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Cuantificación de la carga utilizando tecnología IMU en el baloncesto formativo: Una revisión sistemática

Load Quantification Using IMU Technology in Youth Basketball. A systematic Review

Quantificação da carga com recurso à tecnologia IMU no basquetebol juvenil: uma revisão sistemática

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RESUMEN

La cuantificación de la carga de entrenamiento y competición es fundamental en el baloncesto formativo, debido a las altas exigencias físicas y los procesos de maduración de los jugadores. Este estudio sintetizó la evidencia científica sobre la cuantificación de la carga de partido mediante dispositivos inerciales en jugadores de 12 a 18 años. Siguiendo las directrices PRISMA y con protocolo registrado en PROSPERO, se revisaron 21 estudios obtenidos de Web of Science y PubMed. La mayoría se centró en categoría sub-18 y utilizó unidades de medición inercial (IMU) basadas en tecnología UWB o sistemas LPS. Las variables de carga externa más analizadas fueron distancia total, aceleraciones, desaceleraciones, saltos, impactos y PlayerLoad™, mientras que la carga interna, principalmente frecuencia cardíaca, se evaluó con menor frecuencia. Los resultados muestran que la carga depende de la posición, el periodo del partido, el nivel del rival y el rol del jugador. No obstante, persisten limitaciones metodológicas y falta de estandarización e inclusión en las muestras analizadas.

Palabras clave: Carga Externa; Carga Interna; Dispositivos Inerciales; Deportes de Equipo; Condición Física.

ABSTRACT

Monitoring training and competition load are essential during developmental stages, where youth athletes face high physical demands while undergoing biological and motor maturation. This study synthesized the scientific evidence on match-load quantification in youth basketball using inertial measurement technology. A systematic review was conducted on the Web of Science and PubMed following PRISMA guidelines, with the protocol registered in PROSPERO. Twenty-one quantitative studies involving 5v5 basketball players aged 12–18 years were included. Most studies focused on under-18 male and female players competing at sub-elite or elite levels and mainly used IMUs based on ultra-wide band (UWB) or local positioning systems (LPS). External load variables, including total

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distance, accelerations, decelerations, jumps, impacts, and PlayerLoad™, were the most frequently analyzed, whereas internal load indicators, primarily heart rate–based measures, were less consistently reported. Match load was influenced by playing position, match period, opponent level, and player role, highlighting the need for standardized and more inclusive monitoring approaches.

Keywords: External Load; Internal Load; Inertial Devices; Team Sport; Physical Fitness.

RESUMO

A monitorização da carga de treino e competição é fundamental nas etapas de formação, em que os atletas enfrentam elevadas exigências físicas durante processos de maturação biológica e motora. Este estudo sintetizou a evidência científica sobre a quantificação da carga de jogo no basquetebol de formação através de tecnologia baseada em dispositivos inerciais. Foi realizada uma revisão sistemática nas bases de dados Web of Science e PubMed, seguindo as diretrizes PRISMA e com protocolo registado no PROSPERO. Foram analisados 21 estudos quantitativos com jogadores de basquetebol 5x5 entre os 12 e os 18 anos. A maioria incidiu sobre atletas sub-18 de níveis subelite ou elite e utilizou IMUs baseadas em tecnologia UWB ou sistemas LPS. As variáveis de carga externa mais reportadas incluíram distância total, acelerações, desacelerações, saltos, impactos e PlayerLoad™, enquanto a carga interna, sobretudo baseada na frequência cardíaca, foi menos analisada. Os resultados reforçam a necessidade de protocolos padronizados e abordagens de monitorização mais inclusivas.

Palavras chave: Carga Externa; Carga Interna; Dispositivos Inerciais; Desportos Coletivos; Condição Física.

INTRODUCTION

In modern sport, the quantification of training and competition load represents a fundamental component for optimizing performance, minimizing injury risk, and promoting sustainable physical and motor development, particularly in youth and developmental contexts (Arede et al., 2022). In intermittent, high-intensity sports such as basketball, characterized by a complex set of physical interaction (Russell et al., 2021), technical (Conte et al., 2015), tactical (Martinho et al., 2025), and psychological demands (Kostopoulos et al., 2024) the need for objective tools that enable a holistic monitoring of load has become essential. Among the emerging technologies with the greatest applicability, future potential, and a substantial body of high-impact scientific research, inertial measurement units (IMUs) have gained considerable prominence as portable and highly versatile systems capable of providing comprehensive real-time information with unprecedented levels of validity and reliability (Kobsar et al., 2020).

Training load can be understood as the physiological, mechanical, and psychological stimulus experienced by an athlete during participation in specific tasks (Vanrenterghem et al., 2017). The dynamic interaction between internal load and external load constitutes the foundation upon which training and competition processes are designed, planned, and adjusted (Svilar et al., 2018; Sosa-Marín et al., 2025). However, in youth categories—where athletes are undergoing continuous biological, cognitive, and motor maturation, the accurate load measurement becomes particularly relevant. Structural and functional immaturity of the organism may result in decontextualized or poorly controlled exposure to training stimuli can lead to functional overload, overuse injuries, or interference with motor learning processes (Drew & Finch, 2016; Scanlan et al., 2025).

IMUs have been shown to be valid and reliable tools for quantifying external load in basketball, enabling the recording of accelerations, decelerations, and other high-intensity actions with high temporal resolution (Kobsar et al., 2020). Among the most used parameters in the literature are accelerometry-derived variables (Gómez-Carmona et al., 2020a), velocity (Pino-Ortega et al., 2020), PlayerLoad™ (Gómez-Carmona et al., 2020b), and the number of impacts and jumps (Pino-Ortega et al., 2018), among others. Unlike other technologies such as global positioning systems (GPS), whose utility is limited in indoor sports due to the inability to receive satellite signals, IMUs provide an effective and context-appropriate solution for monitoring load in indoor basketball environments (Ibáñez et al., 2023).

Youth basketball also presents contextual particularities that further complicate the precise quantification of load. Unlike senior categories, where load is often closely aligned with competitive performance objectives, developmental stages must simultaneously address goals related to technical–tactical learning, holistic athlete development, and the protection of psychobiological growth (Branquinho et al., 2022). Consequently, task design must address both the appropriateness of training load and the quality of the motor stimulus (González-Espinosa et al., 2020). IMU technology, by enabling precise registration of both the volume and intensity of movement performed, offers the possibility of adjusting pedagogical tasks to an optimal level of demand, thereby avoiding both undertraining and overtraining (González-Espinosa et al., 2019).

Moreover, IMUs allow for segmented analyses of load according to playing position, task type, or even at the individual player level (McKay et al., 2022), representing a critical advantage in youth contexts where high inter-individual variability is common. In this regard, it has been observed that interior players exhibit load profiles that differ from those of perimeter players (Mancha-Triguero et al., 2020), due to variations in movement patterns, number of jumps, and frequency of impacts. Such information can be used not only to individualize training planning but also to establish more effective recovery strategies and to prevent mechanical imbalances that could lead to injury. Nevertheless, the implementation of this technology requires a critical perspective, a solid scientific foundation, and an ethical commitment to the principles of positive youth athlete development.

Accordingly, several studies have explored the use of IMUs in basketball competitions; however, most have focused on adult and professional-level populations (García et al., 2020; Ferioli et al., 2020; Vázquez-Guerrero, 2019). As a result, the available literature in youth categories remains limited. The main challenge lies in integrating this technology coherently within a multidisciplinary framework that considers the physiological, biomechanical, psychological, and social dimensions of youth training, ensuring that the combination of all factors and outcomes is ultimately focused on better preparing the athlete who is still in a formative stage.

The objectives of the present review were: i) To synthesize the existing evidence related to match load analysis in youth basketball categories; ii) To identify the most frequently used instruments and variables; iii) To analyze the most frequently used keywords in the literature search related to the selected topic. Considering these aspects and the need to systematize the available evidence in youth categories, a systematic review was designed to rigorously identify, organize, and analyze existing studies on load quantification using IMUs.

MATERIALS AND METHODS

Design

The methodological design adopted in the present study was a systematic review design (Ibáñez & Feu, 2026), as it was oriented toward the analysis and systematization of existing knowledge related to the quantification of training and competition load in youth basketball players, within the specific context of a championship (regular competition games). In this regard, a systematic review of the scientific literature was conducted, understood as a structured process of identification, selection, evaluation, and synthesis of previous studies (scientific articles, specialized books, and bibliographic reviews) related to the object of study. This review was carried out following a rigorous methodological protocol that included the definition of inclusion and exclusion criteria, the operational definition of variables of interest, data coding, and subsequent descriptive analysis, without performing metaanalytic procedures for the quantitative integration of results. The protocol for this systematic review was prospectively registered in the International Prospective Register of Systematic Reviews (PROSPERO; Registration Number CRD420251248727; https://www.crd.york.ac.uk/PROSPERO/view/CRD420251248727), ensuring transparency, methodological rigor, and replicability of the review process.

The study was conducted in accordance with the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Page et al., 2021), which involved: 1) The formulation of precise objectives through a clear, explicit, and replicable methodology; 2) The execution of a comprehensive and systematic search for empirical evidence, subject to predefined eligibility criteria; 3) The critical appraisal of the quality and internal validity of the included studies; and 4) The structured presentation of findings, accompanied by a qualitative synthesis of their main characteristics and results.

Sample

The analyzed documents consisted of books, articles published in journals indexed in scientific databases, book chapters, and doctoral theses addressing the topic of study. The results of the initial search, conducted by entering the selected keywords into Web of Science (WoS) and PubMed, yielded a total of 155 documents. These records were analyzed using the PRISMA methodology (Page et al., 2021), which was applied exclusively for the purposes. The final number of documents selected for inclusion in the study sample was 21 (March 2026).

The selection of the Web of Science database was based on the fact that this search engine integrates, in a consolidated manner, several highly relevant scientific databases, including: 1) Web of Science Core Collection; 2) Current Contents Connect; 3) Derwent Innovations Index; 4) Korean Journal Database; 5) MEDLINE; 6) Russian Science Citation Index; and 7) SciELO Citation Index. It should be noted that the documents retrieved from these sources were previously analyzed using the PRISMA methodology, which was applied exclusively within the framework of the present study to ensure a systematic and rigorous approach.

Inclusion and Exclusion Criteria

The search was conducted in both English and Spanish. The selected keywords were: ""(*Basketball* AND *Youth* AND ("*Match load*" OR "*External load*" OR "*Internal load*") AND "*Inertial devices*") NOT "*Training load*"". The Boolean operators "AND" and "OR" were used, as the aim was to maximize sensitivity while maintaining specificity, to retrieve studies that fulfilled all inclusion criteria. For documents to be accepted and analyzed, they were required to meet the predefined inclusion and exclusion criteria.

Inclusion criteria:

i) Studies related to 5v5 basketball.
ii) Samples consist of youth athletes aged between 12 and 18 years.
iii) Research focusing on athlete load performance (internal load and/or external load).
iv) Articles, book chapters or other documents (e.g., doctoral theses) published in English, Portuguese, or Spanish.
v) Quantitative studies employing objective methods of analysis.
vi) Research studies, reviews, or meta-analyses that report performance data included in reviews.
vii) Full-text articles available.

Exclusion criteria:

i) Studies related to basketball in which the object of study was not performance, internal load, or external load.
ii) Articles, book chapters or other documents (e.g., doctoral theses) nonpublished in English, Portuguese, or Spanish.
iii) Articles for which the full text could not be obtained and therefore could not be referenced.
iv) Studies using exclusively qualitative methodologies or quantitative approaches based on subjective analysis methods.
v) Studies focused on 3x3 basketball.
vi) Studies involving amateur or professional-level athletes (non-including NCAA samples).
vii) Studies on recreational basketball or wheelchair basketball.

Variables

The classification applied to the documents was as follows: author(s), year, type of document, title, keywords, sample, materials used, variables analyzed, data collection process, and main results (Table 1).

Table 1
Variables analyzed in the documents included in the review.

Variable	Description
Author(s)	Author names
Year	Year of publication of the document
Title	Title of the document
Keywords	Keywords identified by the authors in their documents
Sample	Number of participants included in the study and sample level
Materials used	Type of materials used (devices employed)
Variables analyzed	Type of variables and main characteristics evaluated in the document
Data collection process	Brief description of the process (number of matches, tournaments, etc.) and relevant information about the manuscript
Main results	Summary of the most relevant findings reported in the study

Furthermore, based on the primary variable “keywords” from each document, thematic categories were constructed to identify the main conceptual foci of the literature and to analyze their distribution within the field of study. This process led to the creation of a secondary variable, enabling a more precise and structured analysis of the selected documents.

Procedure

Systematic literature reviews require the application of rigorous methodological procedures and analytical tools that allow for the coherent organization and clarification of the continuous development of scientific contributions within a given field (Akudjedu et al., 2026). In this context, the PRISMA methodology (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) was adopted (Page et al., 2021). This framework is structured around four clearly defined phases: 1) Identification; 2) Screening; 3) Eligibility; and 4) Inclusion (see Figure 1).

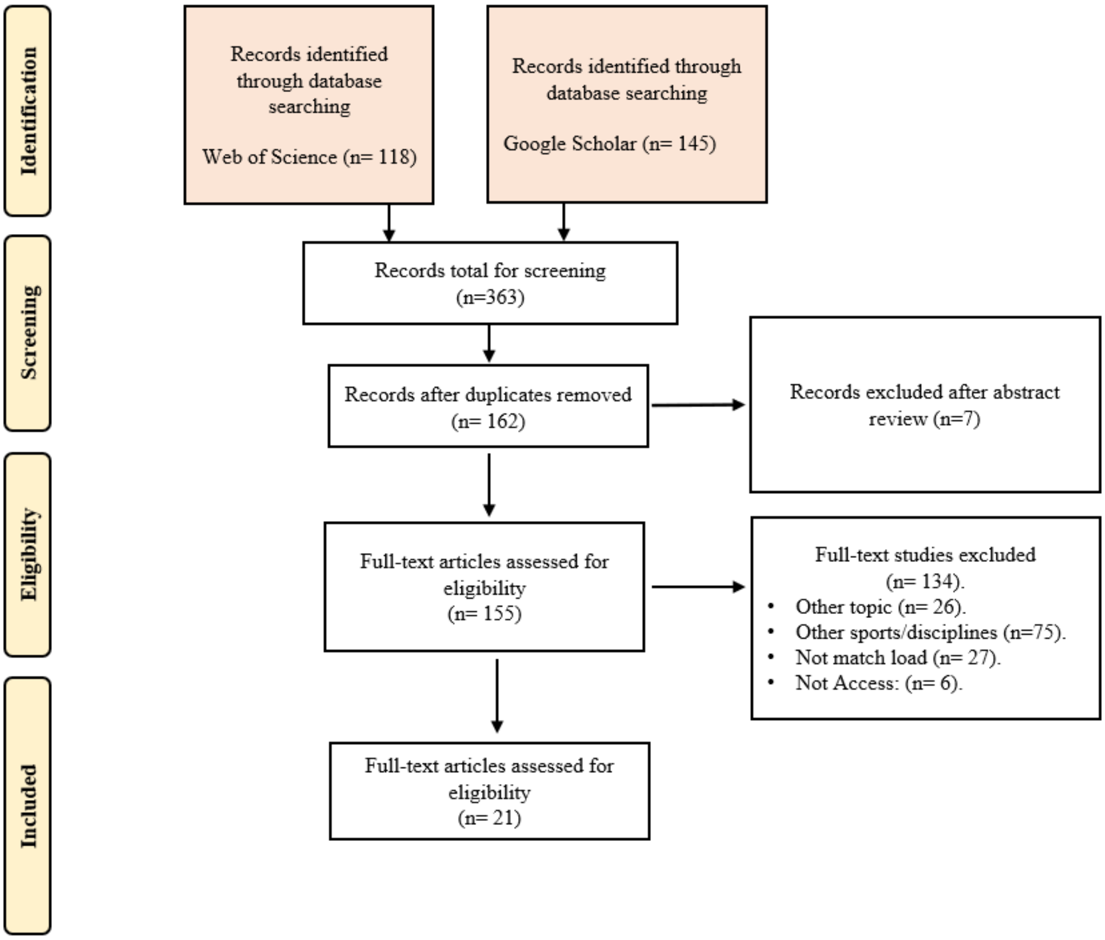
During the identification phase, a total of 155 documents were retrieved from different databases, considering the selected terms both in the title and in the topic fields. This approach allowed for an initial delimitation of the object of study in general terms (March 2026). Subsequently, in the screening phase, a detailed examination of titles, abstracts, and keywords was conducted, selecting only those documents whose focus was explicitly related to competitive load in youth basketball players. At this stage, the predefined inclusion and exclusion criteria were strictly applied. Following text coding, the sample was reduced to 40 documents specifically focused on assessing the workload quantification in basketball games.

During the eligibility phase, the selected documents retrieved from the Web of Science (WoS) and PubMed databases were analyzed in depth, with particular attention to the relevance of their content to the research objective. Finally, in the inclusion phase, the studies deemed valid were subjected to analysis in accordance with the variables previously defined in the methodological section.

The exclusion of certain documents was based on several reasons: 1) in some cases, although the object of study was mentioned, it did not constitute the primary focus of the investigation (*n* = 26); 2) other documents addressed sports disciplines other than basketball or modalities such as 3x3 basketball, which were not relevant to the aims of the present study (*n* = 75); 3) additionally, studies that focused on basketball but did not specifically address match load were excluded (*n* = 27); and 4) finally, five documents were excluded due to the inability to access either the full text or the abstract, which prevented a rigorous evaluation for potential inclusion in the final sample (*n* = 6). The research question was formulated following the PICOS model: Population (youth basketball players aged 12–18), Intervention (use of IMU devices), Comparison (not applicable), Outcomes (variables and values obtained for external and internal load) and Study Design.

Figure 1

Graphical representation of the PRISMA process applied in the literature review.



Bibliometric Analysis

The methodological quality of the studies included in the sample was assessed using the *Standard Quality Assessment Criteria for Evaluating Primary Research Papers from a Variety of Fields* developed by Kmet, Lee, and Cook (2004). This instrument was selected due to its applicability across diverse quantitative research designs and its ability to systematically evaluate key methodological components, including study design, participant selection, variable definition, analytical procedures, and the consistency between results and conclusions. The assessment process enabled a structured appraisal of the methodological rigor and overall quality of the studies included in the review (Table 2).

The co-authorship network analysis revealed the existence of several clearly defined collaborative clusters within the scientific literature related to workload monitoring and physical demands in youth basketball. The largest and most influential cluster was led by authors such as Ibáñez, García-Rubio and Pino-Ortega, who exhibited the highest degree of interconnectivity and scientific productivity, reflecting their central role in the development of research associated with external load, contextual factors, accelerations, and performance analysis in young basketball players. A second cluster brought together researchers such as Gutiérrez-Vargas and Rojas-Valverde, whose studies primarily focused on physiological demands, sex-related differences, and workload responses according to playing position and competitive context. Furthermore, additional thematic clusters were identified around authors such as Sosa and Lorenzo, mainly associated with the study of velocity thresholds and peak demands using local positioning systems. In contrast, smaller peripheral groups addressed topics related to competition structure, physical persistency, technical performance, and the influence of opponent-related contextual variables. Overall, the network structure demonstrated a high degree of thematic specialization combined with strong collaborative connections among the leading authors, suggesting the progressive consolidation of an emerging scientific field focused on external workload quantification and performance monitoring in youth basketball (Figure 2).

Figure 2

Graphical representation of the co-authorship networks of the selected articles.

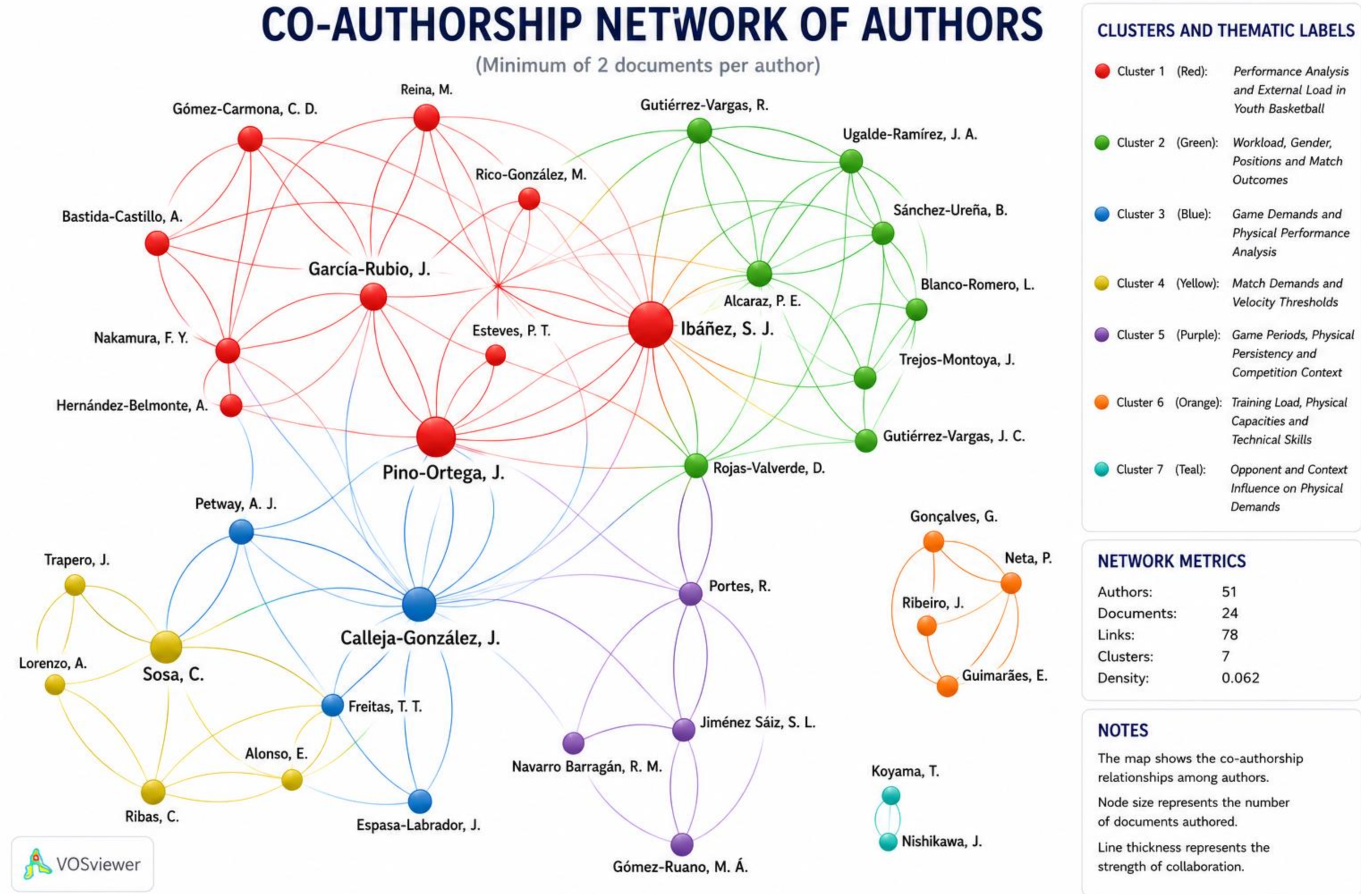


Table 2

Results obtained from the analysis through the methodological quality.

Reference	Study type	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total score (out of 28)	General Justification Summary
Reina et al., (2020).	Quantitative observational	2	2	1	1	N/A	N/A	N/A	2	1	2	2	1	2	2	18	The study presented a clear objective and an appropriate observational design. Variables and statistical analyses were adequately defined, and conclusions were consistent with the findings. However, participant selection procedures and confounding factor control were only partially described.
Petway et al., (2020).	Quantitative observational longitudinal	2	2	1	2	N/A	N/A	N/A	2	1	2	2	1	2	2	19	The study presented a clear objective and an appropriate observational design. Variables and statistical analyses were adequately defined, and conclusions were consistent with the findings. However, participant selection procedures and confounding factor control were only partially described.
Sosa et al., (2021).	Quantitative observational comparative	2	2	1	2	N/A	N/A	N/A	2	1	2	2	1	2	2	19	The study presented a clear objective and an appropriate observational design. Variables and statistical analyses were adequately defined, and conclusions were consistent with the findings. However, participant selection procedures and confounding factor control were only partially described.
Reina et al., (2019).	Quantitative observational descriptive	2	2	1	2	N/A	N/A	N/A	2	1	2	2	1	2	2	19	The study presented a clear objective and an appropriate observational design. Variables and statistical analyses were adequately defined, and conclusions were consistent with the findings. However, participant selection procedures and confounding factor control were only partially described.
Ibáñez et al., (2024).	Quantitative observational descriptive	2	2	1	2	N/A	N/A	N/A	2	1	2	2	1	2	2	19	The study presented a clear objective and an appropriate observational design. Variables and statistical analyses were adequately defined, and conclusions were consistent with the findings. However, participant selection procedures and confounding factor control were only partially described.
Portes et al., (2022).	Quantitative observational longitudinal	2	2	1	2	N/A	N/A	N/A	2	1	2	2	1	2	2	19	The study presented a clear objective and an appropriate observational design. Variables and statistical analyses were adequately defined, and conclusions were consistent with the findings. However, participant selection procedures and confounding factor control were only partially described.

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Gál-Pottyondy et al., (2025).	Quantitative observational correlational	2	2	1	2	N/A	N/A	N/A	2	1	2	2	1	2	2	19	The study presented a clear objective and an appropriate observational design. Variables and statistical analyses were adequately defined, and conclusions were consistent with the findings. However, participant selection procedures and confounding factor control were only partially described.
Gutiérrez-Vargas et al., (2021).	Quantitative observational comparative	2	2	1	2	N/A	N/A	N/A	2	1	2	2	1	2	2	19	The study presented a clear objective and an appropriate observational design. Variables and statistical analyses were adequately defined, and conclusions were consistent with the findings. However, participant selection procedures and confounding factor control were only partially described.
Pérez-Chao et al., (2020).	Quantitative observational descriptive	2	2	1	2	N/A	N/A	N/A	2	1	2	2	1	2	2	19	The study presented a clear objective and an appropriate observational design. Variables and statistical analyses were adequately defined, and conclusions were consistent with the findings. However, participant selection procedures and confounding factor control were only partially described.
Urbonavičius (2020).	Quantitative observational longitudinal	2	2	1	2	N/A	N/A	N/A	2	1	2	2	1	2	2	19	The thesis presented an appropriate longitudinal observational design and valid workload monitoring methods. Some methodological details, including sample size adequacy and confounding control, were insufficiently specified.
Gonçalves et al., (2025).	Quantitative observational comparative longitudinal	2	2	1	2	N/A	N/A	N/A	2	1	2	2	1	2	2	19	The study presented a clear objective and an appropriate observational design. Variables and statistical analyses were adequately defined, and conclusions were consistent with the findings. However, participant selection procedures and confounding factor control were only partially described.
Gómez-Carmona et al., (2019).	Quantitative observational comparative	2	2	1	2	N/A	N/A	N/A	2	1	2	2	1	2	2	19	The study presented a clear objective and an appropriate observational design. Variables and statistical analyses were adequately defined, and conclusions were consistent with the findings. However, participant selection procedures and confounding factor control were only partially described.
Pérez-Chao et al., (2023).	Quantitative observational comparative	2	2	1	2	N/A	N/A	N/A	2	1	2	2	1	2	2	19	The study presented a clear objective and an appropriate observational design. Variables and statistical analyses were adequately defined, and conclusions were consistent with the findings. However, participant selection procedures and confounding factor control were only partially described.
Pino-Ortega et al., (2019).	Quantitative observational longitudinal	2	2	1	2	N/A	N/A	N/A	2	1	2	2	1	2	2	19	The study presented a clear objective and an appropriate observational design. Variables and statistical analyses were adequately defined, and conclusions were consistent with the findings. However, participant selection procedures and confounding factor control were only partially described.

Espasa-Labrador et al., (2025).	Quantitative observational correlational	2	2	1	2	N/A	N/A	N/A	2	1	2	2	2	2	2	20	The study presented a clear objective and an appropriate observational design. Variables and statistical analyses were adequately defined, and conclusions were consistent with the findings. However, participant selection procedures and confounding factor control were only partially described.
Brown (2024).	Quantitative observational longitudinal	2	2	1	2	N/A	N/A	N/A	2	2	2	2	2	2	2	21	The thesis presented an appropriate longitudinal observational design and valid workload monitoring methods. Some methodological details, including sample size adequacy and confounding control, were insufficiently specified.
Koyama et al., (2024).	Quantitative observational comparative	2	2	1	2	N/A	N/A	N/A	2	1	2	2	2	2	2	20	The study presented a clear objective and an appropriate observational design. Variables and statistical analyses were adequately defined, and conclusions were consistent with the findings. However, participant selection procedures and confounding factor control were only partially described.
Reina et al., (2020).	Quantitative observational descriptive	2	2	1	2	N/A	N/A	N/A	2	1	2	2	1	2	2	19	The study presented a clear objective and an appropriate observational design. Variables and statistical analyses were adequately defined, and conclusions were consistent with the findings. However, participant selection procedures and confounding factor control were only partially described.
Portes et al., (2020).	Quantitative observational comparative	2	2	1	2	N/A	N/A	N/A	2	1	2	2	1	2	2	19	The study presented a clear objective and an appropriate observational design. Variables and statistical analyses were adequately defined, and conclusions were consistent with the findings. However, participant selection procedures and confounding factor control were only partially described.
Gutiérrez-Vargas et al., (2021).	Quantitative observational analytical	2	2	1	2	N/A	N/A	N/A	2	1	2	2	2	2	2	20	The study used an appropriate analytical design with suitable multivariate statistical procedures. Variables were adequately operationalized, although sample size adequacy and confounding control were not fully specified.
Irid et al., (2025).	Quantitative observational: analytical	2	2	1	2	N/A	N/A	N/A	2	1	2	2	2	2	2	20	The study presented a clear objective and an appropriate observational design. Variables and statistical analyses were adequately defined, and conclusions were consistent with the findings. However, participant selection procedures and confounding factor control were only partially described.

N/A: Not Applicable; 1. Clearly described objective; 2. Appropriate design; 3. Appropriate subject selection; 4. Subject characteristics described; 5. Randomization; 6. Investigator blinding; 7. Participant blinding; 8. Well-defined variables; 9. Appropriate sample size; 10. Appropriate analytical methods; 11. Variance estimation; 12. Confounding control; 13. Detailed results; 14. Conclusions supported.

The methodological quality of the included studies was assessed using the Standard Quality Assessment Criteria for Evaluating Primary Research Papers from a Variety of Fields (QualSyst). The studies analyzed presented overall methodological quality scores ranging from moderate to high quality, with final scores generally varying between 18/24 and 21/24 points after excluding non-applicable criteria (N/A). According to the established interpretation criteria, studies with higher scores demonstrated greater methodological rigor in aspects such as study design, variable definition, statistical analysis, and consistency between results and conclusions, whereas lower scores were mainly associated with limited reporting of participant selection procedures and insufficient control of potential confounding factors.

RESULTS

Following the application of the PRISMA protocol and the coding of the selected documents, the results were organized according to the variables defined in the methodological section. The main characteristics of the included studies (Table 3), as well as the trends identified in the literature, are presented below.

The application of the PICOS strategy (Table 4) to the selected studies reveals a clear and consistent research pattern within youth basketball performance analysis. Regarding the population (P), most studies focus on adolescent players (primarily U17–U18), frequently competing at elite or sub-elite levels, with a predominance of male samples, although female cohorts are also represented. In terms of intervention/exposure (I), none of the studies implement experimental interventions; instead, they examine external and internal load variables, including accelerations, decelerations, velocity thresholds, and peak match demands, typically monitored through advanced tracking technologies.

Concerning the comparison (C) component, many studies incorporate meaningful comparative conditions, such as playing position, gender, match period, competition phase, opponent level, or player status (e.g., starters vs. rotation players). These comparisons enhance the analytical depth and practical applicability of the findings. The outcomes (O) are largely consistent across studies, focusing on physical and physiological demands, workload profiles, and the influence of contextual factors on performance. Finally, with respect to study design (S), most investigations adopt observational and descriptive approaches, with some longitudinal designs, reflecting the practical constraints of performance research in real-game environments.

Overall, the PICOS analysis highlights a body of literature characterized by strong ecological validity and applied relevance, although limited by the predominance of non-experimental designs.

Table 3

Methodological characteristics and main results of the studies included in the review.

Study (Year)	Sample / TIER	Instrument & Variables	Key Results (Condensed)
Brown (2024)	13 NCAA D-I females	Catapult; PL, PL·min⁻¹, EE	Higher match participation resulted in distinct load profiles. PL·min⁻¹ peaked in Q1. Explosive efforts were associated with free-throw performance.
Koyama et al. (2024)	18 collegiate males	Accelerometry; PL, distance, sprints, jumps, RPE	Stronger opponents elicited higher external loads. RPE showed an inverse trend, suggesting contextual modulation of perceived effort.
Reina et al. (2020a)	48 U18 females (Final Four)	WIMU Pro; TD, HID, PL, impacts	Competitive demands increased across tournament days. Day 3 was most demanding; forwards accumulated more minutes and high-intensity actions.
Portes et al. (2020)	U18 males and females	WIMU Pro; TD, Acc/Dec, PL	Males showed higher high-intensity loads. Sex- and position-specific differences were evident, particularly in guards and forwards.
Gutiérrez-Vargas et al. (2021a)	64 U18 sub-elite	Inertial (UWB); TD, jumps, HR	Load varied by sex and position. Guards and forwards showed more explosive actions. Match outcome influenced physical demands.
Irid et al. (2025)	31 U18 players	LPS; intensity-based windows	Shorter time windows revealed substantially higher peak demands. Males showed higher values across all variables.
Espasa-Labrador et al. (2025)	15 semi-pro males	UWB; TD, PL, jumps	Total distance, PlayerLoad and jumps were associated with scoring actions and shooting efficiency.
Pino-Ortega et al. (2019)	94 elite U18 males	WIMU Pro; TD, HID, PL	Higher-ranked teams experienced greater demands. Guards and forwards showed higher loads; Q1 was the most demanding quarter.
Pérez-Chao et al. (2023)	13 U18 males	Accelerometry; distance, Acc/Dec, PL	No significant differences were observed between quarters won or lost.
Gómez-Carmona et al. (2019)	96 elite U18 males	WIMU Pro; TD, HID, PL, impacts	Unbalanced matches showed greater load differences, particularly in impact-related variables.
Gonçalves et al. (2025)	13 U16 males	WIMU Pro; distance, HR, Acc/Dec	Starters accumulated greater match loads, whereas rotation players showed higher HR responses.
Urbanovicius (2020)	20 NCAA D-I players	Catapult; distance, Acc/Dec, HR	Higher loads were associated with improved performance but also increased fatigue and injury risk.
Pérez-Chao et al. (2020)	12 elite U18 males	Catapult; speed, Acc/Dec, COD	Peak demands were short but intense and varied according to playing position.
Gutiérrez-Vargas et al. (2021b)	64 U18 sub-elite	WIMU Pro; TD, HID, PL	Males showed higher external and internal demands. Guards and forwards experienced greater loads than interior players.
Gál-Pottyondy et al. (2025)	45 youth players	UWB; distance, speed, EE	Higher pre-match load was associated with improved match performance, with positional differences observed.
Portes et al. (2022)	48 U18 females	UWB; distance, Acc/Dec	Load slightly decreased across quarters. Intensity variables were maintained across consecutive matches.
Ibáñez et al. (2024)	94 elite players	WIMU Pro; TD, HID, PL	Playing position explained most intensity differences. Loads increased during key match moments.
Reina et al. (2019)	48 U18 females	WIMU Pro; Acc/Dec, intensity ranges	Perimeter players performed more explosive actions. Q4 showed the lowest values.
Sosa et al. (2021)	10 elite juniors	Catapult; distance, intensity	Most time was spent at low speeds. Acc/Dec, COD and jumps were more relevant than high-speed running.
Petway et al. (2020)	7 NCAA D-I males	Stats; distance, speed, Acc/Dec	Neuromuscular performance declined throughout the season, highlighting the importance of load tolerance.
Reina et al. (2020)	48 U18 females	WIMU Pro (UWB) TD, HID, PL, impacts	Forwards showed greater load variability than other positions. The most demanding quarters were Q3 and Q4.

NCAA: *National Collegiate Athletic Association;* ***D-I:*** *First Division;* ***PL:*** *PlayerLoad;* ***PL/min:*** *PlayerLoad/minute;* ***RPE:*** *Rate Perceived Exertion;* ***TD:*** *Total Distance;* ***HID:*** *High Intensity Distance;* ***Acc/Dec:*** *Aceleration/Deceleration,* ***HR****. Heart Rate,* ***LPS:*** *Local Position System,* ***UWB:*** *Ultra Wided Band,* ***COD:*** *Change of Direction.*

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Table 4
Table of the analyzed studies assessed using the PICOS strategy.

Author (Year)	Population (P)	Intervention (I)	Comparison (C)	Outcomes (O)	Study Design (S)
Reina et al. (2020a)	Youth basketball players	External load	Playing position, game period, playing time	Load variation	Observational
Petway et al. (2020)	NCAA players	Game activity and neuromuscular performance	Season phases	Seasonal changes	Longitudinal
Sosa et al. (2021)	Male players	Absolute velocity thresholds	Age categories	Velocity differences	Observational
Reina et al. (2019)	U18 female players	Accelerations and decelerations	-	Physical profile	Observational
Ibáñez et al. (2024)	Youth players	Accelerations and decelerations	-	Demand profile	Observational
Portes et al. (2022)	Elite junior players	Physical load	Game quarters, consecutive games	Physical persistency	Longitudinal
Gál-Pottyondy et al. (2025)	Adolescent players	Pre-match physical demands	Match relation	Performance relationship	Observational
Gutiérrez-Vargas et al. (2021a)	Youth players	Physical and physiological demands	Gender, position, outcome	Load differences	Observational
Pérez-Chao et al. (2020)	Youth players	Peak match demands	-	Peak identification	Observational
Urbonavičius (2020)	U17–U18 players	Internal and external load	Age categories	Load monitoring	Observational
Gonçalves et al. (2025)	Youth players	Training vs competition load	Starters vs rotation	Performance differences	Observational
Gómez-Carmona et al. (2019)	Youth players	External load	Match outcome	Outcome influence	Observational
Pérez-Chao et al. (2023)	U18 male players	Peak demands	Game result and quarter	Contextual influence	Observational
Pino-Ortega et al. (2019)	Elite U18 players	External load	Contextual factors	Congestion impact	Observational
Espasa-Labrador et al. (2025)	Youth male players	Physical demands	Game performance	Performance relationship	Observational
Brown (2024)	NCAA female players	Load monitoring	-	Load profile	Descriptive
Koyama et al. (2024)	Basketball players	Physical demands	Opponents	Load differences	Observational
Reina et al. (2020b)	Youth female players	Speed profile	-	Physical demands	Observational
Portes et al. (2020)	Elite junior players	External load	Gender	Gender differences	Observational
Gutiérrez-Vargas et al. (2021b)	Youth players	Internal and external load	Gender and period	Load factors	Observational (factorial)

Most of the included studies were conducted with male and female players in the junior or Under-18 category, generally competing at sub-elite or elite developmental levels. These investigations predominantly employed inertial devices based on UWB or LPS technology, commercial IMU systems (e.g., Catapult™ and WIMU Pro™). The most frequently analyzed variables were related to external load, with particular emphasis on total distance and distance segmented by intensity, accelerations and decelerations, jumps, impacts, and derived metrics such as PlayerLoad™. Additionally, several studies incorporated internal load indicators, especially heart rate and %HRmax. The results indicate that physical demands are influenced by factors such as playing position, opponent level, phase of the game, game score, and whether the player is a starter or a substitute. These findings confirm that perimeter players typically perform higher-intensity actions; workloads tend to vary between quarters, and winning teams or those competing at higher levels generally endure greater demands (making it crucial to exercise caution in managing workloads, as relationships may arise from association rather than causation) (). The available evidence reinforces the usefulness of microsensors for characterizing competitive demands in youth basketball; however, it also reveals notable methodological heterogeneity and a predominance of studies focusing on male populations, factors that limit the generalizability of the findings (extended version table in the annexes section).

In addition to the descriptive analysis of samples, instruments, and variables, a conceptual examination of the keywords provided by the authors was conducted to identify the thematic cores structuring research in this field. Table 5 presents the results of this keyword analysis for the documents included in the review, grouped into categories that allow visualization of the main conceptual and terminological foci employed in the analyzed literature.

The analysis of the keywords presented in Table 5 reveals that the literature on load quantification in youth basketball is structured around a limited number of predominant conceptual cores. The most frequent descriptors correspond to terms related to data analysis and big data (28.83%), internal and external load (19.82%), and the conceptualization of sport as a collective modality (17.12%), which confirms methodological orientation centered on objective measurement and on understanding the game as a complex system. To a lesser extent, terms associated with accelerometry (6.31%), gender (6.31%), characteristics of youth samples (4.50%), and competition (3.60%) were identified, together with more specific references to playing position (2.70%) and the technology employed (10.81%). These findings indicate that existing studies prioritize the objective quantification of physical demands and the use of advanced technological systems, while aspects such as sex-based analyses, detailed population characterization, and competitive specificities receive comparatively less attention, highlighting areas with potential for further development in future research.

Overall, these results allow the identification of the main methodological, conceptual, and applied trends in current literature. Based on these findings, the discussion addresses the emerging thematic axes and their relevance for understanding load in youth basketball.

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Table 5
Results of the keywords from the selected documents grouped by thematic category.

Category	n	%	Descriptors
Accelerometry	7	6.31%	Acceleration; Accelerometer; Accelerometry; Deceleration; Acceleration Ratio; RSI; Speed
Sample	5	4.50%	Adolescent; Youth; Youth athletes; Youth players
Basketball/ Team Sport	19	17.12%	Basketball; Basketball skills; Collective sports; Sports; Sport-Specific Performance; Team Sport
Data analysis / Big Data	32	28.83%	Big Data; Data mining; Data reduction; Game analysis; Game demands; Game outcome; Game period; Match analysis; Match performance; Most demanding periods; Performance analysis; Physical demands; Physical performance; Player monitoring; Pre-match; Principal Component Analysis; Profile; Quarter
Competition	4	3.60%	Competition; Training dose; Exertion
Load	22	19.82%	External load; Fatigue; Internal load; Internal loads; Kinematics; Load; Load monitoring; Neuromuscular outputs; Training and game demands; Vertical jump; On-court performance; Peak demands; Performance
Technology	12	10.81%	Global Positioning System; Indoor; Inertial devices; Local Positioning System; Monitoring; Ultra-wide band
Gender	7	6.31%	Gender; Men; Sex; Women athlete; Women
Playing Position	3	2.70%	Playing position; Playing positions; Playing

DISCUSSION

The aim of this systematic review was to synthesize the available evidence on load quantification in youth basketball using inertial technologies, identifying the instruments employed, the most frequently analyzed variables, and the conceptual patterns present in the literature. The results reveal, first, a limited body of scientific production in youth categories, with only 22 studies meeting the inclusion criteria, reflecting the still limited implementation. In addition, some studies incorporate internal load indicators based on heart rate; however, their inclusion is less consistent across studies. Finally, the keyword analysis shows that the most recurrent concepts are related to load, performance analysis, and the use of big data, indicating a research line that prioritizes objective measurement and data systematization, while presenting important gaps in areas such as the study of female categories, contextual analysis, and the pedagogical application of findings (Bustamante-Sánchez et al., 2025). These results highlight both the technological progress achieved in the field and the areas in which significant knowledge gaps remain.

The analysis of the descriptors included in Table 3 indicates that the scientific literature on quantifying workload in youth basketball is structured into distinct blocks or themes. These areas are based on core concepts, which give rise to the main thematic axes. To organize the interpretation of the results in a coherent manner, Figure 3 presents an integrative conceptual framework that structures the principal axes identified in the literature. The high frequency of terms related to data analysis and big data, external and internal load, and the specific nature of team sports suggests that the literature prioritizes a predominantly technological and quantitative approach, focused on the objective measurement of performance and competitive demands. In contrast, categories such as gender, playing position, characteristics of youth samples, or the technologies employed are less represented, suggesting the existence of conceptual gaps and areas of comparatively lower development within the field. This uneven distribution of keywords not only reflects the prevailing interests of the scientific community but also justifies the need to structure the discussion around the most relevant and emerging conceptual domains.

Figure 3.

Conceptual representation of the main thematic axes identified in the review

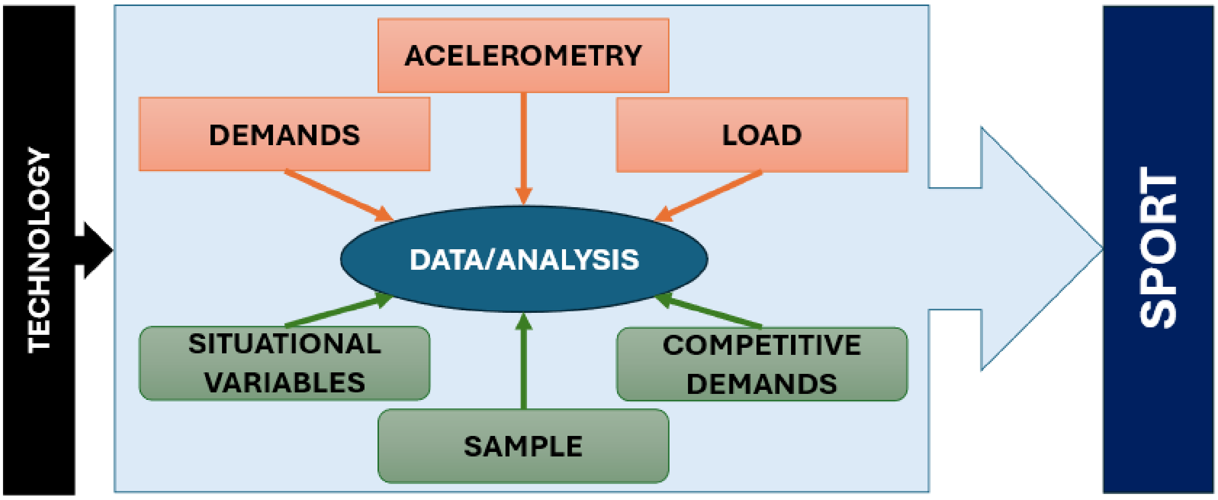

Figure 3 conceptually synthesizes how the incorporation of inertial technologies has expanded researchers' capacity to record and analyze large volumes of performance-related data in youth basketball. This information is organized around three situational categories that condition the nature of the measurements: contextual variables associated with the timing and setting of data collection, the characteristics of the analyzed samples, and the specific demands of competition, which determine the type and intensity of the actions performed by players. In parallel, the figure illustrates that the variables most frequently reported in the literature are primarily grouped around game demands, the quantification of internal and external load, and accelerometry-derived indicators—elements that constitute the core of analysis using inertial devices. Overall, these factors converge toward a common purpose: to achieve a more precise understanding of the physical and mechanical demands inherent to basketball, thereby enabling progress toward more comprehensive, contextualized, and transferable evaluation models within the developmental domain.

Based on this framework, the discussion is structured according to these axes to provide a coherent and in-depth analysis of the patterns observed in the literature and their relevance for understanding competitive demands in youth categories.

Technology and Utility of Inertial Measurement Units (IMUs)

Load quantification using inertial devices has been widely recognized as a precise and versatile tool for performance monitoring and injury prevention in sporting contexts (when used with caution and care) (Dudley et al., 2023). Several authors have highlighted that the accelerometers, gyroscopes, and magnetometers integrated into these units enable the collection of detailed information on accelerations, decelerations, jumps, and impacts, providing objective data that enhances the understanding of the actual physical demands imposed on athletes (Bastida-Castillo et al., 2019; Akenhead & Nassis, 2016; Cummins et al., 2013). Moreover, recent studies have shown that the use of this technology allows for more individualized control of external load, thereby optimizing decision-making processes related to training planning and recovery (Rago et al., 2019). Nevertheless, one of the main obstacles to its widespread implementation is the high economic cost associated with acquiring these systems, as well as the proprietary software required for data analysis, which limits access primarily to elite centers or institutions with greater financial resources (Bastida-Castillo et al., 2019).

Technological Accessibility and Implementation Barriers

This high economic cost may partially explain the limited amount of scientific literature employing inertial devices as the primary tool for load quantification, particularly in amateur, educational, or resource-constrained contexts. As an alternative, some studies have opted for lower-cost methods, such as low-cost accelerometers or subjective ratings of perceived exertion (RPE); however, these approaches present limitations in terms of reliability and precision (considering that their use requires certain prior nuances and training for athletes) (Evans et al., 2014; Impellizzeri et al., 2005).

Consequently, several authors have proposed the combined use of accessible technologies with validated methodological approaches as a more cost-effective means of approximating load quantification (Reina et al., 2019; Bustamante-Sánchez et al., 2025). This perspective underscores the need to promote strategies that facilitate equitable access to reliable technologies and to encourage research aimed at comparing and validating more affordable alternatives.

Load Variables: External Load, Internal Load, and Complementary Indicators

In the studies analyzed, the main variables used to quantify training and competition load in basketball are grouped into two broad categories: external load and internal load. External load has been predominantly assessed through variables derived from local positioning systems (LPS) and accelerometry, including total distance covered, distance segmented by speed zones, the number of accelerations and decelerations, changes of direction, PlayerLoad™, and the frequency of explosive actions (Svilar et al., 2018; Vázquez-Guerrero et al., 2019). These metrics allow for the characterization of both the intensity and volume of the physical demands to which players are exposed during training sessions and matches, providing objective information on activity profiles. In contrast, internal loads have been mainly monitored through heart rate, heart rate training zones, and ratings of perceived exertion (RPE), which reflect the physiological response of the organism to external demands (Fox et al., 2020). The combined use of both dimensions offers a comprehensive view of the demands imposed and the individual responses of athletes.

Complementary Indicators and Their Contextual Relevance

In addition to these primary variables, some studies incorporate complementary indicators that, although they are not fundamental to the quantification of the load, facilitate the contextualization and interpretation of the data. These include measures of subjective well-being, sleep quality, mood state, blood biomarkers, and injury records (Reina et al., 2022; Gómez-Carmona et al., 2021). Such complementary variables enable the identification of accumulated fatigue states (López-Sierra et al., 2024), potential overload risks, and performance trends that may not be fully captured by internal or external load variables alone. However, their use is less frequent, partly due to the need for additional resources, specialized personnel, and standardized measurement protocols. Thus, while internal and external load variables remain the core of monitoring practices in basketball, the inclusion of complementary indicators represents a valuable opportunity to refine decision-making processes and to individualize training and recovery strategies.

Differences According to Competitive Level

An examination of the available literature suggests significant differences in training load and competitive demands depending on the competitive level of basketball teams, whether professional, semi-professional, or developmental. Previous studies have shown that elite teams exhibit higher volumes and intensities of both external and internal load, reflected in greater values of distance covered, accelerations, changes of direction, and heart rate compared with lower competitive categories (Vázquez-Guerrero et al., 2019; Puente et al., 2017). These differences can be explained by multiple factors: high-level teams typically face more demanding schedules, with a greater number of matches per season and shorter recovery periods between sessions, and they also have access to specialized coaching staff and advanced technological resources to plan and monitor loads more precisely (Svilar et al., 2018). Conversely, in developmental or semi-professional levels, logistical constraints, lower degrees of professionalization, and the prioritization of technical–tactical development over competitive physical performance result in distinct load patterns, generally characterized by lower intensity and less systematic control. These structural differences must be considered when interpreting results and when extrapolating recommendations from one competitive level to another, to avoid generalizations that may compromise the external validity of proposed interventions.

Gender Inequalities in Research and Technological Application

Several systematic reviews and original studies have highlighted a clear imbalance in scientific production related to the analysis of training and competition load between male and female basketball teams. Most of the published research focuses on male populations, both at professional and developmental levels, whereas studies involving female categories are considerably less frequent (Fox et al., 2020; Gómez-Carmona et al., 2021). For example, Torres-Ronda et al. (2016) and Vázquez-Guerrero et al. (2019) provide detailed descriptions of physical demands and load distribution in high-level male competitions using advanced technologies such as local positioning systems (LPS) and accelerometry. In contrast, comparable studies in women's basketball are scarce and, in many cases, present less robust designs or smaller samples, which hinders the generalizability of findings (Reina et al., 2022). As a result, a substantial proportion of current recommendations for load monitoring are derived from male data, without adequately considering potential physiological, tactical, and competitive differences between sexes.

The reasons underlying this gap are complex and multifactorial. The literature points to historical and structural factors, such as higher levels of professionalization, financial investment, and availability of technological resources in men's basketball, which have facilitated the implementation of advanced monitoring systems (Svilar et al., 2018; Puente et al., 2017). Additionally, women's leagues often receive less media exposure and, in many contexts, have reduced access to specialized technical and scientific staff, limiting the systematic generation of data (Conte et al., 2015). Differences in competitive calendars and season structures may also influence research priorities, leading to a greater focus on male competitions with broader international exposure. This lack of sex-specific evidence hampers the development of individualized, evidence-based training programs for female players, underscoring the need to promote longitudinal studies in women's populations that allow for precise characterization of their demands and optimization of preparation and recovery processes (Espasa-Labrador et al., 2021).

These findings highlight the urgent need to expand research in female populations by incorporating more robust and representative study designs that enable the establishment of sex-specific load quantification models and advance toward a more equitable and contextualized understanding of youth basketball.

Need for Methodological Standardization and Research Coherence

Despite the growing use of inertial technologies, the present review reveals substantial heterogeneity in experimental designs, data collection protocols, and operational definitions of load variables, which complicates direct comparisons across studies and limits the synthesis of available evidence. The absence of unified criteria regarding aspects such as intensity thresholds, acceleration segmentation, or the duration of analysis windows highlights the need to develop standardized methodological criteria that enhance the external validity of findings and facilitate the development of comparable and transferable models for applied settings (Gómez-Carmona et al., 2020).

The different conceptual themes raised include the technological evolution of IMUs in the evaluation of sports aspects, accessibility barriers, heterogeneity of variables, differences associated with competitive level, and gender inequalities reveal a field that is expanding but remains fragmented. The literature demonstrates significant advances in the description of the physical and mechanical demands of youth basketball; however, important challenges persist related to methodological standardization, sample quality and diversity, and the transfer of findings to real training contexts. Overcoming these challenges will be essential to consolidate a more precise, inclusive, and applicable framework for load monitoring, contributing to the optimization of the athletic development of young male and female players.

Despite the methodological rigor of this review, certain limitations must be acknowledged when interpreting the results. The primary limitation lies in the scarcity and heterogeneity of available studies, both in terms of design and analyzed variables, which hinders the establishment of precise comparisons and the formulation of generalizable conclusions regarding load quantification in youth basketball. This limitation represents a clear opportunity for future research, which should be oriented toward the standardization of measurement protocols, the unification of thresholds and indicators, and the expansion of longitudinal studies that allow for a better understanding of how demands evolve throughout player development. Furthermore, the limited presence of studies involving female athletes and non-elite contexts highlights the need to promote research lines that include more diverse samples, real competitive situations, and accessible technologies, with the aim of building a more representative and practically applicable body of knowledge across different sport development environments.

CONCLUSIONS

The present systematic review demonstrates that the use of inertial devices for load quantification in youth basketball remains limited due to the low number of available studies, due both to the scarce availability of studies and to the technological and economic constraints that hinder their implementation in developmental team contexts. The findings indicate that most research has been conducted in male populations competing at sub-elite to elite levels, predominantly employing LPS/UWB systems and focusing analyses on external load variables derived from accelerometry and PlayerLoad™, while internal load measures have received less consistent attention. Likewise, the analysis of keywords and conceptual patterns suggests a clear orientation toward quantitative, data-driven approaches based on large datasets; however, important gaps persist regarding sample diversity, methodological standardization, and the inclusion of contextual and pedagogical perspectives.

These findings reinforce the need to progress toward more accessible, inclusive, and standardized monitoring models that enhance the applicability of technology in developmental stages and allow for a more precise interpretation of competitive demands. To this end, future studies should incorporate female samples and non-elite competitive levels, employ homogeneous protocols that facilitate comparisons across investigations, and explore complementary indicators that provide a more holistic view of the training and competition process. This review contributes to clarifying the current state of knowledge and identifying priority lines of development to optimize load quantification in young male and female basketball players.

Match load quantification in youth basketball

The systematic integration of inertial devices into youth basketball represents an opportunity to advance toward evidence-based training models, provided that their use is accompanied by robust methodological criteria, equitable accessibility, and an educational perspective centered on the holistic development of the young athlete.

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Match load quantification in youth basketball

AUTHORS	YEAR	TITLE	JOURNAL / SOURCES	PARTICIPANTS, SAMPLE AND SPORTING LEVEL	INSTRUMENT	VARIABLES ANALYZED	KEY RESULTS
Brown	2024	Comprehensive microsensor load monitoring in NCAA Division I women's basketball	Final Degree Project	13 female players, 20.08 ± 1.55 years. 66 training sessions and 29 matches. NCAA Division I collegiate level	Catapult inertial devices	PlayerLoad, PlayerLoad/min, Explosive Efforts	Players with greater match participation exhibited different load profiles compared to those with lower rotation. PlayerLoad/min was higher in the first quarter. A relationship was found between explosive ratio and free throws.
Koyama et al.	2024	A comparison of the physical demands generated by playing different opponents in basketball friendly matches	Biology of Sport	18 male collegiate-level players	Triaxial accelerometry	PlayerLoad, estimated distance, sprints, jumps, explosive efforts, RPE	Playing against stronger opponents generated significantly higher external loads. Perceived internal load (RPE) may follow an inverse pattern due to psychological or contextual factors.
Reina et al.	2020	Activity demands and speed profile of young female basketball players using ultra-wide band technology	International Journal of Environmental Research and Public Health	48 U18 female players (Guards n=13; Forwards n=22; Centers n=13). 6 Final Four matches at national championship level	WIMU Pro (UWB)	Total distance, high-intensity distance, sprint distance, number of sprints, maximal sprint speed, PlayerLoad, impacts	Day 3 of competition was more demanding than Day 1. Forwards played more minutes per match and performed more high-intensity actions than other positions.
Portes et al.	2020	Comparing the external loads encountered during competition between elite, junior male and female basketball players	International Journal of Environmental Research and Public Health	25 male players (17 years); 48 female players. 11 elite junior official matches	WIMU Pro (UWB)	Total distance, high-intensity distance, accelerations, decelerations, Acc/Dec ratio, PlayerLoad, PlayerLoad/min	Male players performed more high-intensity actions than females. Male guards showed more explosive actions than female guards. Female forwards showed more explosive actions than male forwards.
Gutiérrez-Vargas et al.	2021	Exploratory factor analysis of match period and sex-related differences of external and internal workload demands in youth basketball players	The Open Sports Science Journal	32 male players; 32 female players. U18 sub-elite	Inertial devices (UWB)	Total distance, accelerations, decelerations, jumps, HRmax, %HRmax	Female guards and male forwards performed more explosive or high-intensity actions. Male centers spent more time at 80–90% HRmax. When teams won, guards performed more explosive actions; when teams lost, centers covered greater distances.
Irid et al.	2025	Exploring the most demanding scenarios in elite youth basketball: a comprehensive analysis across playing positions and time windows	Biology of Sport	20 male players; 11 female players. 40 official matches. U18	Inertial devices (LPS)	Load variables (total distance, high-intensity distance, accelerations, decelerations, jumps, changes of direction) grouped by intensity across 10, 30, 60, and 120 s intervals	Shorter analysis windows revealed higher peak demands. Male players showed higher values than females across all variables.
Espasa-Labrador et al.	2025	Exploring the relationship between game performance and physical demands in youth male basketball players	Preprint	15 male players (16.3 ± 0.7 years). 7 official matches. Spanish 4th division	Inertial devices (UWB)	Total distance, accelerations, decelerations, PlayerLoad, jumps	Total distance, PlayerLoad, and number of jumps were significantly related to scoring, two-point shots, and shooting efficiency.

Reina et al.	2020	How external load of youth basketball players varies according to playing position, game period and playing time	International Journal of Performance Analysis of Sport	48 U18 female players. 6 Final Four matches	WIMU Pro (UWB)	Total distance, high-intensity distance, sprint distance, number of sprints, maximal sprint speed, PlayerLoad, impacts	Forwards showed greater load variability than other positions. The most demanding quarters were Q3 and Q4.
Pino-Ortega et al.	2019	Impact of contextual factors on external load during a congested-fixture tournament in elite U18 basketball players	Frontiers in Psychology	94 elite male players (17.6 ± 0.8 years). 13 Adidas Next Generation Tournament matches	WIMU Pro (UWB)	Total distance, high-intensity distance, sprint distance, number of sprints, maximal sprint speed, PlayerLoad, impacts	Higher-ranked teams exhibited greater competitive demands. Guards and forwards experienced higher loads than centers. Q1 was the most physically demanding quarter.
Pérez-Chao et al.	2023	Influence of game and quarter results on external peak demands during games in under-18 male basketball players	Biology of Sport	13 U18 male players. 9 matches	—	Distance covered, distance at different intensities, accelerations, decelerations, PlayerLoad	Most variables showed no significant differences between quarters that were won or lost.
Gómez-Carmona et al.	2019	Influence of match outcome on external load demands during official competition in youth male basketball	Cuadernos de Psicología del Deporte	96 elite U18 male players. 13 Adidas Next Generation Tournament matches	WIMU Pro (UWB)	Total distance, high-intensity distance, sprint distance, number of sprints, maximal sprint speed, PlayerLoad, impacts	Matches with unbalanced results showed greater load differences than closely contested matches. The largest differences were found in impact variables.
Gonçalves et al.	2025	Internal and external loads during formal training and competition, physical capacities and technical skills in youth basketball: a comparison between starters and rotation players	Journal of Human Kinetics	13 U16 male players. 10 weeks of matches	WIMU Pro (UWB)	Distance covered, heart rate, movement intensity, accelerations, decelerations	Starters experienced greater match loads than rotation players. Starters showed lower HRmax values than rotation players.
Urbanovicius	2020	Monitoring internal and external loads in male U18 and U17 basketball players	Doctoral Thesis	20 NCAA Division I collegiate basketball players (12 males, 8 females)	Catapult inertial devices	Distance covered, accelerations, decelerations, heart rate	Players with higher match loads showed greater physical and technical performance but also increased fatigue and injury risk.
Pérez-Chao et al.	2020	Peak match demands in young basketball players: approach and applications	International Journal of Environmental Research and Public Health	12 elite male players (17.56 ± 0.67 years)	Catapult inertial devices (UWB)	Distance covered, maximal speed, accelerations, decelerations, changes of direction, triaxial accelerometry	Young players showed shorter but more intense peak periods. Peak demands varied according to the playing position.
Gutiérrez-Vargas et al.	2021	Physical and physiological demands according to gender, playing position, and match outcomes in youth basketball players	RICYDE. International Journal of Sport Science	32 male and 32 female U18 sub-elite players	WIMU Pro (UWB)	Total distance, high-intensity distance, sprint distance, number of sprints, maximal sprint speed, PlayerLoad, impacts	Male players showed higher external and internal demands than females. Guards and forwards experienced greater demands than interior players. Winning teams showed higher loads, although not always significantly.

Gál-Pottyondy et al.	2025	Physical demands of international pre-matches and their relationship with official match statistics among adolescent basketball players	Biomedical Human Kinetics	45 players (U19 boys, U16 boys, U16 girls). 15 international pre-matches	Inertial devices (UWB)	Distance covered, accelerations, decelerations, maximal speed, explosive efforts	A relationship was found between pre-match physical load and competitive performance. Higher pre-match demands were associated with better match performance. Demands vary by playing position.
Portes et al.	2022	Physical persistency across game quarters and during consecutive games in elite junior basketball players	International Journal of Environmental Research and Public Health	48 elite junior female players (U18). 133 individual cases	Inertial devices (UWB)	Distance covered, accelerations, decelerations, triaxial accelerometry	Load values slightly decreased across quarters. In consecutive matches, player load remained stable. Intensity variables were maintained despite accumulated fatigue.
Ibáñez et al.	2024	Profile of accelerations and decelerations in young basketball players	Applied Sciences	94 elite players. 1205 individuales cases	WIMU Pro (UWB)	Total distance, high-intensity distance, sprint distance, number of sprints, maximal sprint speed, PlayerLoad, impacts	Playing positions were the main factor explaining differences in intensity actions. Load was higher during key moments of the match.
Reina et al.	2019	The acceleration and deceleration profiles of U18 women's basketball players during competitive matches	Sports	48 U18 female players. 6 Final Four matches	WIMU Pro (UWB)	Accelerations, decelerations, intensity-segmented ranges	Perimeter players performed more explosive actions. Differences were observed across match quarters, with Q4 showing the lowest values.
Sosa et al.	2021	Specific absolute velocity thresholds during male basketball games using a local positioning system: differences between age categories	Applied Sciences	10 elite junior male players. 18 official matches	Catapult inertial devices (UWB)	Total distance and distance at different intensities	Most distance and playing time were spent walking or standing. Speeds above 24 km/h had limited relevance. However, acceleration, deceleration, changes of direction, and jumping were crucial for performance.
Petway et al.	2020	Seasonal variations in game activity profiles and players' neuromuscular performance in collegiate Division I basketball: non-conference vs. conference tournament	Frontiers in Sports and Active Living	7 NCAA Division I male players. 31 matches	Stats Sports VU software	Distance covered, maximal speed, accelerations, decelerations	Neuromuscular performance declined across the season. Findings highlight the importance of load tolerance and robustness during periods of high match density.