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SPORTS PERFORMANCE

What are the demands of volleyball match-play? A systematic review of the external and internal loads encountered according to playing position, number of sets, and player sex

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ABSTRACT
Although volleyball is widely practiced and researched around the world, no research has performed the fundamental initial step of consolidating findings regarding match-play demands in the sport. Consequently, this systematic review synthesized the available evidence on the external and internal loads experienced by volleyball players during match-play. Studies were included if they reported external and/or internal load data during indoor volleyball match-play for players of any age, sex, or competitive level. PubMed, Scopus, SPORTDiscus, and Web of Science were searched on July 7, 2025, with the methodological quality of included studies assessed using the Observational Study Quality Evaluation tool. Twenty-eight studies were included. Setters performed the greatest jump volumes, while middle blockers and outside/opposite hitters performed the most high jumps (>50 cm). Internal load also varied by position, with middle blockers, liberos, and setters typically reporting the highest perceived exertion (≈5.3 to 7.7 AU across the number of sets played). Females performed more jumps but at lower heights and generally reported higher internal loads than males. This review provides a foundational reference concerning volleyball match loads to guide player monitoring, training, and recovery strategies, while also generating useful recommendations for future research.

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KEYWORDS
Training load; RPE; gender; monitoring; microsensor; video analysis

1. Introduction

Volleyball is a globally recognised team sport with more than 500 million players participating in the sport across more than 220 countries (Hulteen et al., 2017). Its popularity spans from recreational to various higher competitive levels, making it one of the most widely played sports worldwide. The game itself is defined by a series of powerful, short-duration efforts that demand high levels of coordination, speed, and power (Rebelo, Valente-dos-Santos, et al., 2025). Teams compete by spiking the ball over the net to win points, which occurs when the ball contacts the ground within the boundaries of the opposing team's court or an error from the opposing team is made. Each position on the court plays a distinct role, including setters who coordinate offensive plays, outside and opposite hitters responsible for attacking, middle blockers who lead the net defense, and liberos who specialise in reception and floor defense (Rebelo, Valente-dos-Santos, et al., 2025). Play involves rapid transitions between offense and defense with repeated execution of intense actions such as jumping, sprinting, blocking, and diving (Drikos et al., 2018; Yiannis & Panagiotis, 2005). Consequently, match-play is intermittent in nature being characterised by brief high-intensity activity bouts interspersed with periods of lower-intensity movement or complete rest (Sheppard et al., 2009). Anaerobic metabolic pathways are predominantly utilised for energy provision during these high-intensity bouts, with aerobic pathways also being recruited, particularly during stoppages between

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points and sets (Sheppard et al., 2007). Match demands may also fluctuate across sets and positions given different tactical strategies, team lineups, and fatigue states among players are likely to be encountered (Rebelo, Valente-dos-Santos, et al., 2025; Sheppard et al., 2009).

To precisely quantify the match demands encountered in team sports – including volleyball – training load monitoring has become a cornerstone of applied sports science practice and research (Impellizzeri et al., 2019). In volleyball, managing these loads is important to optimise performance and reduce the risk of overtraining or sustaining an injury among players (Rebelo, Pereira, Broek, et al., 2025). Training load is often conceptualised as the combination of exercise intensity and duration (Banister et al., 1975; Impellizzeri et al., 2023), being typically divided into external load and internal load constructs (Impellizzeri et al., 2019). External load refers to the objective physical work performed by players (Impellizzeri et al., 2019), such as the number of jumps, movement distances, velocities, and accelerations performed (Rebelo, Pereira, Nakamura, et al., 2025). These variables are often obtained with video tracking systems, inertial measurement units (IMUs), or other wearable technologies (Rebelo, Pereira, Nakamura, et al., 2025). In contrast, internal load represents player responses to the external demands (Impellizzeri et al., 2019), encompassing physiological markers like heart rate and blood lactate concentration (Rebelo, Pereira, et al., 2024) as well as perceptual indicators like rating of perceived exertion (RPE) (Rebelo, Pereira, Martinho, & Valente-dos-Santos, 2023). The interplay between external and internal loads provides volleyball coaches and practitioners with a comprehensive understanding of performance readiness, recovery needs, and training adaptation regarding their players (Impellizzeri et al., 2019, 2023).

Over recent years, research interest in quantifying the external and internal loads experienced by volleyball players has grown considerably. Several systematic reviews have contributed to this field (M. Pisa et al., 2022; M. F. Pisa et al., 2022; Rebelo, Pereira, Martinho, & Valente-dos-Santos, 2023; Rebelo, Pereira, et al., 2024); however, many of these reviews have adopted an isolated focus on either external (M. Pisa et al., 2022) or internal (M. F. Pisa et al., 2022; Rebelo, Pereira, Martinho, & Valente-dos-Santos, 2023) load variables rather than comprehensively collating them together. This contrasts with a growing movement in load-monitoring research toward integrated approaches that examine the interaction between external and internal load metrics (van der Zwaard S et al., 2023). Additionally, some reviews have limited their scope to players of a specific sex (M. Pisa et al., 2022; M. F. Pisa et al., 2022) or playing level (Rebelo, Pereira, Martinho, & Valente-dos-Santos, 2023), while others combine data from training and match contexts (M. Pisa et al., 2022; M. F. Pisa et al., 2022; Rebelo, Pereira, et al., 2024), making it difficult to identify the demands of competitive match-play according to important player factors like position, sex, and competitive level. Given the limitations of existing systematic reviews, a clear need is apparent for a focused review on the match demands in volleyball players to provide a unified synthesis of external and internal loads experienced in relation to player position, number of sets played, player sex, and competitive level. Providing this level of detail when collating the evidence is important, as load responses and match demands may differ markedly between different playing positions, male and female players, and sub-elite and elite levels. In this regard, team sport coaches and support staff apply load monitoring practices to mitigate injury and illness risk as well as inform the training program to ultimately optimise performance among their players (de Leeuw Aw, van der Zwaard S, et al., 2022; Timmerman et al., 2024), with a strong reliance on evidence published in the literature (Schwarz et al., 2021). Consequently, a nuanced understanding of match loads in consideration of these factors may allow volleyball coaches and practitioners to better tailor training, monitoring, and recovery protocols to the specific demands faced by their players.

The present review aimed to systematically synthesise the available evidence on the external and internal loads experienced during match-play in volleyball. A secondary aim was to examine how these loads vary based on key factors, including playing position, number of sets played, player sex, and competitive level. Additionally, where data permit, the review will explore variations in loads across sets, acknowledging that fatigue, tactical adjustments, and pacing strategies may alter demands throughout matches. Finally, this review also aims to identify the approaches and variables adopted to quantify match loads in volleyball, highlighting methodological inconsistencies and issues that should be rectified as well as gaps in the literature that warrant further investigation.

2. Methods

2.1. Registration and protocol

This systematic review was developed according to the Preferred Reporting Items for Systematic Reviews (PRISMA) guidelines (available in the Supplementary Material – Appendix 1) (Page et al., 2021) and prospectively registered on the International Platform of Registered Systematic Review and Meta-analysis

Protocols (registration number: INPLASY202570024). The protocol was published on 6 July 2025, and is accessible online (doi: 10.37766/inplasy2025.7.0024).

2.2. Eligibility criteria

Studies were selected based on predefined eligibility criteria grounded in a Population, Concept, and Context (PCC) framework tailored for observational research (Pollock et al., 2023). The population of interest included volleyball players of any age, sex, and competitive level, provided they participated in indoor volleyball match-play. Studies focused on beach (Bellinger et al., 2021) or sitting (Liang & Liang, 2023) volleyball were excluded due to the unique match loads these versions of the sport elicit.

The concept guiding study selection centered on the quantification of external and/or internal load during volleyball match-play. External load metrics that were considered eligible for inclusion encompassed jump count, jump height, total distance covered, accelerations, decelerations, movement velocities, spike or swing frequency and intensity, and other movement-derived variables captured with video tracking systems, IMUs, or local positioning systems (LPS). Eligible internal load metrics for inclusion comprised, but were not limited to, heart rate, blood lactate concentration, RPE, heart rate variability (HRV), and biochemical or hormonal markers. Studies reporting only technical-tactical outcomes without concurrent load metrics were excluded. Likewise, studies that reported loads only during training sessions or loads that were summated across training sessions and matches rather than distinctly in match-play (and not able to be provided by authors when contacted) were excluded.

Observational designs including cohort, case-control, and cross-sectional studies were eligible for inclusion. Studies with experimental interventions were only considered eligible if baseline match-play load data were reported independently and before the intervention. No restrictions were applied regarding the number of matches analysed per study. Only full-text studies published in peer-reviewed journals were considered, with conference abstracts, editorials, reviews, theses, preprints, or unpublished manuscripts excluded. Eligible studies had to be published in English, Portuguese (European or Brazilian), Spanish, or French. Studies published in other languages were excluded due to constraints in translation among the authors. When sufficient data were available, results were grouped and synthesised according to key factors including playing position, number of sets played, player sex, and competitive level.

2.3. Information sources

The literature search for this systematic review was conducted on 7 July 2025. Four electronic databases were searched including PubMed (National Center for Biotechnology Information), Scopus (Elsevier), SPORTDiscus (EBSCOhost), and Web of Science (Clarivate Analytics). All databases were searched from their inception to the date of the search. No restrictions were applied regarding the publication date during the search process.

2.4. Search strategy

The search strategy was structured using a combination of three conceptual components: (1) the sport of interest (volleyball), (2) the competitive context (match-play), and (3) relevant external and internal load metrics. The structure was conceptually framed to reflect the Population (volleyball players), Context (competitive matches), and Outcomes (external and internal load metrics) relevant to the review question. Key terms included in the search strategy were 'volleyball', 'match', 'match-play', 'competition', and 'game', in combination with terms such as 'heart rate', 'rating of perceived exertion', 'internal load', 'jump count', 'LPS', 'accelerometer', 'inertial measurement unit', and 'external load', among others. The complete search strategy for each database, including Boolean operators and syntax, is provided in Supplementary Material (Appendix 2).

2.5. Selection and data collection process

All records retrieved through the database searches were uploaded into CADIMA, a web-based tool for conducting systematic reviews. Duplicate entries were manually identified and removed by one author (AR) based on title, author names, and journal. The screening process then proceeded in two stages: (1) title/abstract screening and (2) full-text screening. Two authors (AR and DVM) independently screened all records/reports at each stage, with disagreements resolved through discussion or consultation with a third author (ATS) when necessary. During the full-text screening phase, some reports were identified as potentially eligible but lacked sufficient clarity or specificity in the reporting of match-play data. For instance, outcome data were sometimes reported only in figures, aggregated across training and match sessions, or presented over weekly or monthly periods. In such cases, corresponding authors were contacted via email (with co-authors copied in) between July 10–12, 2025, to request disaggregated match-specific data, ideally stratified by playing position and set. Reports were excluded if the necessary data could not be retrieved.

Data extraction was independently performed by the same two authors (AR and DVM). Any disagreements were resolved through discussion, with input from the remaining four authors (ES, AP-L, AL-S, and ATS) when necessary. Rather than using a pre-established standardised template, the authors developed the final data extraction structure based on the target tables intended for the manuscript. These table headings were informed by the Cochrane Consumers and Communication Review Group's recommendations to guide the collection of key information: participant characteristics (including player sex, age, body mass and height), competition details (competitive level and location), comparison groups, and reported outcomes. Positional classification followed conventional volleyball terminology used and recommended in the literature (Rebelo, Valente-dos-Santos, et al., 2025), namely: setter, opposite hitter, middle blocker, outside hitter, defensive specialist, and libero. The competitive level of participants was determined based on the framework proposed by McKay et al (McKay et al., 2022), which categorises players into five tiers considering their competition, training load, and professional status. For this review, high school and university players were classified as Tier 3 because they followed structured training schedules and competed regularly, although they were not engaged in full-time professional sport. Similarly, players competing in second divisions, or even in some first divisions from countries where they are not fully professional, were also classified as Tier 3. Players were classified as Tier 4 if they competed professionally on a full-time basis in high-level domestic leagues. Tier 5 classification was reserved for world-class players who competed in the most competitive international leagues or represented their countries at the highest level of competition, such as the Olympic Games or the Fédération Internationale de Volleyball (FIVB) Nations League.

2.6. Risk of bias assessment

The methodological quality and risk of bias of all included studies were assessed using the Observational Study Quality Evaluation (OSQE) tool (Drukker et al., 2021). This tool provides tailored versions for different types of observational study designs – cohort, case-control, and cross-sectional – each with distinct scoring structures and item content. During data extraction, the design of each included study was recorded to ensure the appropriate OSQE version was applied. Before commencing the risk of bias assessment, the information sheet accompanying the OSQE was completed as recommended by the developers. This sheet outlines how each item should be interpreted in the context of the current systematic review, based on its specific research objectives and inclusion criteria. This step was necessary to ensure consistency in the scoring process across studies and among authors. The finalised information sheet is provided in Supplementary Material (Appendix 3).

The OSQE cohort and case-control versions consist of 14 mandatory items and up to two optional items: one addressing effect modification (Item 15) and another evaluating sample size adequacy (Item 16). In contrast, the OSQE cross-sectional version is based on a subset of items (specifically, Items 1, 3, 4, 5, 12, 13, and 14), with Items 11, 15, and 16 considered optional. Each OSQE item was scored as 'Yes' (criterion fulfilled), 'No' (criterion not fulfilled), or 'Unknown'. A star system was used where the optimal response to an item earned one star. Item 1 was an exception – it was only awarded a star if all its sub-criteria were met, reflecting high standards in internal/external validity, selection transparency, and dropout handling. All optional items were considered during this review. While the OSQE generates a numerical score based on stars, the tool developers emphasize the interpretive weight of the qualitative comments and explanation fields (Drukker et al., 2021). Accordingly, our assessment emphasized critical domains such as outcome measurement, representativeness, confounding control, and completeness of reporting. Two authors (AR and DVM) independently assessed the risk of bias for each included study. Discrepancies were resolved through discussion or adjudicated by a third author (ATS) when necessary.

2.7. Synthesis methods

All studies that met the inclusion criteria were considered eligible for narrative synthesis. Given the high degree of heterogeneity in the outcome measures included, data reporting formats, and descriptive statistics utilised, a meta-analysis was not feasible. Therefore, we opted for a descriptive synthesis of findings.

Data were extracted and organized into structured tables to enable meaningful comparison across studies. Separate synthesis tables were developed to present external and internal load outcomes, with results reported either per match or per set, depending on data availability. When sufficient detail was provided, we further categorised results based on the number of sets played – namely, three-set, four-set, and five-set matches. Where possible, outcomes were also disaggregated according to playing position.

Due to substantial heterogeneity in study designs, reporting formats, and metric definitions, formal meta-analysis was not feasible. Therefore, a narrative synthesis approach was adopted. In accordance with best-practice guidance for synthesis without meta-analysis (Campbell et al., 2020), when multiple studies reported the same metric in comparable units and under the same contextual conditions (i.e., identical playing position and sex), we calculated simple arithmetic unweighted mean values to present a representative estimate. This descriptive pooling was limited to metrics consistently reported across studies, such as jump counts and sRPE. In circumstances where reporting was too heterogeneous to permit aggregation, we instead presented value ranges to illustrate variability across studies. These aggregated estimates are intended to support interpretability and applied practitioner use rather than serve as inferential meta-analytic outputs.

The synthesis was structured around outcome types (external and internal loads), key moderators (playing position, player sex, and competitive level), and data granularity (per match and per set). A dedicated table was constructed to summarize the types of devices used to measure external loads. Additionally, based on the synthesis tables, we identified methodological inconsistencies or issues, the most common outcome variables reported, and highlighted under-represented combinations of player samples and load measures to inform future research directions.

3. Results

3.1. Study selection

The search across four databases yielded a total of 2360 records: PubMed (n = 223), Scopus (n = 773), SPORTDiscus (n = 693), and Web of Science (n = 671). After the removal of 995 duplicate records, 1365 unique records were retained for title and abstract screening. No automation tools were used during this stage.

Of the 1365 records screened by title and abstract, 1294 were excluded for not meeting the eligibility criteria. The remaining 71 reports were retrieved for full-text evaluation. Interrater reliability during the screening phases was strong. At the title and abstract screening stage, the percent agreement between authors was 99.0%, with a kappa coefficient of 0.885, indicating almost perfect agreement. At the full-text screening stage, the percent agreement between authors was 94.4%, with a kappa coefficient of 0.765, reflecting substantial agreement.

Among the 71 full-text reports assessed, 14 were immediately excluded for the following reasons: 7 reports did not report load data during match-play (Hernández-Cruz et al., 2017; Kasabalis et al., 2005; Lima et al., 2023; R. F. Lima et al., 2022; Mroczek et al., 2011; Ribeiro et al., 2008; Tillman et al., 2004), 5 reports presented duplicate datasets already included in other studies (Edwards & Casto, 2013, 2015; Edwards & Kurlander, 2010; Hernández-Cruz et al., 2017; Roy et al., 2019), 1 report was not published in an accepted language (Sattler, 2020), and 1 report was a conference paper (Gielen et al., 2020). In turn, 13 of the remaining 57 reports were immediately included in the review (Akarçeşme et al., 2022; Akyildiz et al., 2022; González Millán et al., 2002; González et al., 2005; Hank et al., 2024; Hsieh et al., 2025; Lima et al., 2019; Pawlik & Mroczek, 2023; Rocha & Barbanti, 2007; Skazalski, Whiteley, & Bahr, 2018; Song et al., 2024; Vlantes & Readdy, 2017; Wang et al., 2025), with 44 reports (Altundag et al., 2022; Bouzigues et al., 2024; Cardoso et al., 2021; Clemente et al., 2019; de Alcaraz Ag et al., 2017; de Leeuw Aw, van Baar R, et al., 2022; Debien et al., 2018; Edwards & Turan, 2020; Filaire et al., 1997; Foster & Bunn, 2024; Freitas-Júnior et al., 2020; Gielen et al., 2022; Guthrie et al., 2023; Herring & Fukuda, 2022; Karaca et al., 2018; Kocabaş et al., 2018; Kupperman et al., 2021; Lima et al., 2021; R. Lima et al., 2022; Lima et al., 2024; Lin et al., 2024; Maciel Rabello et al., 2019; Mendes et al., 2018; Moreira et al., 2013; Mortatti et al., 2018; Muñoz & Bunn, 2024; Oliveira et al., 2024; Palao et al., 2024; Pawlik et al., 2020; Peñailillo et al., 2018; Piatti et al., 2022; Rebelo, Martinho, et al., 2024; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Rodríguez-Marroyo et al., 2014; Roy et al., 2020; Sheppard et al., 2009; Skazalski, Whiteley, Hansen, et al., 2018; Souglis et al., 2015; Taylor et al., 2019, 2022; Timoteo et al., 2021; Wnorowski et al., 2013; Wolfe et al., 2019) requiring additional clarification for inclusion by contacting the authors. Specifically, clarification was needed when data were aggregated across training and matches, reported without specifying the number of sets played, or presented without stratification by playing position. Out of these 44 reports, 15 studies were ultimately included in the review following clarification (de Alcaraz Ag et al., 2017; de Leeuw Aw, van Baar R, et al., 2022; Edwards & Turan, 2020; Freitas-Júnior et al., 2020; Gielen et al., 2022; Herring & Fukuda, 2022; Lima et al., 2021; R. Lima et al., 2022; Lima et al., 2024; Muñoz & Bunn, 2024; Rebelo, Martinho, et al., 2024; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Roy et al., 2020; Wolfe et al., 2019). A complete breakdown of the inclusion and exclusion decisions and communication timeline for all 71 reports is presented in Supplementary Material (Appendix 4).

In total, 28 studies were included in this systematic review (Akarçeşme et al., 2022; Akyildiz et al., 2022; de Alcaraz Ag et al., 2017; de Leeuw Aw, van Baar R, et al., 2022; Edwards & Turan, 2020; Freitas-Júnior et al., 2020; Gielen et al., 2022; González Millán et al., 2002; González et al., 2005; Hank et al., 2024; Herring & Fukuda, 2022; Hsieh et al., 2025; Lima et al., 2021; R. Lima et al., 2022; Lima et al., 2019, 2024; Muñoz & Bunn, 2024; Pawlik & Mroczek, 2023; Rebelo, Martinho, et al., 2024; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Rocha & Barbanti, 2007; Roy et al., 2020; Skazalski, Whiteley, & Bahr, 2018; Song et al., 2024; Vlantes & Readdy, 2017; Wang et al., 2025; Wolfe et al., 2019). Of these, 20 studies reported external loads (Akyildiz et al., 2022; de Alcaraz Ag et al., 2017; de Leeuw Aw, van Baar R, et al., 2022; Hank et al., 2024; Herring & Fukuda, 2022; Hsieh et al., 2025; Lima et al., 2021; R. Lima et al., 2022; Lima et al., 2019, 2024; Muñoz & Bunn, 2024; Pawlik & Mroczek, 2023; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Rocha & Barbanti, 2007; Skazalski, Whiteley, & Bahr, 2018; Song et al., 2024; Vlantes & Readdy, 2017; Wang et al., 2025; Wolfe et al., 2019), including jump-related metrics (n = 18) (Akyildiz et al., 2022; de Alcaraz Ag et al., 2017; de Leeuw Aw, van Baar R, et al., 2022; Herring & Fukuda, 2022; Hsieh et al., 2025; Lima et al., 2021; R. Lima et al., 2022; Lima et al., 2019, 2024; Muñoz & Bunn, 2024; Pawlik & Mroczek, 2023; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Rocha & Barbanti, 2007; Skazalski, Whiteley, & Bahr, 2018; Song et al., 2024; Vlantes & Readdy, 2017; Wang et al., 2025), speed, distance, acceleration, or deceleration metrics (n = 5) (Akyildiz et al., 2022; Hank et al., 2024; Song et al., 2024; Vlantes & Readdy, 2017; Wang et al., 2025), and arm swing data (n = 2) (de Alcaraz Ag et al., 2017; Wolfe et al., 2019). Fifteen studies examined internal loads (Akarçeşme et al., 2022; Akyildiz et al., 2022; de Leeuw Aw, van Baar R, et al., 2022; Edwards & Turan, 2020; Freitas-Júnior et al., 2020; Gielen et al., 2022; González Millán et al., 2002; González et al., 2005; Lima et al., 2021, 2024; Rebelo, Martinho, et al., 2024; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Roy et al., 2020; Song et al., 2024), which included session-RPE (sRPE) (n = 10) (Akyildiz et al., 2022; de Leeuw Aw, van Baar R, et al., 2022; Freitas-Júnior et al., 2020; Lima et al., 2021, 2024; Rebelo, Martinho, et al., 2024; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Roy et al., 2020; Song et al., 2024) and physiological markers (n = 5) (Akarçeşme et al., 2022; Edwards & Turan, 2020; Gielen et al., 2022; González Millán et al., 2002; González et al., 2005). All 10 studies assessing sRPE used the Borg CR10 scale; however, the timing of RPE collection following match-play varied across studies. More precisely, 6 studies did not specify the exact timing of RPE collection (Akyildiz et al., 2022; de Leeuw Aw, van Baar R, et al., 2022; Freitas-Júnior et al., 2020; Lima et al., 2024; Roy et al., 2020; Song et al., 2024), although 2 of these studies stated that ratings were obtained immediately after matches (Lima et al., 2024; Song et al., 2024). Among the remaining studies, 1 collected RPE 15 minutes post-match (Rebelo, Pereira, Broek, et al., 2025), 1 collected RPE 30 minutes post-match (Lima et al., 2021), 1 collected RPE 10–30 minutes post-match (Rebelo, Martinho, et al., 2024), and 1 collected RPE 15–20 minutes post-match (Rebelo, Pereira, Martinho, Amorim, et al., 2023). Among the physiological measures, heart rate (n = 3) (Akarçeşme et al., 2022; Gielen et al., 2022; González et al., 2005), blood lactate concentration (n = 2) (Akarçeşme et al., 2022; González Millán et al., 2002), and hormonal markers (n = 1) (Edwards & Turan, 2020) were reported. A visual summary of the study selection process is provided in the PRISMA flow diagram (Figure 1).

3.2. Study characteristics

The 28 studies included in this review comprised a similar distribution of male and female samples, with 15 studies recruiting male players (de Alcaraz Ag et al., 2017; de Leeuw Aw, van Baar R, et al., 2022; Gielen et al., 2022; González Millán et al., 2002; González et al., 2005; Hsieh et al., 2025; Lima et al., 2019, 2021, 2024; Pawlik & Mroczek, 2023; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Skazalski, Whiteley, & Bahr, 2018; Song et al., 2024; Wang et al., 2025) and 13 studies recruiting female players (Akarçeşme et al., 2022; Akyildiz et al., 2022; Edwards & Turan, 2020; Hank et al., 2024; Herring & Fukuda, 2022; R. Lima et al., 2022; Muñoz & Bunn, 2024; Pawlik & Mroczek, 2023; Rebelo, Martinho, et al., 2024; Rocha & Barbanti, 2007; Roy et al., 2020; Vlantes & Readdy, 2017; Wolfe et al., 2019). When classified by competitive level, most studies involved players competing at Tier 3 (n = 15) (de Alcaraz Ag et al., 2017; Edwards & Turan, 2020; Gielen et al., 2022; González Millán et al., 2002; González et al., 2005; Herring & Fukuda, 2022; Hsieh et al., 2025; Lima et al., 2021; R. Lima et al., 2022; Lima et al., 2019, 2024; Muñoz & Bunn, 2024; Roy et al., 2020; Vlantes & Readdy, 2017; Wolfe et al., 2019), followed by Tier 4 (n = 13) (Akarçeşme et al., 2022; de Alcaraz Ag et al., 2017; de Leeuw Aw, van Baar R, et al., 2022; Gielen et al., 2022;

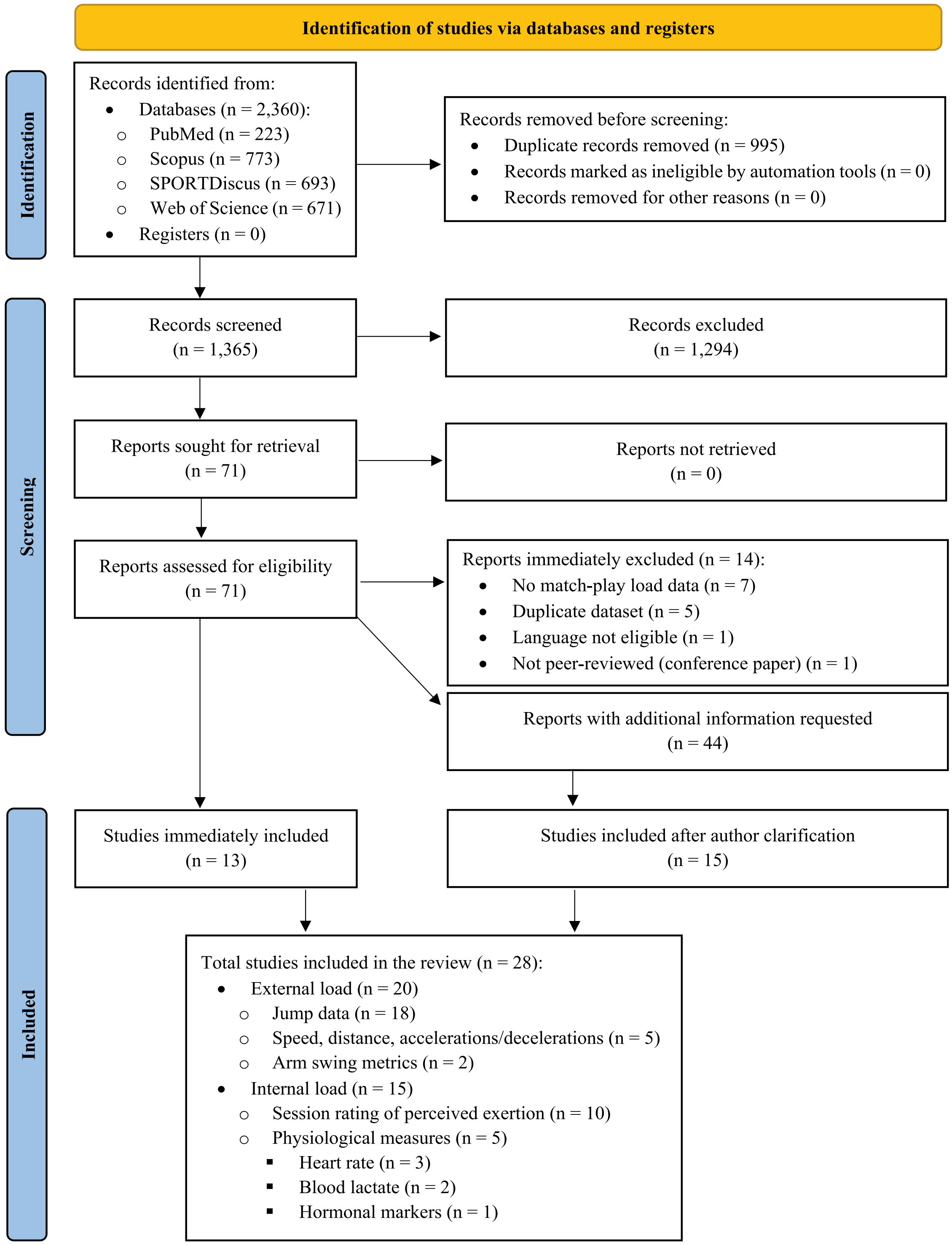


Figure 1. PRISMA flow diagram for this systematic review.

Hank et al., 2024; Pawlik & Mroczek, 2023; Rebelo, Martinho, et al., 2024; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Rocha & Barbanti, 2007; Skazalski, Whiteley, & Bahr, 2018; Song et al., 2024; Wang et al., 2025), and Tier 5 (n = 5) (Akarçeşme et al., 2022; Akyildiz et al., 2022; de Alcaraz Ag et al., 2017; Hank et al., 2024; Pawlik & Mroczek, 2023). In this way, several studies investigated high school and collegiate players (Edwards & Turan, 2020; Herring & Fukuda, 2022; Muñoz & Bunn, 2024; Roy et al., 2020; Vlantes & Readdy, 2017; Wolfe et al., 2019). Two studies included female high school players in the United States (Edwards & Turan, 2020; Muñoz & Bunn, 2024), while 3 studies examined female college players in the United States (Herring & Fukuda, 2022; Vlantes & Readdy, 2017; Wolfe et al., 2019) and 1 additional study focused on female college players in Canada (Roy et al., 2020). At the national league level, competitions in Portugal were the most represented, with 5 studies examining male players from the Portuguese First Division (Lima et al., 2019, 2021, 2024; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023) and 2 studies assessing female players from the same competition (R. Lima et al., 2022; Rebelo, Martinho, et al., 2024). In turn, 3 studies analysed male players competing in the Spanish First Division (de Alcaraz Ag et al., 2017; González Millán et al., 2002; González et al., 2005), 2 studies examined female players from the Turkish First Division (Akarçeşme et al., 2022; Akyildiz et al., 2022), and 2 studies involved players participating in the European Volleyball Confederation (CEV) Women's Champions League (Akyildiz et al., 2022; Hank et al., 2024). Additionally, single studies were conducted with players from the Brazilian Women's First Division (Rocha & Barbanti, 2007), the Olympic Games (men) (de Alcaraz Ag et al., 2017), national team competitions (de Leeuw Aw, van Baar R, et al., 2022), the Polish Women's and Men's First Divisions (Pawlik & Mroczek, 2023), the Belgian Men's First and Second Divisions (Gielen et al., 2022), the South Korean Men's First Division (Song et al., 2024), the Qatari Men's First Division (Skazalski, Whiteley, & Bahr, 2018), and the Taiwanese Men's First Division (Hsieh et al., 2025).

3.3. Risk of bias in studies

Risk of bias was assessed for all 28 included studies using the OSQE tool according to their design: cross-sectional (n = 8) (Akarçeşme et al., 2022; de Alcaraz Ag et al., 2017; González Millán et al., 2002; González et al., 2005; Hank et al., 2024; Lima et al., 2019; Rocha & Barbanti, 2007; Vlantes & Readdy, 2017) or cohort (n = 20) (Akyildiz et al., 2022; de Leeuw Aw, van Baar R, et al., 2022; Edwards & Turan, 2020; Freitas-Júnior et al., 2020; Gielen et al., 2022; Herring & Fukuda, 2022; Hsieh et al., 2025; Lima et al., 2021; R. Lima et al., 2022; Lima et al., 2024; Muñoz & Bunn, 2024; Pawlik & Mroczek, 2023; Rebelo, Martinho, et al., 2024; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Roy et al., 2020; Skazalski, Whiteley, & Bahr, 2018; Song et al., 2024; Wang et al., 2025; Wolfe et al., 2019). The detailed scoring and justification for each study are presented in Supplementary Material (Appendix 5).

Across the 8 cross-sectional studies, OSQE scores ranged from 5 (González Millán et al., 2002; González et al., 2005; Lima et al., 2019) to 8 (Hank et al., 2024) out of a maximum of 10 stars. The most frequent limitations among these studies related to comparability and control for confounding. Specifically, none of the cross-sectional studies received stars for the two items addressing whether statistical analyses controlled for relevant confounders and whether reporting followed a predefined analysis protocol. Additionally, 1 study received a veto on representativeness due to an inadequately defined sample and unclear inclusion criteria (González Millán et al., 2002).

Among the 20 cohort studies, total scores ranged from 10 (Gielen et al., 2022; Hsieh et al., 2025; Lima et al., 2021, 2024; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Roy et al., 2020) to 14 (de Leeuw Aw, van Baar R, et al., 2022; Rebelo, Martinho, et al., 2024; Rebelo, Pereira, Broek, et al., 2025) stars out of a possible 16. The most common sources of bias among these studies were again related to confounding and selective reporting. Fifteen (Akyildiz et al., 2022; Freitas-Júnior et al., 2020; Gielen et al., 2022; Herring & Fukuda, 2022; Hsieh et al., 2025; Lima et al., 2021; R. Lima et al., 2022; Lima et al., 2024; Muñoz & Bunn, 2024; Pawlik & Mroczek, 2023; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Roy et al., 2020; Skazalski, Whiteley, & Bahr, 2018; Song et al., 2024; Wang et al., 2025) of the 20 cohort studies did not receive stars for the two corresponding OSQE items evaluating whether confounders were appropriately controlled and whether analyses were transparently pre-specified.

3.4. Results of synthesis

3.4.1. Devices and technologies used to quantify external load

Twenty included studies reported external load metrics during volleyball match-play using various technologies, which are summarised in Table 1. Eleven studies used IMUs, specifically the Vert device (Mayfonk Athletic, Fort Lauderdale, FL, USA), to quantify external load (de Leeuw Aw, van Baar R, et al., 2022; Herring & Fukuda, 2022; Hsieh et al., 2025; Lima et al., 2021; R. Lima et al., 2022; Lima et al., 2019, 2024; Muñoz & Bunn, 2024; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Skazalski, Whiteley, & Bahr, 2018). Five studies relied on video-based analysis to derive external load metrics (de Alcaraz Ag et al., 2017; Hank et al., 2024; Pawlik & Mroczek, 2023; Rocha & Barbanti, 2007; Wolfe et al., 2019), encompassing manual or semi-automated tracking of jump count (de Alcaraz Ag et al., 2017; Rocha & Barbanti, 2007), jump height estimation (Pawlik & Mroczek, 2023), total distance covered (Hank et al., 2024), and the number of arm swings (de Alcaraz Ag et al., 2017; Wolfe et al., 2019). The specific video systems and procedures varied among studies,

Table 1. Devices and technologies used to assess external load across the included studies.

Study	Location/Competition	Sex	Competitive level	Device
Hank et al. (2024)	Europe/CEV Champions League	F	Tier 4/5	Video camera (HDC90E; Sony Ltd., Tokyo, Japan; 50 fps; 1920 × 1,080 pix)
Pawlik & Mroczek (2023)	Poland/1st Division	M/F	Tier 4/5	Video camera
de Leeuw et al. (2022)	Netherlands/National Team	M	Tier 4	IMU (Vert, Mayfonk Athletic, Fort Lauderdale, FL, USA)
Lima et al. (2022)	Portugal/1st Division	F	Tier 3	IMU (Vert, Mayfonk Athletic, Fort Lauderdale, FL, USA)
Wang et al. (2025)	South Korea/1st Division	M	Tier 4	LPS (Catapult Vector S7, Catapult Sports, Melbourne, VIC, Australia)
Rebelo et al. (2023)	Portugal/1st Division	M	Tier 4	IMU (Vert, Mayfonk Athletic, Fort Lauderdale, FL, USA)
Hsieh et al. (2025)	Taiwan/1st Division	M	Tier 3	IMU (Vert, Mayfonk Athletic, Fort Lauderdale, FL, USA)
Song et al. (2024)	South Korea/1st Division	M	Tier 4	LPS (Catapult Vector S7, Catapult Sports, Melbourne, VIC, Australia)
Lima et al. (2024)	Portugal/1st Division	M	Tier 3	IMU (Vert, Mayfonk Athletic, Fort Lauderdale, FL, USA)
Rocha and Barbanti, (2007)	Brazil/1st Division	F	Tier 4	Video camera (Panasonic, VHS-C, NV-R500)
Rebelo et al. (2025)	Portugal/1st Division	M	Tier 4	IMU (Vert, Mayfonk Athletic, Fort Lauderdale, FL, USA)
Muñoz and Bunn, (2024)	USA/High School	F	Tier 3	IMU (Vert, Mayfonk Athletic, Fort Lauderdale, FL, USA)
Akyildiz et al. (2022)	Turkey/1st Division	F	Tier 5	LPS (Kinexon, GMBH, Precision Technologies, Kinexon One, Munich, Germany)
de Alcaraz et al. (2017)	Spain/1st Division/Olympics	M	Tier 3/4/5	Video camera
Lima et al. (2021)	Portugal/1st Division	M	Tier 3	IMU (Vert, Mayfonk Athletic, Fort Lauderdale, FL, USA)
Skazalski et al. (2018)	Qatar/1st Division	M	Tier 4	IMU (Vert, Mayfonk Athletic, Fort Lauderdale, FL, USA)
Lima et al. (2019)	Portugal/1st Division	M	Tier 3	IMU (Vert, Mayfonk Athletic, Fort Lauderdale, FL, USA)
Wolfe et al. (2019)	USA/Collegiate	F	Tier 3	Video camera
Vlantes and Readdy, (2017)	USA/Collegiate	F	Tier 3	GNSS (Optimeye S5, Catapult Sports, Melbourne, VIC, Australia)
Herring and Fukuda, (2022)	USA/Collegiate	F	Tier 3	IMU (Vert, Mayfonk Athletic, Fort Lauderdale, FL, USA)

F = female; fps = frames per second; GNSS = global navigation satellite system; IMU = inertial measurement unit; LPS = local positioning system; M = male.

although all used recorded match footage for retrospective analysis.

The remaining 4 studies used a global navigation satellite system (GNSS) (Vlantes & Readdy, 2017) or a LPS to quantify movement and impact-based demands (Akyildiz et al., 2022; Song et al., 2024; Wang et al., 2025). These systems provided data on jump count (Song et al., 2024; Vlantes & Readdy, 2017; Wang et al., 2025), jump height (Song et al., 2024; Wang et al., 2025), player load (Vlantes & Readdy, 2017), maximum speed, and frequency of accelerations and decelerations (Song et al., 2024; Vlantes & Readdy, 2017; Wang et al., 2025). Used systems were produced either by Catapult (Song et al., 2024; Vlantes & Readdy, 2017; Wang et al., 2025) or Kinexon (Akyildiz et al., 2022).

3.4.2. External load per set and playing position

Across the 11 studies that reported external load per set (Table 2), 6 studies focused specifically on female volleyball players from various competitive levels (Hank et al., 2024; R. Lima et al., 2022; Muñoz & Bunn, 2024; Pawlik & Mroczek, 2023; Vlantes & Readdy, 2017; Wolfe et al., 2019). Across different competitive levels, setters consistently recorded the highest jump counts per set (Muñoz & Bunn, 2024; Vlantes & Readdy, 2017). When jump height was assessed, outside hitters generally showed the highest values, followed by opposite hitters, middle blockers, and setters (R. Lima et al., 2022). Explosive efforts were less commonly reported, with middle blockers executing the most (Vlantes & Readdy, 2017). Arm swing metrics were only assessed in 1 study, with outside hitters performing the most swings (Wolfe et al., 2019).

Among male players, 6 studies reported external load metrics per set (de Alcaraz Ag et al., 2017; Hsieh et al., 2025; Lima et al., 2019; Pawlik & Mroczek, 2023; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Wang et al., 2025). Setters generally recorded the most jumps per set, followed by middle blockers and outside/opposite hitters (Lima et al., 2019; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Wang et al., 2025). When jump height was considered, middle blockers and outside/opposite hitters typically performed the most high jumps (> 50 cm), while setters led in medium jumps (30–50 cm) (Rebelo, Pereira, Martinho, Amorim, et al., 2023; Wang et al., 2025). Notably, liberos recorded relatively high explosive efforts (i.e., registered when there is an acceleration performed in X or Y axes > 3.5 $m{\cdot}s^{-2}$), surpassing all other playing positions (Pawlik & Mroczek, 2023).

3.4.3. Internal load per set

Three studies reported internal load metrics separately for each set (Akarçeşme et al., 2022; González Millán et al., 2002; González et al., 2005), with data presented in Table 3. Among Tier 4/5 female players, Akarçeşme et al. (Akarçeşme et al., 2022) showed blood lactate concentrations increased from the first to the second

Table 2. External load metrics reported per set during volleyball match-play across included studies.

Study	Location/Competition	Sex	Age (years)	Body mass (kg)	Height (cm)	Competitive level	N	Playing position	Jumps count *All*	Jumps count *Low (10–30 cm)*	Jumps count *Medium (30–50 cm)*	Jumps count *High (> 50 cm)*
Wang et al. (2025)	South Korea/1st Division	M	24.5 ± 5.5	76.7 ± 2.2	187.0 ± 3.4	Tier 4	4	S	27.4 ± 4.3	2.0 ± 1.8	15.7 ± 3.2	9.7 ± 2.4
			27.8 ± 3.6	86.1 ± 5.7	195.5 ± 4.5		8	OH/OPP	21.1 ± 3.9	4.6 ± 3.9	2.8 ± 1.6	13.7 ± 3.6
			29.6 ± 4.7	90.8 ± 4.4	199.8 ± 3.1		6	MB	22.4 ± 4.8	3.7 ± 2.3	4.1 ± 2.0	14.7 ± 3.8
			26.7 ± 4.6	59.5 ± 1.9	172.0 ± 6.7		3	L	3.5 ± 1.5	2.6 ± 1.3	0.8 ± 0.5	0.1 ± 0.1
Rebelo et al. (2023)	Portugal/1st Division	M	26.3 ± 5.8	79.0 ± 13.8	188.3 ± 3.4	Tier 4	3	S	29.6 ± 4.4	7.9 ± 1.9	18.4 ± 4.2	3.4 ± 1.4
			29.6 ± 5.8	92.8 ± 4.8	198.5 ± 0.5		2	OPP	21.5 ± 4.9	1.9 ± 2.0	5.3 ± 1.3	14.3 ± 2.9
			27.8 ± 4.1	99.1 ± 8.0	201.5 ± 5.6		4	MB	25.1 ± 4.1	1.8 ± 1.5	7.0 ± 3.5	16.3 ± 4.6
			29.7 ± 5.6	89.5 ± 3.2	194.0 ± 4.3		4	OH	20.5 ± 4.4	3.5 ± 1.9	3.8 ± 1.6	13.2 ± 2.7
Muñoz & Bunn (2024)	USA/High School	F	16.5 ± 0.9	1.9 ± 0.6	177 ± 9	Tier 3	1	S	34.8 ± NR			0.3 ± NR
							2	OPP	21.7 ± 0.3			2.0 ± 2.5
							3	MB	14.1 ± 13.3			3.6 ± 3.1
							5	OH	10.9 ± 5.3			3.2 ± 1.6
							1	DS	14.7 ± NR			0.1 ± NR
de Alcaraz et al. (2017)	Spain/Under-14	M	NR	NR	NR	Tier 3	NR	All	113.5 ± 29.3#			
	Spain/Under-16					Tier 3			160.8 ± 27.5#			
	Spain/Under-19					Tier 3			162.6 ± 23.0#			
	Spain/1st Division					Tier 4			188.0 ± 24.7#			
	Olympic Games					Tier 5			181.3 ± 16.6#			
Lima et al. (2019)	Portugal/1st Division	M	26.7 ± 7.2	86.5 ± 6.3	193 ± 8	Tier 3	1	S	31.7 ± NR			
							3	MB	20.7 ± NR			
							3	OH	13.3 ± NR			
Vlantes & Readdy (2017)	USA/Collegiate	F	20.0 ± NR	69.4 ± NR	179.0 ± NR	Tier 3	1	S	42.8 ± 10.0			
							2	MB	30.0 ± 8.7			
							6	OH	16.0 ± 7.0			
							2	DS	8.3 ± 3.5			
Study	**Location/ Competition**	**Sex**	**Age (y)**	**Body mass (kg)**	**Height (cm)**	**Competitive level**	**N**	**Playing position**	*All*	**Average jump height (cm)** *Serve*	*Spike*	*Block*
Pawlik & Mroczek (2023)	Poland/1st Division	M	NR	91.7 ± 8.3	201.5 ± 5.7	Tier 4/5	39	All		62.9 ± 19.6	70.3 ± 18.7	53.2 ± 19.8
		F	NR	74.5 ± 7.1	185.8 ± 6.2					38.3 ± 14.8	46.4 ± 14.2	41.6 ± 14.2
Lima et al. (2022)	Portugal/1st Division	F	24.1 ± 6.1	66.5 ± 6.9	175.4 ± 6.5	Tier 3	2	S	33.6 ± NR			
							2	OPP	43.2 ± NR			
							3	MB	40.9 ± NR			
							3	OH	47.5 ± NR			
Hsieh et al. (2025)	Taiwan/1st Division	M	25.4 ± 3.1	81.0 ± 5.6	187 ± 5	Tier 3	1	S	49.3 ± 1.6			
							3	MB	59.9 ± 5.2			
							5	OH	57.4 ± 6.7			
Lima et al. (2019)	Portugal/1st Division	M	26.7 ± 7.2	86.5 ± 6.3	193 ± 8	Tier 3	1	S	45 ± 14	54 ± 10	55 ± 7	58 ± 10
							3	MB	55 ± 15	41 ± 14	65 ± 12	53 ± 12
							3	OH	58 ± 12	52 ± 16	68 ± 12	58 ± 12
Study	**Location/ Competition**	**Sex**	**Age (y)**	**Body mass (kg)**	**Height (cm)**	**Competitive level**	**N**	**Playing position**	**Player load (AU)**	**Explosive efforts (N) All axes**	**X and/or Y axes**	**Arm swings**
Wang et al. (2025)	South Korea/1st Division	M	24.5 ± 5.5	76.7 ± 2.2	187.0 ± 3.4	Tier 4	4	S		12.9 ± 2.8	3.2 ± 1.1	
			27.8 ± 3.6	86.1 ± 5.7	195.5 ± 4.5		8	OH/OPP		19.6 ± 4.2	5.9 ± 3.4	
			29.6 ± 4.7	90.8 ± 4.4	199.8 ± 3.1		6	MB		19.1 ± 5.8	4.4 ± 3.0	
			26.7 ± 4.6	59.5 ± 1.9	172.0 ± 6.7		3	L		7.8 ± 1.6	7.8 ± 1.7	

(*Continued*)

Table 2. (Continued).

Study	Location/Competition	Sex	Age (years)	Body mass (kg)	Height (cm)	Competitive level	N	Playing position	Jumps count			
									All	*Low (10–30 cm)*	*Medium (30–50 cm)*	*High (> 50 cm)*
de Alcaraz et al. (2017)	Spain/Under-14	M	NR	NR	NR	Tier 3	NR	All				95.5 ± 15.3#
	Spain/Under-16					Tier 3						101.3 ± 16.2#
	Spain/Under-19					Tier 3						98.0 ± 13.3#
	Spain/1st Division					Tier 4						101.3 ± 14.0#
	Olympic Games					Tier 5						98.8 ± 10.0#
Wolfe et al. (2019)	USA/Collegiate	F	19 ± 1	73.5 ± 9.4	180 ± 8	Tier 3	3	S				5.3 ± 3.2
							4	MB				5.8 ± 2.0
							7	OH				10.7 ± 3.7
Vlantes & Readdy (2017)	USA/Collegiate	F	20.0 ± NR	69.4 ± NR	179.0 ± NR	Tier 3	1	S	110.0 ± 19.5	8.3 ± 2.6*	3.5 ± 2.0	
							2	MB	76.0 ± 14.1	11.3 ± 4.3*	6.3 ± 3.3	
							6	OH	73.8 ± 18.3	6.5 ± 3.6*	3.8 ± 2.7	
							2	DS	80.3 ± 21.1	1.0 ± 1.1*	3.0 ± 2.6	

DS = defensive specialist; F = female; L = libero; M = male; MB = middle blocker; NR = not reported; OH = outside hitter; OPP = opposite hitter; S = setter.
Note: Explosive efforts determined across all axes and for X and Y axes were registered when > 3.5 m·s^{-2}. * indicates these data are reflective of high-impact player load (AU) rather than a count of explosive efforts and encompasses only accelerations > 2.5 m·s^{-2}. # indicates these data are reflective of all playing positions summed together rather than per individual player.

set in all positions, peaking notably in liberos (7.0 ± 5.2 mmol·L^{-1} in set two) before decreasing in the third set. In male Tier 3 players, González Millán et al. (González Millán et al., 2002) reported stable blood lactate concentrations across four sets, with values for middle blockers ranging between 3.6–4.4 mmol·L^{-1} and slightly lower values for liberos (3.1–3.7 mmol·L^{-1}). Heart rate also tended to rise across sets for setters and outside or opposite hitters, whereas liberos showed the highest heart rate in the first set (147 ± 13 beats·min^{-1}), which then slightly decreased in subsequent sets (Akarçeşme et al., 2022). Fpr male Tier 3 players, González et al. (González et al., 2005) observed that middle blockers had the highest heart rate in the second set (156 ± 13 beats·min^{-1}), compared with the other sets. Liberos maintained a relatively stable heart rate across all four sets, averaging between 135–139 beats·min^{-1}.

3.4.4. External and internal load in 3-set, 4-set, and 5-set matches

In 3-set matches, male Tier 3 and 4 players showed positional differences in jump demands (Table 4). Setters recorded the most jumps (≈66–126), followed by middle blockers, outside hitters (≈60–90), and opposite hitters (≈38–60), while liberos consistently performed the fewest (< 21) (Lima et al., 2024; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Skazalski, Whiteley, & Bahr, 2018; Song et al., 2024; Wang et al., 2025). Setters led in medium jumps (30–50 cm), typically exceeding 30 per match, while middle blockers and opposite hitters performed the most high jumps (> 50 cm), often surpassing 25 (Rebelo, Pereira, Martinho, Amorim, et al., 2023; Song et al., 2024; Wang et al., 2025).

In 3-set matches, female setters recorded the most jumps (≈140–200), followed by middle blockers (≈95–-117), opposite hitters (≈102), and outside hitters (≈60–-87) (Rocha & Barbanti, 2007; Skazalski, Whiteley, & Bahr, 2018). Defensive specialists and liberos consistently performed the fewest jumps (< 35) (Akyildiz et al., 2022; Vlantes & Readdy, 2017). The only study reporting jump height in female players across 3-set matches, found outside hitters exhibited the highest average output (≈52 cm), followed by middle blockers (≈48 cm) and opposite hitters (≈45 cm) (Herring & Fukuda, 2022).

Four studies reported non-jumping external load metrics in 3-set matches (Table 5) (Akyildiz et al., 2022; Song et al., 2024; Vlantes & Readdy, 2017; Wang et al., 2025). In male Tier 4 play, setters performed 37–43 explosive efforts, while middle blockers and outside/opposite hitters often exceeded 56 (Song et al., 2024; Wang et al., 2025). In female Tier 5 competition, outside and opposite hitters covered the most distance (≈3400

Table 3. Internal load metrics reported per set during volleyball match-play across included studies.

Study	Location/ Competition	Sex	Age (years)	Body mass (kg)	Height (cm)	Competitive level	N	Playing position	Blood lactate concentration (mmol·L^{-1})				Heart rate (beats·min^{-1})						
													Maximum			Average			
									1st Set	2nd Set	3rd Set	4th Set	1st Set	2nd Set	3rd Set	1st Set	2nd Set	3rd Set	4th Set
Akarçeşme et al. (2022)	Turkey/1st Division	F	22.2 ± 2.6	61.3 ± 5.2	180.2 ± 2.6	Tier 4/5	6	S	1.5 ± 0.3	3.1 ± 1.5	2.2 ± 1.0		121 ± NR	148 ± NR	136 ± NR	98 ± 11	97 ± 29	108 ± 27	
			21.8 ± 1.5	67.6 ± 2.9	183.7 ± 6.0		6	OH/OPP	1.4 ± 0.5	2.0 ± 1.1	3.0 ± 2.7		171 ± NR	189 ± NR	211 ± NR	115 ± 32	128 ± 45	128 ± 23	
			22.5 ± 2.0	68.5 ± 7.6	183.8 ± 4.8		6	MB	1.7 ± 0.5	3.2 ± 2.7	3.0 ± 2.8		196 ± NR	186 ± NR	162 ± NR	126 ± 32	126 ± 32	125 ± 19	
			20.5 ± 1.7	59.5 ± 1.9	172.0 ± 6.7		6	L	1.9 ± 0.6	7.0 ± 5.2	2.0 ± 1.7		172 ± NR	179 ± NR	166 ± NR	147 ± 13	141 ± 31	118 ± 34	
González Millán et al. (2002)	Spain/1st Division	M	24.3 ± NR	84.3 ± NR	188 ± NR	Tier 3	10	MB	4.4 ± 1.2	3.8 ± 0.7	3.6 ± 1.5	4.0 ± 1.7							
			27.2 ± NR	76.5 ± NR	180 ± NR		10	L	3.7 ± 1.9	3.1 ± 1.3	3.1 ± 1.5	3.1 ± 1.8							
González et al. (2005)	Spain/1st Division	M	24.3 ± NR	84.3 ± NR	188 ± NR	Tier 3	10	MB								148 ± 16	156 ± 13	149 ± 14	142 ± 18
			27.2 ± NR	76.5 ± NR	180 ± NR		10	L								137 ± 17	139 ± 18	135 ± 15	136 ± 15

F = female; L = libero; M = male; MB = middle blocker; NR = not reported; OH = outside hitter; OPP = opposite hitter; S = setter.

Table 4. External jump load metrics reported during 3-set volleyball matches across included studies.

Study	Location/Competition	Sex	Age (years)	Body mass (kg)	Height (cm)	Competitive level	N	Playing position	Jumps (count)				Average jump height (cm)
									All	Low (10–30 cm)	Medium (30–50 cm)	High (> 50 cm)	
Wang et al. (2025)	South Korea/1st Division	M	24.5 ± 5.5	76.7 ± 2.2	187.0 ± 3.4	Tier 4	4	S	78.7 ± 16.3	7.0 ± 8.5	44.5 ± 13.1	27.2 ± 9.3	
			27.8 ± 3.6	86.1 ± 5.7	195.5 ± 4.5		8	OH/OPP	62.1 ± 14.0	13.2 ± 11.7	8.9 ± 5.7	40.0 ± 12.0	
			29.6 ± 4.7	90.8 ± 4.4	199.8 ± 3.1		6	MB	69.0 ± 16.3	11.6 ± 8.2	13.1 ± 6.2	44.4 ± 12.6	
			26.7 ± 4.6	59.5 ± 1.9	172.0 ± 6.7		3	L	10.9 ± 4.2	8.0 ± 3.1	2.8 ± 1.8	0.2 ± 0.4	
Rebelo et al. (2023)	Portugal/1st Division	M	26.3 ± 5.8	79.0 ± 13.8	188.3 ± 3.4	Tier 4	3	S	66.7 ± 3.4	16.7 ± 1.2	34.7 ± 2.1	15.3 ± 2.1	
			29.6 ± 5.8	92.8 ± 4.8	198.5 ± 0.5		2	OPP	48.7 ± 2.1	7.0 ± 0.8	15.7 ± 1.2	26.0 ± 1.6	
			27.8 ± 4.1	99.1 ± 8.0	201.5 ± 5.6		4	MB	70.8 ± 14.5	6.0 ± 3.5	24.0 ± 12.7	40.8 ± 10.0	
			29.7 ± 5.6	89.5 ± 3.2	194.0 ± 4.3		4	OH	60.5 ± 5.5	7.5 ± 0.5	8.5 ± 3.5	44.5 ± 2.5	
Song et al. (2024)	South Korea/1st Division	M	28.2 ± 4.4	84.5 ± 10.7	191.4 ± 9.8	Tier 4	3	S	126.3 ± 34.3	28.8 ± 10.9	68.4 ± 20.6	29.2 ± 12.9	
							8	OH/OPP	78.6 ± 19.7	31.1 ± 15.7	9.2 ± 6.8	38.3 ± 21.5	
							5	MB	87.9 ± 29.8	24.9 ± 11.5	18.1 ± 8.8	45.0 ± 20.4	
							3	L	20.6 ± 6.7	16.4 ± 5.8	4.2 ± 2.1	1.1 ± 0.3	
de Leeuw et al. (2022)	Netherlands/National Team	M	27.0 ± 3.0	91.2 ± 6.4	200 ± 1.0	Tier 4	2	S	121.0 ± 11.0				39.8 ± 8.7
							2	OPP	77.0 ± NR				56.4 ± 18.8
							5	MB	76.3 ± 17.0				54.0 ± 12.7
							6	OH	62.5 ± 5.5				55.4 ± 13.0
Lima et al. (2024)	Portugal/1st Division	M	20.4 ± 6.3	82.8 ± 5.5	191.6 ± 7.6	Tier 3	2	S	68.2 ± NR				62.3 ± NR
							2	OPP	38.1 ± NR				71.5 ± NR
							3	MB	62.1 ± NR				66.7 ± NR
							4	OH	69.7 ± NR				70.3 ± NR
Rebelo et al. (2025)	Portugal/1st Division	M	34.8 ± 0.3	86.7 ± 0.9	191.0 ± 2.0	Tier 4	2	S	87.3 ± 19.4				
			27.1 ± 3.4	90.1 ± 10.6	196.5 ± 0.5		2	OPP	60.0 ± 8.3				
			27.8 ± 6.2	100.4 ± 9.5	202.8 ± 8.0		4	MB	76.9 ± 13.1				
			28.7 ± 2.2	90.8 ± 2.6	193.3 ± 2.3		4	OH	58.7 ± 12.2				
			25.2 ± 3.5	77.2 ± 5.5	178.0 ± 2.0		2	L	8.5 ± 8.2				

(Continued)

Table 4. (Continued).

Study	Location/Competition	Sex	Age (years)	Body mass (kg)	Height (cm)	Competitive level	N	Playing position	Jumps (count)				Average jump height (cm)
									All	Low (10–30 cm)	Medium (30–50 cm)	High (> 50 cm)	
Akyildiz et al. (2022)	Turkey/1st Division	F	22 ± 0.9	71.4 ± 6.3	195.1 ± 7.6	Tier 5	2	S	139.6 ± 37.4				
							2	OPP	102.3 ± 26.6				
							4	MB	95.0 ± 30.8				
							4	OH	87.4 ± 21.7				
							2	L	10.6 ± 4.8				
Lima et al. (2021)	Portugal/1st Division	M	21.7 ± 4.2	85.7 ± 8.7	192.4 ± 6.3	Tier 3	2	S					43.6 ± NR
							2	OPP					47.9 ± NR
							3	MB					54.3 ± NR
							3	OH					57.8 ± NR
Skazalski et al. (2018)	Qatar/1st Division	M	NR	NR	NR	Tier 4	14	S	76.0 ± NR				
								OPP	59.0 ± NR				
								MB	67.0 ± NR				
								OH	55.0 ± NR				
Vlantes & Readdy (2017)	USA/Collegiate	F	20.0 ± NR	69.4 ± NR	179.0 ± NR	Tier 3	1	S	200 ± 20.6				
							2	MB	117 ± 24.2				
							6	OH	60 ± 24.2				
							2	DS	35 ± 9.0				
Herring & Fukuda (2022)	USA/Collegiate	F	NR	NR	NR	Tier 3	6	OPP	39.7 ± NR				45.1 ± NR
							4	MB	72.5 ± NR				48.2 ± NR
							4	OH	59.8 ± NR				51.8 ± NR

DS = defensive specialist; F = female; L = libero; M = male; MB = middle blocker; NR = not reported; OH = outside hitter; OPP = opposite hitter; S = setter.

Table 5. External load metrics that are not jump-based reported during 3-set volleyball matches across included studies.

Study	Location/ Competition	Sex	Age (y)	Body mass (kg)	Height (cm)	Competitive level	N	Playing position	Player load (AU)		Explosive efforts (count)		Repeated high-intensity efforts (count)
									Total	High impact	All axes	X and/or Y axes	
Wang et al. (2025)	South Korea/1st Division	M	24.5 ± 5.5	76.7 ± 2.2	187.0 ± 3.4	Tier 4	4	S			37.2 ± 10.8	10.1 ± 4.3	0.4 ± 0.5
			27.8 ± 3.6	86.1 ± 5.7	195.5 ± 4.5		8	OH/OPP			56.7 ± 14.2	16.8 ± 10.3	1.6 ± 1.3
			29.6 ± 4.7	90.8 ± 4.4	199.8 ± 3.1		6	MB			56.4 ± 16.5	12.0 ± 7.0	2.4 ± 1.7
			26.7 ± 4.6	59.5 ± 1.9	172.0 ± 6.7		3	L			23.9 ± 5.8	23.8 ± 5.6	0.5 ± 0.5
Song et al. (2024)	South Korea/1st Division	M	28.2 ± 4.4	84.5 ± 10.7	191.4 ± 9.8	Tier 4	3	S			43.1 ± 14.9		1.9 ± 0.7
							8	OH/OPP			58.3 ± 27.3		1.9 ± 1.2
							5	MB			61.0 ± 26.3		2.7 ± 1.8
							3	L			27.4 ± 13.4		1.9 ± 1.2
Vlantes and Readdy, (2017)	USA/Collegiate	F	20.0 ± NR	69.4 ± NR	179.0 ± NR	Tier 3	1	S	490 ± 45.9	31 ± 4.5		14 ± 3.8	
							2	MB	338 ± 32.8	40 ± 6.2		27 ± 9.8	
							6	OH	290 ± 73.8	24 ± 10.2		13 ± 8.2	
							2	DS	360 ± 78.8	8 ± 3.4		14 ± 10.5	

Study	**Location/ Competition**	**Sex**	**Age (years)**	**Body mass (kg)**	**Height (cm)**	**Competitive level**	**N**	**Playing position**	**Accelerations**		**Decelerations**		**Maximum speed (km·h^{-1})**	**Distance (m)**
									Total (count)	**Peak (m·s^{-2})**	**Total (count)**	**Peak (m·s^{-2})**		
Akyildiz et al. (2022)	Turkey/1st Division	F	22 ± 0.9	71.4 ± 6.3	195.1 ± 7.6	Tier 5	2	S	98.7 ± 13.1	2.9 ± 0.3	91.2 ± 12.4	−2.8 ± 0.3	16.5 ± 1.3	3283.2 ± 468.1
							2	OPP	123.9 ± 34.1	3.0 ± 0.3	108.5 ± 31.4	−2.8 ± 0.4	16.2 ± 1.8	3366.0 ± 641.1
							4	MB	75.9 ± 22.2	2.5 ± 0.3	50.4 ± 15.9	−2.4 ± 0.4	14.7 ± 2.1	2603.8 ± 452.2
							4	OH	129.1 ± 31.1	2.8 ± 0.4	108.5 ± 30.4	−2.8 ± 0.5	16.2 ± 2.3	3491.7 ± 591.5
							2	L	70.5 ± 24.8	3.1 ± 0.4	68.6 ± 24.1	−3.1 ± 0.5	16.6 ± 2.1	2836.2 ± 525.1

AU = arbitrary units; DS = defensive specialist; F = female; L = libero; M = male; MB = middle blocker; NR = not reported; OH = outside hitter; OPP = opposite hitter; S = setter.
Note: Explosive efforts determined across all axes and for X and Y axes were registered when > 3.5 m·s^{-2}. High-impact player load (AU) encompasses only accelerations > 2.5 m·s^{-2}. Repeated high-intensity efforts encompass three or more accelerations > 2.79 m·s^{-1} being performed, with recovery periods of < 21 s between them.

Table 6. Session rating of perceived exertion reported during 3-set volleyball matches across included studies.

Study	Location/Competition	Sex	Age (years)	Body mass (kg)	Height (cm)	Competitive level	N	Playing position	sRPE (AU)
de Leeuw et al. (2022)	Netherlands/National Team	M	27.0 ± 3.0	91.2 ± 6.4	200 ± 1.0	Tier 4	2	S	6.7 ± 1.1
							2	OPP	5.8 ± 1.7
							5	MB	6.7 ± 1.2
							6	OH	6.6 ± 1.3
							2	L	6.5 ± 1.3
Rebelo et al. (2023)	Portugal/1st Division	M	26.3 ± 5.8	79.0 ± 13.8	188.3 ± 3.4	Tier 4	3	S	4.0 ± 1.4
			29.6 ± 5.8	92.8 ± 4.8	198.5 ± 0.5		2	OPP	3.3 ± 0.5
			27.8 ± 4.1	99.1 ± 8.0	201.5 ± 5.6		4	MB	4.3 ± 1.9
			29.7 ± 5.6	89.5 ± 3.2	194.0 ± 4.3		4	OH	3.0 ± 1.0
			30.8 ± 4.2	68.8 ± 1.0	173.5 ± 0.5		2	L	2.8 ± 1.5
Song et al. (2024)	South Korea/1st Division	M	28.2 ± 4.4	84.5 ± 10.7	191.4 ± 9.8	Tier 4	3	S	5.3 ± 0.9
							8	OH/OPP	5.1 ± 1.3
							5	MB	5.8 ± 1.3
							3	L	5.3 ± 1.4
Lima et al. (2024)	Portugal/1st Division	M	20.4 ± 6.3	82.8 ± 5.5	191.6 ± 7.6	Tier 3	2	S	3.9 ± NR
							2	OPP	3.9 ± NR
							3	MB	5.3 ± NR
							4	OH	5.3 ± NR
Rebelo et al. (2024)	Portugal/1st Division	F	28.3 ± 4.6	73.3 ± 6.3	180.0 ± 8.1	Tier 4	2	OPP	4.2 ± 0.7
							3	MB	5.7 ± 0.9
							3	OH	6.6 ± 1.4
							1	L	3.4 ± 2.6
Rebelo et al. (2025)	Portugal/1st Division	M	34.8 ± 0.3	86.7 ± 0.9	191.0 ± 2.0	Tier 4	2	S	5.3 ± 0.9
			27.1 ± 3.4	90.1 ± 10.6	196.5 ± 0.5		2	OPP	5.7 ± 1.2
			27.8 ± 6.2	100.4 ± 9.5	202.8 ± 8.0		4	MB	5.0 ± 1.1
			28.7 ± 2.2	90.8 ± 2.6	193.3 ± 2.3		4	OH	5.7 ± 1.2
			25.2 ± 3.5	77.2 ± 5.5	178.0 ± 2.0		2	L	4.4 ± 1.0
Akyildiz et al. (2022)	Turkey/1st Division	F	22 ± 0.9	71.4 ± 6.3	195.1 ± 7.6	Tier 5	2	S	6.3 ± 1.3
							2	OPP	6.7 ± 1.2
							4	MB	6.7 ± 1.5
							4	OH	7.2 ± 1.3
							2	L	6.8 ± 1.6
Freitas-Júnior et al. (2020)	Brazil/3rd Division	M	22.9 ± 3.0	83.2 ± 10.8	186.9 ± 6.9	Tier 3	15	NR	2.0 ± 0.9
Lima et al. (2021)	Portugal/1st Division	M	21.7 ± 4.2	85.7 ± 8.7	192.4 ± 6.3	Tier 3	2	S	6.8 ± NR
							2	OPP	7.0 ± NR
							3	MB	7.2 ± NR
							3	OH	7.0 ± NR
Roy et al. (2020)	Canada/Collegiate	F	NR	NR	175 ± 8	Tier 3	2	S	5.4 ± 1.6
							1	OPP	5.8 ± 0.4
							4	MB	5.6 ± 1.2
							6	OH	5.4 ± 1.0
							2	L	5.1 ± 1.8

AU = arbitrary units; F = female; L = libero; M = male; MB = middle blocker; NR = not reported; OH = outside hitter; OPP = opposite hitter; S = setter; sRPE = session rating of perceived exertion.

m) and reached the highest peak speeds (≈16.2 km·h^{-1}) (Akyildiz et al., 2022). Collegiate female Tier 3 data showed setters had the highest player load (490 AU) and middle blockers displayed the most high-impact and horizontal explosive actions (Vlantes & Readdy, 2017).

Ten studies reported sRPE following 3-set matches (Akyildiz et al., 2022; de Leeuw Aw, van Baar R, et al., 2022; Freitas-Júnior et al., 2020; Lima et al., 2021, 2024; Rebelo, Martinho, et al., 2024; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Roy et al., 2020; Song et al., 2024) (Table 6). Male Tier 3 and 4 players reported sRPE ranging from ≈2.8 to 5.8 AU, with middle blockers generally highest and liberos/setters lowest (Lima et al., 2024; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Song et al., 2024). Among females, values were typically higher than males, reaching 6.3–7.2 AU in Tier 5 competition (Akyildiz et al., 2022) and ≈6.6 AU for outside hitters in Tier 4 play, with liberos lowest (≈3.4 AU) (Rebelo, Martinho, et al., 2024). Collegiate female Tier 3 data (≈5.1–5.8 AU) aligned more closely with male Tier 4 ranges (Roy et al., 2020). In female Tier 4–5 players, blood lactate concentrations ranged from 2.3 mmol·L^{-1} in setters to 3.0 mmol·L^{-1} in middle blockers, with maximum heart rates between 141–189 beats·min-1 and average heart rates between 101–131 beats·min-1 across positions (Akarçeşme et al., 2022). In male Tier 4 players, average match heart rates were higher than those observed in Tier 4 and 5 female players for all positions analysed, including outside hitters (156 beats·min^{-1}) and liberos (153 beats·min^{-1}) (Gielen et al., 2022).

Similar positional trends to that apparent in 3-set matches were observed in 4- and 5-set matches, although loads were typically larger due to the cumulative demands across more points generally being played. Detailed load data for these longer matches are presented in Supplementary Material (Appendix 6).

4. Discussion

This systematic review was conducted to address the growing interest in understanding the external and internal load demands experienced by volleyball players during match-play by providing the most comprehensive synthesis of literature on this topic to date with novel insights according to player position, number of sets played, player sex, and competitive level.

4.1. Position-specific match loads

Outside hitters and middle blockers consistently accumulated the most high jumps (> 50 cm) (Muñoz & Bunn, 2024; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Song et al., 2024; Wang et al., 2025). Setters, in contrast, performed the most low (10–30 cm) and medium (30–50 cm) jumps, reinforcing their unique movement profiles (Rebelo, Pereira, Martinho, Amorim, et al., 2023; Song et al., 2024; Wang et al., 2025). Although setters may not perform the most intense jumps, the cumulative nature of their movements – including frequent hopping, repositioning, and setting under time pressure – likely explains why they experience the highest total player load among collegiate female players (Vlantes & Readdy, 2017). Middle blockers exhibited greater high-impact player loads (defined by accelerations > 2.5 $m{\cdot}s^{-2}$ in any direction) than setters (Vlantes & Readdy, 2017), likely due to the combination of rapid accelerations and multiple maximal-effort jumps performed over short time intervals. Middle blockers consistently exhibited high sRPE across both male (de Leeuw Aw, van Baar R, et al., 2022; Lima et al., 2024; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Song et al., 2024) and female (Akyildiz et al., 2022; Rebelo, Martinho, et al., 2024; Roy et al., 2020) players, which aligns with the neuromuscular and perceptual strain associated with repetitive jumping combined with quick lateral movement for blocking and transitioning to attack. Their physical role requires not only vertical output but also high-frequency engagements in horizontal and lateral directions, which can accumulate significant mechanical and internal stress across matches. Liberos displayed very limited jumping activity but often showed the highest number of horizontal explosive efforts (Wang et al., 2025) and peak decelerations (Akyildiz et al., 2022), suggesting their match load is rather specific in terms of movement intensity and direction. This position-specific finding for liberos also indicates that conventional jump-based monitoring alone would underestimate their loading demands during matches.

Importantly, the review also demonstrates that these trends are consistent across studies from different countries and competitive levels. From collegiate players in the United States (Vlantes & Readdy, 2017) to professional players in Portugal (Rebelo, Pereira, Martinho, Amorim, et al., 2023), South Korea (Song et al., 2024; Wang et al., 2025), and Turkey (Akyildiz et al., 2022), the position-specific findings for load metrics remain largely preserved. This consistency strengthens the ecological validity of the findings and supports their generalization across different volleyball settings.

4.2. Match loads according to the number of sets

As expected, total jump volume increased progressively with the number of sets played across nearly all playing positions. For instance, setters frequently exceeded 150 jumps in 5-set matches (Akyildiz et al., 2022; Rebelo, Pereira, Broek, et al., 2025; Song et al., 2024; Vlantes & Readdy, 2017), compared to ≈ 65 (+131%) in 3-set matches and ≈125 (+20%) in 4-set matches (de Leeuw Aw, van Baar R, et al., 2022; Lima et al., 2024; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Skazalski, Whiteley, & Bahr, 2018; Wang et al., 2025). This increase in jump frequency is likely a function of both their consistent court presence and the centrality of their tactical role, which requires frequent jumping actions even in non-attacking scenarios such as blocking or overhead setting (Afonso et al., 2010). Beyond jump metrics, setters showed a marked progressive rise in explosive efforts and total player load as the number of sets increased. On average, setters performed ≈40 explosive efforts in 3-set matches, rising to ≈ 52 efforts in 4-set matches (+29%) and ≈58 efforts in 5-set matches (+44%) (Song et al., 2024; Wang et al., 2025). Similarly, player load increased from ≈490 AU in 3-set matches to ≈ 627 AU in 4 sets (+28%) and ≈680 AU in 5-set matches (+39%) (Vlantes & Readdy, 2017).

Middle blockers emerged as the position most sensitive to more sets being played in terms of jump count and intensity. Not only did their total jumps increase substantially in 5-set matches (commonly surpassing 120 jumps), but they also consistently maintained a prominent proportion of high jumps (> 50 cm) (Akyildiz et al., 2022; Lima et al., 2024; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Vlantes & Readdy, 2017). A marked increase in explosive and repeated high-intensity efforts in 5-set matches was also apparent for middle blockers, compared to 4-set and 3-set matches (Song et al., 2024; Vlantes & Readdy, 2017; Wang et al., 2025). For instance, Wang et al. (Wang et al., 2025) observed that middle blockers performed nearly five repeated high-intensity efforts across 5-set matches, increasing from 2.4 in 3-set matches (+104%) and 3.5 in 4-set matches (+40%). These repeated actions, typically involving short recovery opportunities (< 21 s), underscore the accumulating neuromuscular load that middle blockers experience when matches are extended. This finding may relate to their tactical role in performing a high number of blocks and transition movements, often executed in rapid succession. Middle blockers also frequently reported high sRPE compared to other positions, particularly in female players (Akyildiz et al., 2022; Rebelo, Martinho, et al., 2024; Roy et al., 2020), aligning with their intense neuromuscular demands described earlier.

Outside and opposite hitters also showed elevated jumping loads in 5-set matches compared to 3- and 4-set matches. Across studies, outside hitters performed between 55–87 jumps in 3-set matches, 66–100 jumps in 4-set matches, and 58–19 jumps in 5-set matches (Akyildiz et al., 2022; de Leeuw Aw, van Baar R, et al., 2022; Herring & Fukuda, 2022; Lima et al., 2024; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Skazalski, Whiteley, & Bahr, 2018; Song et al., 2024; Vlantes & Readdy, 2017; Wang et al., 2025). Opposite hitters followed a similar trend, with 40–102 jumps performed in 3-set matches, 38–127 jumps performed in 4-set matches, and 67–157 jumps performed in 5-set matches (Akyildiz et al., 2022; de Leeuw Aw, van Baar R, et al., 2022; Herring & Fukuda, 2022; Lima et al., 2024; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Skazalski, Whiteley, & Bahr, 2018; Song et al., 2024; Vlantes & Readdy, 2017; Wang et al., 2025). Moreover, Akyildiz et al. (Akyildiz et al., 2022) reported that outside and opposite hitters consistently covered greater total distances in 5-set matches (5220 m and 5484 m, respectively), compared to 3-set (3492 m and 3366 m, respectively) and 4-set (4610 m and 4736 m, respectively) matches.

While liberos and defensive specialists exhibited a minimal increase in jump activity across matches with more sets (García de Alcaraz & Usero, 2019), they often reported elevated sRPE in 5-set matches (≈7.1 AU), compared to 3- (≈4.9 AU) and 4-set (≈5.7 AU) matches (García de Alcaraz & Usero, 2019). These findings further support the notion that sRPE is sensitive not only to external load, but also to the total cognitive and emotional cost of maintaining high-level performance over extended play (Foster et al., 2021). Importantly, 5-set matches are typically closely contested, with the outcome often undecided until the final points, meaning players are exposed to greater psychological pressure for longer. This sustained competitive stress, combined with the need to maintain concentration and decision-making quality under fatigue, likely contributes to the higher perceptual demands reported during these longer matches.

4.3. Sex-specific match loads

Clear sex-based differences emerged the jump frequency and jump height during match-play. Overall, female players tended to accumulate more jumps per match compared to male players, particularly in the setting and attacking positions. This finding was most evident in Tier 3 (Herring & Fukuda, 2022; Vlantes & Readdy, 2017) and Tier 5 (Akyildiz et al., 2022) female teams, where setters often exceeded 160 jumps per 5-set match, while opposite hitters consistently surpassed 120 jumps. For example, Akyildiz et al. (Akyildiz et al., 2022) showed all female attacking positions (outside hitters, middle blockers, and opposite hitters) performed more than 85 jumps per match, with opposite hitters accumulating over 150 in 5-set matches. In contrast, most Tier 4 male players (Rebelo, Pereira, Martinho, Amorim, et al., 2023; Wang et al., 2025) rarely exceeded 100 jumps per 5-set match, apart from setters and middle blockers. This finding suggests that various factors like match structure, tactical distribution, and rally characteristics may collectively contribute to an increased jump volume per position among female players compared to male players. While females exhibited greater total jump loads, males consistently achieved higher average jump heights across positions. For instance, average jump heights for male outside hitters and middle blockers regularly exceeded 55 cm (Hsieh et al., 2025; Lima et al., 2019), with spiking actions surpassing 70 cm among Tier 4 players (Pawlik & Mroczek, 2023). In comparison, average jump heights for female outside hitters were ≈47–52 cm and even lower for setters (≈34 cm) (Herring & Fukuda, 2022; R. Lima et al., 2022). Such differences likely reflect underlying anthropometric and neuromuscular factors and carry meaningful implications for practice (Rebelo, Valente-dos-Santos, et al., 2025). Specifically, males tend to exhibit greater concentric force and power relative to body mass, as well as higher rates of force development and larger countermovement displacement, which contribute to enhanced take-off velocity and jump height (McMahon et al., 2017). These differences are underpinned by muscle architecture (e.g., cross-sectional area) and neuromuscular characteristics such as the ability to generate larger concentric impulses. In contrast, females often rely more on knee flexor torque and exhibit slower neuromuscular activation during the preparatory phase in jumping tasks (McMahon et al., 2017).

When comparing explosive efforts between sexes, clear differences emerged across positions and according to the number of sets played. In 3-set matches, female middle blockers performed more explosive efforts than their male counterparts (27 vs. 12, +125%), while female setters also showed slightly higher values than males (14 vs. 10, +40%) (Vlantes & Readdy, 2017; Wang et al., 2025). However, outside and opposite hitters presented higher values in males than females during 3-set matches (17 vs. 13, +31%) (Vlantes & Readdy, 2017; Wang et al., 2025). In 4-set matches, the disparity in explosive efforts became more pronounced for some positions. Female middle blockers maintained considerably higher values than males (32 vs. 18, +75%), while male outside hitters exceeded female outside hitters (29 vs. 19, +53%) (Vlantes & Readdy, 2017; Wang et al., 2025). In 5-set matches, these patterns were further amplified, where female setters almost doubled the number of explosive efforts compared to male setters (25 vs. 13, +90%) and female middle blockers performed more explosive efforts than males (35 vs. 21, +65%) (Vlantes & Readdy, 2017; Wang et al., 2025). Overall, female players, particularly setters and middle blockers, tended to perform more explosive efforts in matches than males, whereas male liberos consistently exhibited markedly greater demands compared to females. These differences may reflect a combination of sex-specific tactical roles, rally characteristics, and match dynamics, with female matches generally involving longer rallies and more sustained defensive phases, especially for front-row players (Costa et al., 2012).

Clear sex-based differences were also observed in sRPE across positions and according to the number of sets played, with females generally experiencing higher perceptual demands than males. In 3-set matches, female players consistently presented higher sRPE than males across several positions. For example, female outside hitters reported sRPE ≈6.4 AU (Akyildiz et al., 2022; Rebelo, Martinho, et al., 2024; Roy et al., 2020), compared to ≈5.5 AU in males (de Leeuw Aw, van Baar R, et al., 2022; Lima et al., 2021, 2024; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Song et al., 2024) (+16%). Similarly, female middle blockers reported sRPE ≈6.1 AU (Akyildiz et al., 2022; Rebelo, Martinho, et al., 2024; Roy et al., 2020), higher than males ≈5.7 AU in males (de Leeuw Aw, van Baar R, et al., 2022; Lima et al., 2021, 2024; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Song et al., 2024) (+7%). Opposite hitters followed a comparable trend, with females reporting sRPE of 5.6 AU (Akyildiz et al., 2022; Rebelo, Martinho, et al., 2024; Roy et al., 2020) compared to 5.1 AU in males (de Leeuw Aw, van Baar R, et al., 2022; Lima et al., 2021, 2024; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Song et al., 2024) (+10%). Similar trends were observed in 4-set matches, where female middle blockers reported sRPE ≈7.4 AU (Akyildiz et al., 2022; Rebelo, Martinho, et al., 2024; Roy et al., 2020), compared to 6.3 AU in males (de Leeuw Aw, van Baar R, et al., 2022; Lima et al., 2021, 2024; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Song et al., 2024) (+17%), and female outside hitters reported sRPE of ≈6.6 AU (Akyildiz et al., 2022; Rebelo, Martinho, et al., 2024; Roy et al., 2020) compared to 6.1 AU in males (de Leeuw Aw, van Baar R, et al., 2022; Lima et al., 2021, 2024; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Song et al., 2024) (+8%). The most striking sex-based discrepancies were observed in 5-set matches, where the cumulative physical and psychological demands were likely greatest. Female outside hitters reported sRPE of ≈7.9 AU (Akyildiz et al., 2022; Rebelo, Martinho, et al., 2024; Roy et al., 2020) compared to 7.1 AU in males (de Leeuw Aw, van Baar R, et al., 2022; Lima et al., 2021, 2024; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Song et al., 2024) (+11%). Similarly, female middle blockers reported sRPE of ≈7.6 AU (Akyildiz et al., 2022; Rebelo, Martinho, et al., 2024; Roy et al., 2020), compared to 7.1 AU in males (de Leeuw Aw, van Baar R, et al., 2022; Lima et al., 2021, 2024; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Song et al., 2024) (+7%). Female liberos also reported substantially higher sRPE (7.7 AU) (Akyildiz et al., 2022; Rebelo, Martinho, et al., 2024; Roy et al., 2020) compared to male liberos (6.7 AU) (de Leeuw Aw, van Baar R, et al., 2022; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Song et al., 2024) (+15%), likely reflecting longer rallies and extended defensive coverage in female competition. Overall, female players tended to experience greater perceptual demands than males in most positions, with differences reaching ≈15% depending on the number of sets played and playing position. These findings likely reflect several interacting factors that may augment the accumulated physiological and perceptual strain encountered among female players, including longer rally durations and higher ball-contact frequency in match-play.

4.4. *Competitive level-specific match loads*

Clear differences in jumping demands emerged between competitive levels during 3-set matches, with Tier 4 male players generally performing more jumps per match than Tier 3 male players. In 3-set matches among male players, Tier 4 setters performed ≈86 jumps (de

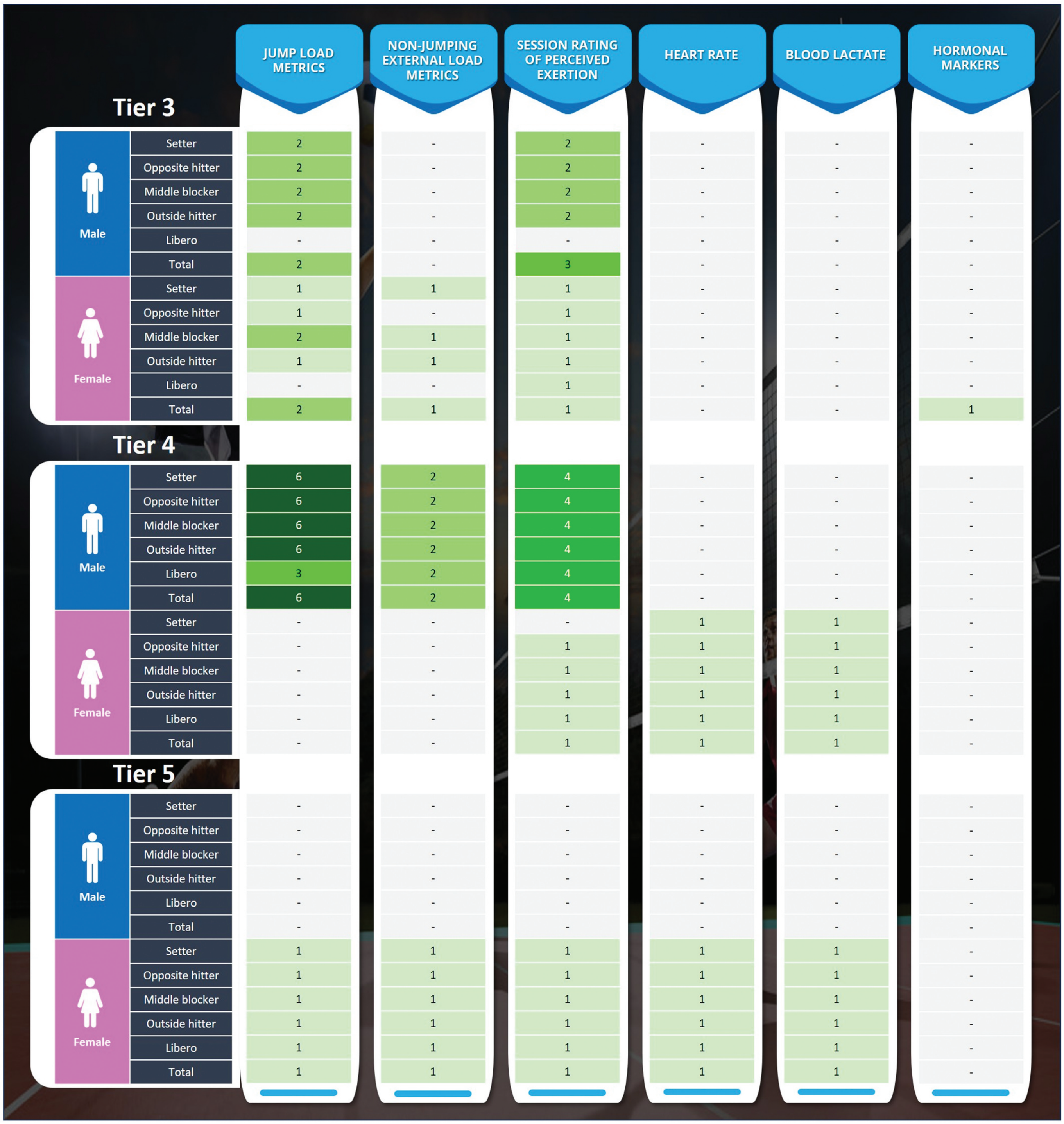
Leeuw Aw, van Baar R, et al., 2022; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Skazalski, Whiteley, & Bahr, 2018; Song et al., 2024; Wang et al., 2025), compared to 68 jumps in Tier 3 setters (Lima et al., 2024) (+26%). Similarly, Tier 4 middle blockers performed 75 jumps (de Leeuw Aw, van Baar R, et al., 2022; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Skazalski, Whiteley, & Bahr, 2018; Song et al., 2024; Wang et al., 2025), compared to 62 jumps in Tier 3 middle blockers (Lima et al., 2024) (+20%). For outside hitters, however, the difference was reversed whereby Tier 3 players performed 70 jumps (Lima et al., 2024) compared to 64 jumps in Tier 4 players (de Leeuw Aw, van Baar R, et al., 2022; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Skazalski, Whiteley, & Bahr, 2018; Song et al., 2024; Wang et al., 2025) (+8%), possibly reflecting differences in team strategies and attack distribution in lower competitions. Opposite hitters displayed the largest discrepancy between competitive levels among males, with Tier 4 players performing ≈64 jumps (de Leeuw Aw, van Baar R, et al., 2022; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Skazalski, Whiteley, & Bahr, 2018; Song et al., 2024; Wang et al., 2025) compared to 38 jumps in Tier 3 players (Lima et al., 2024) (+69%), potentially highlighting a much greater offensive reliance on opposite hitters in higher competitions. Further considering 3-set matches, Tier 3 (Herring & Fukuda, 2022; Vlantes & Readdy, 2017) and Tier 5 (Akyildiz et al., 2022) female middle blockers comparably performed ≈95 jumps, while female outside hitters demonstrated the biggest difference between competitive levels, performing 87 jumps at Tier 5 (Akyildiz et al., 2022) compared to ≈ 60 jumps at Tier 3 (Herring & Fukuda, 2022; Vlantes & Readdy, 2017) (+46%).

Clear differences also emerged in sRPE between competitive levels. Across 3-set matches, Tier 5 female players reported the highest value of 6.7 AU across positions (Akyildiz et al., 2022), higher than the sRPE reported in Tier 4 females (5.5 AU) (Rebelo, Martinho, et al., 2024) (+22%) and Tier 3 females (5.7 AU) (Roy et al., 2020) (+18%). Among males, Tier 4 (de Leeuw Aw, van Baar R, et al., 2022; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Song et al., 2024) and Tier 3 (Lima et al., 2021, 2024) players displayed similar sRPE (≈5.5–5.7 AU), but Tier 3 male middle blockers consistently reported higher responses (6.3 AU) compared to the sRPE of 5.7 AU reported in Tier 4 middle blockers (+11%), which may be attributed to an increased requirement to perform repeated high-intensity efforts in lower competitions. In 4-set matches, Tier 5 female players again showed elevated sRPE, especially for outside hitters (7.6 AU) and middle blockers (7.5 AU) (Akyildiz et al., 2022), compared to Tier 3 females (≈5.9 AU) (Roy et al., 2020) (+28%). Interestingly, Tier 4 female middle blockers reached the highest positional demands overall (8.4 AU) (Rebelo, Martinho, et al., 2024), exceeding even Tier 5 middle blockers (7.5 AU) (Akyildiz et al., 2022), which may reflect specific tactical strategies or smaller rotations among the teams analysed. Tier 3 and Tier 4 male players displayed smaller differences, but the sRPE reported in Tier 3 outside hitters (Lima et al., 2021, 2024) exceeded that reported in Tier 4 outside hitters (5.2 AU) (de Leeuw Aw, van Baar R, et al., 2022; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Song et al., 2024) (+33%), likely reflecting longer rallies and greater offensive responsibility in lower-competitions. In 5-set matches, the gap widened further. Tier 5 female opposite hitters reported a sRPE of 9.7 AU (Akyildiz et al., 2022), higher than reported in Tier 4 female opposite hitters (6.7 AU) (Rebelo, Martinho, et al., 2024) (+30%) and Tier 3 female opposite hitters (6.3 AU) (Roy et al., 2020) (+54%). Among males, Tier 4 setters (≈7.6 AU) and opposite hitters (≈7.5 AU) (de Leeuw Aw, van Baar R, et al., 2022; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Song et al., 2024) reported higher sRPE than their Tier 3 counterparts (6.3–7.1 AU) (Lima et al., 2021, 2024) (+7–19%), but the differences were less pronounced than those between Tier 5 and Tier 3 players. Collectively, these findings suggest that female players competing at higher levels experience disproportionately greater perceptual demands, while male sRPE responses remain more stable across competitive levels.

4.5. Methodological considerations, gaps in the literature, and recommendations for future Research

This systematic review highlights several important methodological limitations and gaps in the literature that must be addressed to improve future research examining the external and internal loads imposed by volleyball match-play. A major limitation across most included studies is the lack of consideration for contextual factors that are known to influence match demands in other indoor, court-based team sports, such as basketball (Petway et al., 2020) and futsal (Spyrou et al., 2022). Variables such as match location (home vs away), season phase (early, mid, or end of season), quality of opposition, and tournament context (regular season vs playoffs) were rarely, if ever, reported in the volleyball literature. This omission prevents a deeper understanding of how match demands may fluctuate depending on the competitive context faced. Therefore, integrating contextual variables into future volleyball research may enhance the ecological validity of findings and provide coaches with more actionable insights.

Another key gap concerns the limited availability of set-specific data using various load metrics (Figure 2). More precisely, heart rate responses were reported in only 1 study involving Tier 4 and Tier 5 female players (Akarçeşme et al., 2022), leaving Tier 3 players and male players entirely unrepresented. Similarly, blood lactate responses were also reported in just 1 study involving Tier 4 and Tier 5 female players (Akarçeşme et al., 2022), with no data for male players on the whole or females competing at other levels. Consequently, large



Tier	Sex	Position	JUMP LOAD METRICS	NON-JUMPING EXTERNAL LOAD METRICS	SESSION RATING OF PERCEIVED EXERTION	HEART RATE	BLOOD LACTATE	HORMONAL MARKERS
Tier 3	Male	Setter	2	-	2	-	-	-
		Opposite hitter	2	-	2	-	-	-
		Middle blocker	2	-	2	-	-	-
		Outside hitter	2	-	2	-	-	-
		Libero	-	-	-	-	-	-
		Total	2	-	3	-	-	-
	Female	Setter	1	1	1	-	-	-
		Opposite hitter	1	-	1	-	-	-
		Middle blocker	2	1	1	-	-	-
		Outside hitter	1	1	1	-	-	-
		Libero	-	-	1	-	-	-
		Total	2	1	1	-	-	1
Tier 4	Male	Setter	6	2	4	-	-	-
		Opposite hitter	6	2	4	-	-	-
		Middle blocker	6	2	4	-	-	-
		Outside hitter	6	2	4	-	-	-
		Libero	3	2	4	-	-	-
		Total	6	2	4	-	-	-
	Female	Setter	-	-	-	1	1	-
		Opposite hitter	-	-	1	1	1	-
		Middle blocker	-	-	1	1	1	-
		Outside hitter	-	-	1	1	1	-
		Libero	-	-	1	1	1	-
		Total	-	-	1	1	1	-
Tier 5	Male	Setter	-	-	-	-	-	-
		Opposite hitter	-	-	-	-	-	-
		Middle blocker	-	-	-	-	-	-
		Outside hitter	-	-	-	-	-	-
		Libero	-	-	-	-	-	-
		Total	-	-	-	-	-	-
	Female	Setter	1	1	1	1	1	-
		Opposite hitter	1	1	1	1	1	-
		Middle blocker	1	1	1	1	1	-
		Outside hitter	1	1	1	1	1	-
		Libero	1	1	1	1	1	-
		Total	1	1	1	1	1	-

Figure 2. Number of studies reporting specific load metrics during volleyball match-play according to playing position, player sex, the number of sets played, and competitive level.

knowledge gaps remain concerning the reliance on rapid glycolysis for energy provision throughout match-play for both sexes. Hormonal markers such as cortisol and testosterone were examined in only 1 study examining Tier 3 players without positional data (Edwards & Turan, 2020), meaning little physiological insight has been provided concerning the anabolic – catabolic status of players throughout volleyball match-play. External load monitoring appeared heavily focused on jump-related outcomes, with 11 studies reporting jump count or jump height according to the number of sets played (Akyildiz et al., 2022; de Leeuw Aw, van Baar R, et al., 2022; Herring & Fukuda, 2022; Lima et al., 2021, 2024; Rebelo, Pereira, Broek, et al., 2025; Rebelo, Pereira, Martinho, Amorim, et al., 2023; Skazalski, Whiteley, & Bahr, 2018; Song et al., 2024; Vlantes & Readdy, 2017; Wang et al., 2025). In contrast, non-jumping external load metrics such as accelerations, decelerations, total distance covered, and player load remain underrepresented in the literature. Among Tier 3 players, only 1 study in females reported such data (Vlantes & Readdy, 2017), while Tier 4 evidence is limited to 2 studies in male players (Song et al., 2024; Wang et al., 2025) and Tier 5 evidence to just 1 study in female players (Akyildiz et al., 2022). This lack of coverage restricts our ability to comprehensively describe the demands of match-play, particularly for positions that rely more on horizontal and multidirectional movements rather than vertical jumping. Another important limitation relates to the underrepresentation of players competing at the Tier 5 level and in some positions. Tier 5 players represent the highest level of competitive play, but have been scarcely studied in the literature, with only 1 study reporting data for world-class female players (Akyildiz et al., 2022). Additionally, liberos are consistently underrepresented in the literature across all competitive levels. No studies analysed Tier 3 liberos, no female liberos were examined at the Tier 4 level, and no male liberos were examined at the Tier 5 level. Given the unique movement profiles and positional responsibilities of liberos (García de Alcaraz & Usero, 2019), this deficiency in evidence represents a major gap in the literature and hinders the development of position-specific monitoring strategies for these players.

Finally, this review identified a broader conceptual limitation regarding the exclusive reliance on external load metrics for monitoring match-play demands. Although technological advances have led to increased availability of external load monitoring systems, focusing solely on external metrics provides an incomplete picture of player readiness and adaptation (Impellizzeri et al., 2019). Interindividual variability in responses to the same external stimulus can be substantial, making it difficult to differentiate between low responders and high responders without integrating internal load metrics (Impellizzeri et al., 2019). Internal load metrics, such as sRPE, heart rate responses, or hormonal markers, are essential for understanding how athletes are physiologically and perceptually coping with match demands. As the internal load determines the adaptation to a given external load (Jeffries et al., 2022), we recommend that future monitoring frameworks prioritise approaches that capture internal load alongside external load for holistic information to be gathered.

Another key limitation that hindered our ability to perform a quantitative meta-analysis was the inconsistent way in which data were reported across studies. Many investigations did not disaggregate outcomes by playing position or number of sets, which restricted meaningful comparisons across studies. Internal load data, particularly sRPE, were always collected using the same CR10 scale but differed in terms of timing post-match, with several studies omitting this detail altogether. Similarly, external load outcomes such as explosive efforts, player load, or jump height were defined using different thresholds or categories, limiting comparability. Most included studies relied on IMUs which have inherent trade-offs in accuracy and reliability when quantifying volleyball-specific movements. Although IMUs offer practical on-court monitoring, their accuracy for jump height depends on sensor placement, sampling rate, and proprietary algorithms, with potential drift and filtering differences across brands (De Bleecker et al., 2025; Skazalski, Whiteley, Hansen, et al., 2018). One study also used GNSS, which have limited accuracy indoors due to satellite signal attenuation (Roell et al., 2018). In some cases, results were only reported graphically or without measures of variability, further preventing quantitative synthesis. To enhance consistency and comparability in future research, we recommend that authors seek to provide the following when examining this area: (1) positional (including liberos) and set-specific values; (2) clear descriptive values accompanied by measures of variability (mean ± SD); (3) clear descriptions of how load measures were collected to permit adequate replication; (4) consistent definitions and intensity thresholds for external load metrics specific to the player sample being investigated; and (5) clear definition of the competitive level and the number of sets that were played overall in matches. Adoption of these reporting practices would allow future reviews to meta-analyse findings and generate stronger, more generalizable conclusions.

4.6. Practical applications

This review provides actionable insights for volleyball practitioners including coaches, strength and conditioning practitioners, sport scientists, and physiotherapists by presenting a comprehensive aggregation of match load data (Figure 3). Specifically, various considerations specific to playing position, number of sets played, player sex, and competitive level are generated from this review that could permit volleyball practitioners to better benchmark demands, tailor training programs, and design individualized monitoring frameworks.

4.6.1. Position-specific applications

- Setters require preparation for sustained, high jump volumes, particularly female setters who consistently showed the greatest totals. Training should therefore emphasize power-based muscular endurance for repeated submaximal efforts and careful load management in this position.
- Middle blockers combine high jump counts with exposure to frequent high-intensity efforts, suggesting a need for neuromuscular monitoring tools (e.g., countermovement jumps, landing assessments) to track fatigue and injury risk.
- Outside and opposite hitters, especially males, rely more on peak outputs (e.g., high jump heights), reinforcing the importance of plyometric and power-oriented training to optimise this performance aspect.
- Liberos, despite low jump counts, display high perceptual and locomotor loads, indicating monitoring should focus on accelerations, decelerations, and cognitive strain rather than vertical jumping.

4.6.2. Set-specific applications

- The disproportionately higher external loads and perceptual internal demands experienced during 5-set matches compared to matches with fewer sets suggest recovery strategies, training volumes, and rotation plans should be adjusted accordingly.

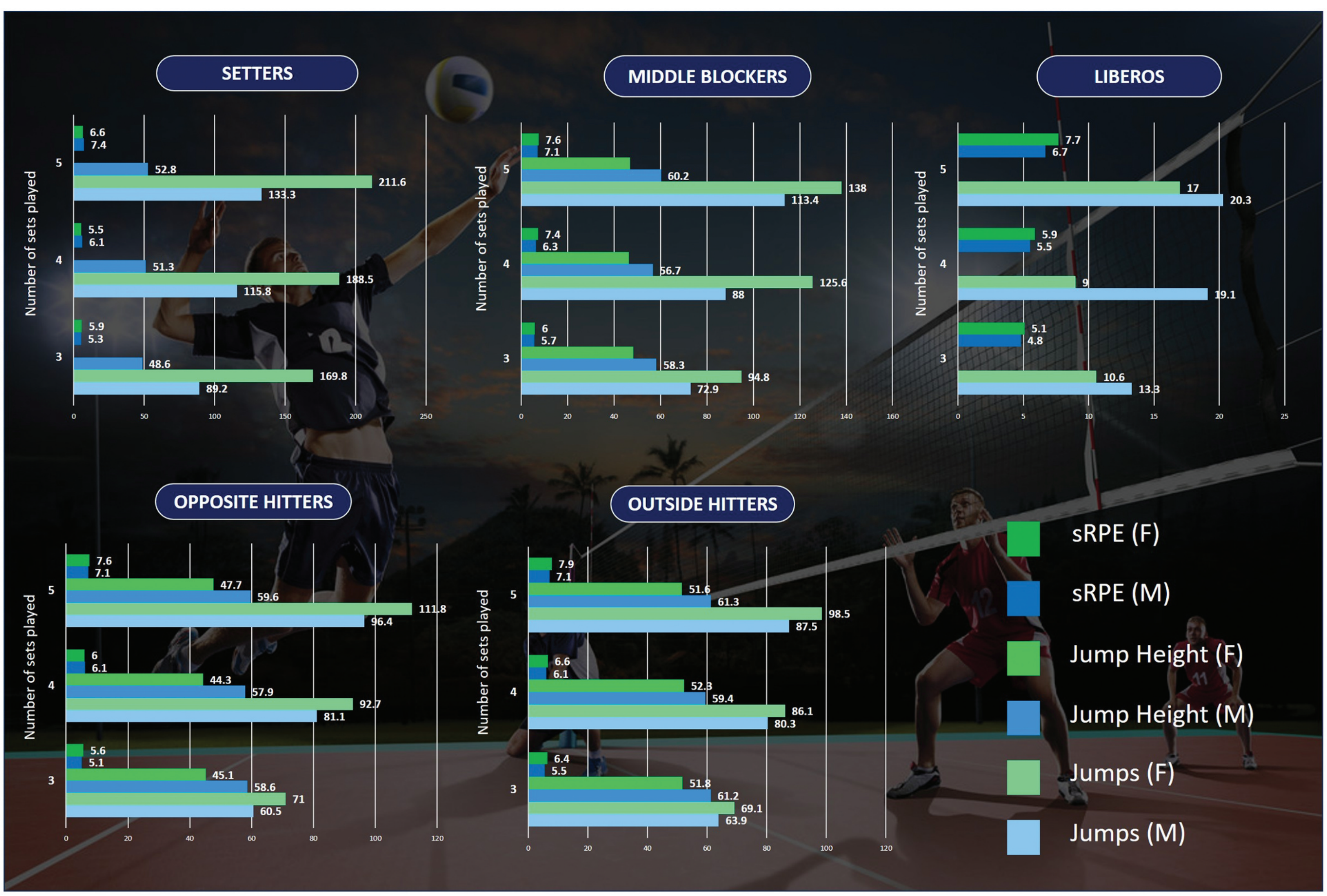


Figure 3. Reference values regarding the external and internal loads encountered during volleyball match-play according to playing position, player sex, and the number of sets played. *Note*: Data were aggregated across competitive levels in each subfigure rather than reported for each separate competitive level.

4.6.3. Sex-specific applications

- Male and female players may differ in absolute outputs (e.g., jump height), but these might be performed at comparable relative intensities. Monitoring and training should therefore emphasize relative thresholds (% of maximum) rather than absolute values when comparing sexes.
- Female players tend to accumulate greater overall jump volumes and higher perceptual internal loads, which reinforces the importance of load management and recovery strategies tailored to cumulative exposure.

4.6.4. Level-specific applications

- Tier 5 players consistently reported the highest internal loads, indicating greater perceptual and physiological strain at world-class levels. Specific recovery protocols and substitution strategies should therefore be developed for Tier 5 players compared to those competing at Tier 3 or Tier 4 levels, which demonstrate rather comparable loads.

5. Conclusions

This systematic review provides the most comprehensive synthesis to date on the external and internal loads encountered during volleyball match-play. In this regard, match loads are highly dependent on playing position, the number of sets played, player sex, and competitive level, highlighting the need for individualized monitoring and training strategies. Standardised reporting of load metrics, monitoring methodologies, and data, alongside improved representation of under-studied populations and integration of multimodal monitoring approaches are critical to advancing both research and practice in this area moving forward.

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