https://doi.org/10.1080/02640410701215066

Gamonales, J. M., Hernández-Beltrán, V., Escudero-Tena, A., & Ibáñez, S. J. (2023). Analysis of the External and Internal Load in Professional Basketball Players. Sports, 11(10), 195. https://doi.org/10.3390/sports11100195

García, F., Schelling, X., Castellano, J., Martín-García, A., Pla, F., & Vázquez-Guerrero, J. (2022). Comparison of the most demanding scenarios during different in-season training sessions and official matches in professional basketball players. Biology of Sport, 39(2), 237-244. https://doi.org/10.5114/biolsport.2022.104064

Haddad, M., Stylianides, G., Djaoui, L., Dellal, A., & Chamari, K. (2017). Session-RPE Method for Training Load Monitoring: Validity, Ecological Usefulness, and Influencing Factors. Frontiers in Neuroscience, 11. https://doi.org/10.3389/fnins.2017.00612

Halson, S. L. (2014). Monitoring Training Load to Understand Fatigue in Athletes. Sports Medicine, 44(S2), 139-147. https://doi.org/10.1007/s40279-014-0253-z

Hamlin, M., & Hellemans, J. (2007). Effect of intermittent normobaric hypoxic exposure at rest on haematological, physiological, and performance parameters in multi-sport athletes. Journal of Sports Sciences, 25(4), 431-441. https://doi.org/10.1080/02640410600718129

Hamlin, M., Wilkes, D., Elliot, C., Lizamore, C., & Kathiravel, Y. (2019). Monitoring Training Loads and Perceived Stress in Young Elite University Athletes. Frontiers in Physiology, 10, 34. https://doi.org/10.3389/fphys.2019.00034

Hopkins, W. G., Marshall, S. W., Batterham, A. M., & Hanin, J. (2009). Progressive statistics for studies in sports medicine and exercise science. Medicine and science in sports and exercise, 41(1), 3-13. https://doi.org/10.1249/MSS.0b013e31818cb278

Impellizzeri, F. M., Rampinini, E., Coutts, A. J., Sassi, A., & Marcora, S. M. (2004). Use of RPE-based training load in soccer. Medicine & Science in Sports & Exercise, 36(6), 1042-1047. https://doi.org/10.1249/01.MSS.0000128199.23901.2F

Li, X., Shang, L., Qin, S., & Yu, H. (2024). The impact of internal and external loads on player performance in Chinese basketball association. BMC Sports Science, Medicine and Rehabilitation, 16(1). https://doi.org/10.1186/s13102-024-00983-6

Palmer, J., Wundersitz, D., Bini, R., & Kingsley, M. (2021). Effect of Player Role and Competition Level on Player Demands in Basketball. Sports, 9(3), 38. https://doi.org/10.3390/sports9030038

Petway, A. J., Freitas, T. T., Calleja-González, J., Medina Leal, D., & Alcaraz, P. E. (2020). Training load and match-play demands in basketball based on competition level: A systematic review. PLOS ONE, 15(3), e0229212. https://doi.org/10.1371/journal.pone.0229212

Scanlan, A., Wen, P., Tucker, P., & Dalbo, V. (2014). The relationships between internal and external training load models during basketball training. Journal of strength and conditioning research, 28(9), 2397-2405. https://doi.org/10.1519/JSC.0000000000000458

Smith, H. K., Bird, S. P., Olsen, P., Kavanagh, T., & Hamlin, M. J. (2024). Validity and reliability of the VXSport (Omni) device on basketball movement parameters. Scientific Journal of Sport and Performance, 3(3), 383-394. https://doi.org/10.55860/QIDN6711

Stojanović, E., Stojiljković, N., Scanlan, A., Dalbo, V., Berkelmans, D., & Milanović, Z. (2018). The Activity Demands and Physiological Responses Encountered During Basketball Match-Play: A Systematic Review. Sports Medicine, 48(1), 111-135. https://doi.org/10.1007/s40279-017-0794-z

Svilar, L., Castellano, J., Jukic, I., & Casamichana, D. (2018). Positional Differences in Elite Basketball: Selecting Appropriate Training-Load Measures. International Journal of Sports Physiology and Performance, 13(7), 947-952. https://doi.org/10.1123/ijspp.2017-0534

Svilar, L., & Jukic, I. (2018). Load monitoring system in top-level basketball team: Relationship between external and internal training load. Kinesiology, 50, 25-33. https://doi.org/10.26582/k.50.1.4

Vázquez-Guerrero, J., Suarez-Arrones, L., Casamichana Gómez, D., & Rodas, G. (2018). Comparing external total load, acceleration and deceleration outputs in elite basketball players across positions during match play. Kinesiology, 50(2), 228-234. https://doi.org/10.26582/k.50.2.11

Vretaros, A. (2024). Describing the Distribution of Training Loads in the Microcycles and Mesocycles of Competitive Basketball. Italian Journal of Sports Rehabilitation and Posturology, 11, 2872.