REVIEW ARTICLE

Physical performance and game demands in beach volleyball: A systematic review

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ABSTRACT

The physical-conditional aspects of the game are a significant research area, focusing on game demands, strength, and kinematic features. This study aimed to synthesise the current state of the art regarding beach volleyball's physical demands. This systematic literature review was conducted in March 2024, following the PRISMA criteria and methodological quality scales. The databases consulted were SPORTDiscus, Web of Science, and Scopus. Data concerning study design, sample size, gender, age-group category, player role, and performance level were considered. The risk of bias was assessed using the 12-item MINORS methodological index scale. A total of 19 studies were included, considering male (6), female (9) or both genders (4) as a sample. According to the athletes' level of performance, 25% of the studies assessed players at the developmental or national level, 50% explored the international context, and the remaining 25% were with elite players. Data regarding game demands, mechanical outcomes related to jump and power, kinematic variables concerning distance covered and running speed, and kinetic measurements for acceleration and deceleration actions are displayed. The data provided by the current review allow a precise comparison, addressing specific performance profiles and future research challenges from the lack of knowledge about this topic.

Keywords: Sand sports, Athletic performance, Game demands, Power, Jump, Technology.

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INTRODUCTION

Beach volleyball (BV) has been part of the Olympic Games in women's and men's categories since Atalanta 1996. In recent years, it has gained popularity due to the development of numerous international competitions. In this regard, an increasing number of research studies display a broad analysis of different physical and conditioning performance factors regarding the anthropometric players' characteristics (Batista et al., 2008; Giatsis et al., 2011), the physical game demands (Medeiros et al., 2014; Palao et al., 2012), the key psychological variables (Belem et al., 2014), or the proper mechanical movements in different techniques such as the spike (Giatsis et al., 2019), joined to technology development (João et al., 2021) for an appropriate monitoring strategies (Bozzini et al., 2021) that allow an improvement in the injury risk prevention programs (Racinais et al., 2021).

Physical demands appear as one of the most studied areas. Considering the multifactorial component of BV physical demands, research has focused on analysing the time of effort and rest in male (Da Costa et al., 2022; Medeiros et al., 2014; Palao et al., 2012) and female athletes (Da Costa et al., 2022; Natali et al., 2019); the jumps and hits performed during the game (Perez-Turpin et al., 2009), also differentiating the age-group category (Medeiros et al., 2014); the distances covered (Hank et al., 2016), speed (Magalhaes et al., 2011), accelerations and decelerations (Bozzini et al., 2021; João et al., 2021), or the heart rate and blood lactate concentration in real contexts (competitions or simulated matches) (Magalhães et al., 2011; Nunes et al., 2020). On the other hand, players' physical characteristics and values have also been assessed in laboratory conditions using the maximum oxygen uptake (VO2max) (Freire et al., 2022), the jumps related to game actions (i.e. block or spike jump) (Batista et al., 2008), or considering mechanical properties such as the height and rate of force development in different type of jumps, both in male and female players (Freire et al., 2022; Riggs & Sheppard, 2009). To contextualise the previous data, researchers have also considered the age category (Bellinger et al., 2021; Medeiros et al., 2014), the gender (Natali et al., 2019; Riggs & Sheppard, 2009), the player role (Da Costa et al., 2021; Medeiros et al., 2014), the type of set (Da Costa et al., 2022; João et al., 2021), the rally duration (Hank et al., 2016), the type of match (i.e. balanced or unbalanced according to the teams' ability (Palao et al., 2012), the level of opposition (Bellinger et al., 2021; Medeiros et al., 2014), and the set outcome (Da Costa et al., 2021; João et al., 2021), among others. Consequently, a substantial body of literature has emerged, joined to a great variety of information using different variables (i.e., SJ, CMJ or spike jump to measure the leg explosive strength) (Freire et al., 2022; Riggs & Sheppard, 2009) or performance level samples (Olympic Games contexts vs. national players). To the authors' knowledge, there are no systematic reviews about BV physical demands. Thus, the information should be carefully organised and reviewed for a better understanding, leading researchers, coaches, and players to an appropriate reference framework that promotes a valid performance profiling of physical and conditioning variables in BV. Based on the previous rationale, this systematic review aimed to synthesise the current state-of-the-art related to BV physical demands, both in-game and laboratory contexts.

MATERIAL AND METHODS

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline (Page et al., 2021).

Eligibility criteria

Regarding the inclusion criteria, the research was limited to (1) scientific experimental articles with peer review, (2) published in English, Spanish or Portuguese, and (3) whose main aim was related to the physical demands in BV. Exclusion criteria involved articles focus on (i) several sports analyses, (ii) indoor volleyball,

(iii) health and injury prevention, (iv) technical-tactical analysis, (v) psychological approach, (vi) methodological studies, or (vii) other aspects of the sports.

Information sources and search strategy

The databases consulted on March 1st, 2024, were Web of Science (Web of Science Core Collection, Current Contents Connect, Derwent Innovations Index, Grants Index, KCI-Korean Journal Database, MEDLINE, ProQuest™ Dissertations & Theses Citation Index and SciELO Citation Index), Scopus, and SPORTDiscus. After an expert's consensus, the search strategy designed to identify relevant studies was applied to the title, abstract or keywords of all databases as ("*beach volley**") AND ("*training*" OR "*match*" OR "*competition*" OR "*game*" OR "*player*" OR "*set*" OR "*work*" OR "*internal*" OR "*external*") AND ("*load*" OR "*demands*" OR "*intensity*" OR "*volume*" OR "*frequency*" OR "*output*" OR "*outcome*").

Selection process

The article selection began with the automated removal of duplicates using the Mendeley Reference Manager (Mendeley Ltd., Elsevier, Version 2.92.0, 2023) software. This process was complemented with a second manual review to ensure no duplicate articles were included. Then, a title and abstract screening was performed for literature classification, and a final complete reading of selected articles was done for inclusion decision. Two independent reviewers (AGA and JMMF) conducted the selection process, and potential discrepancies were resolved by consensus.

Data collection process

The NVIVO (QSR International, Version 14.23.2, 2023) software was used to process the literature. The information generated was exported to a Microsoft Excel (Microsoft Corporation, Redmond, WA, USA) matrix where the pertinent modifications were made to record the most relevant data of each study.

Data items

The results of all physical-conditional variables were grouped into game demands and kinematic and kinetic performance in laboratory tests and matches. The game demands were considered in terms of time, total duration (match and set), work/rest effort (set and rally), as well as the number of points per set. The number of jumps and hits concerning technical action and player role per match, set, and rally were also reported. Kinematic data collected from tests and match contexts, including sprints and distances covered (total and relative), and kinetic variables, such as accelerations and decelerations (per match and zone intensity), were considered. In addition, methodological information such as the study design, sample, gender, age-group category, performance level (McKay et al., 2022) or player role were extracted from articles.

Methodological quality of included studies

The 12-item MINORS methodological index scale for non-randomized (first eight items) and comparative (last four items) studies was used to assess the methodological quality and risk of bias of the included studies (Slim et al., 2003). With a 0 to 2 scale for each item, non-randomized studies could get 16 points, while comparative studies could score 24 (Slim et al., 2003). The scoring process was carried out by two independent authors (AGA and JMMF), who scored 0 (not reported), 1 (reported but inadequate) and 2 (reported and adequate) for each item (Melendez Oliva et al., 2022; Slim et al., 2003).

RESULTS

Study selection

Figure 1 provides a graphical representation (flow diagram) of the articles' selection process. Initially, 35 articles in SPORTDiscus, 60 in Web of Science, and 68 in SCOPUS (n=163) were found. After removing duplicates (n=70), the number of articles was reduced to 93. Then, screening in the abstract section identified seven topics

whose aims were not related to BV physical demands (several sports analysis -n=4, technical-tactical analysis -n=18, psychology -n=7, health and injuries -n=14, indoor/beach volleyball comparison -n=5, training methodology -n=6, and other aspects of the sport -n=7) reduced the number of articles to 32. Finally, after a full content review, 13 articles were excluded for not being directly related to the study's aim, and the remaining 19 were selected for the review.

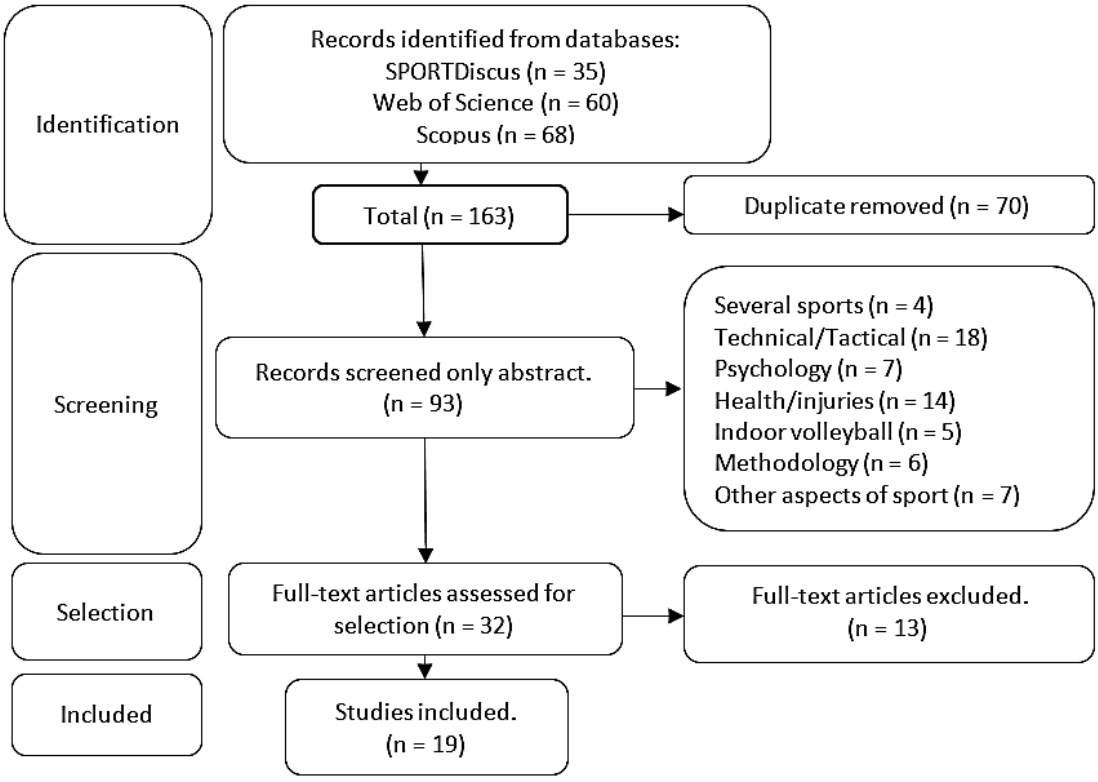

Figure 1. Flow diagram of the systematic review articles' selection process (PRISMA).

Study characteristics

The characteristics of the studies are displayed in Table 1. Overall, six studies explored male players, nine were focused on female players and the other four used both genders. Based on the data collected, a total of 28,819 matches, 60,127 sets, 9,135 rallies and 1985 jumps were considered. However, extreme caution should be addressed with this because not all the studies reported all the variables (this explains how it can be found fewer rallies than sets). According to the athletes' level of performance, 25% of the studies assessed players at the developmental or national level (tiers 2 and 3), 50% analysed players from the international context (tier 4), and the rest 25% took access to the elite worldwide players (tier 5) (McKay et al., 2022). From a methodological point of view, only one study offered information from a validity process (Schmidt et al., 2021), and two studies established an isolated descriptive design. The remaining research studies (n=16) focused on descriptive and comparative analysis, whereas four extended to a correlational analysis. No information about predictive analysis (regressions, prediction decision trees or others) was found.

Risk of bias in studies

The studies' methodological quality and risk of bias were evaluated with the MINORS index for non-randomized and comparative studies (Slim et al., 2003). The scores assigned by the reviewers to each article are shown in Table 2. From the 19 studies assessed, 21% were non-comparative (maximum score of 16),

and 79% were comparative (maximum score of 24). In the non-comparative studies, scores ranged from 10/16 (Perez-Turpin et al., 2009; Perez-Turpin et al., 2008) to 13/16 (Magalhaes et al., 2011; Schmidt et al., 2021), indicating moderate to high methodological quality. For the comparative studies, scores ranged from 18/24 (Batista et al., 2008; Freire et al., 2022; Medeiros et al., 2014; Palao et al., 2012; Riggs & Sheppard, 2009) to 20/24 (Da Costa et al., 2021; Nunes et al., 2020; Oliveira et al., 2018), showing high methodological quality (Table 2). The items with the lowest scores were: item 8 (prospective calculation of the study size) and item 9 (adequate control group), where 100% of the studies scored 0 (not reports); and item 11, (baseline equivalence groups), where 60% of the articles score 1 (different group sample).

Table 1. Study characteristics.

Authors	Aim	Method (design)	Sample		
			n	G	Performance level (**)
Perez-Turpín et al., 2008	To analyse jump patterns and to quantify jump types and their relationship to real competition	A	4 M 9 S 876 jumps	+	European (2005) (4)
Batista et al., 2008	To compare the anthropometric profile and the vertical jump of two groups of Brazilian male high-performance BV players	A B C	Group 1: Top-7; Group 2: 8th-17th ranked	+	Brazilian Ch (2006) (4)
Perez-Turpín et al., 2009	To analyse jump patterns and to quantify jump types and their relationship to real competition	A	4 M 670 jumps	*	European (2006) (4)
Riggs & Sheppard, 2009	To quantify and assess power characteristics during jumps in BV athletes.	A B C	14 men and 16 women	+ *	Australian athletes (3)
Magalhães et al., 2011	To analyse the physiological and neuromuscular impact of a one 3-set BV match	A B	16 men	+	Portuguese athletes (3)
Palao et al., 2012	To assess the duration and number of rallies in men´s and women´s BV matches	A B	28,607 M and 59,699 S	+ *	FIVB World Tour (2000-2010) (4/5)
Medeiros et al., 2014	To assess the effects of age groups and players' role in BV in relation to physical and temporal variables, considering the quality of opposition	A B C	94 S and 3,514 R	+	World Ch (2010-2011) (4/5)
Palao et al., 2015	To assess the ball contacts, jumps, hits, work time, and rest time for women's BV players in relation to their in-game role	A B	69 S and 2,708 R	*	Olympic Games (2008) (5)
Hank et al., 2016	To evaluate distances and durations of horizontal movement of elite female BV players during matches	A B	3 S and 106 R	*	World Tour (no date information) (4)
Oliveira et al., 2018	To describe and compare the training load dynamics of two Olympic BV players	A B	10 training weeks	*	Olympic Games (2016) (5)
Natali et al., 2019	To assess work-rest ratio and physical actions between males and females according to their role	A B	12 M, 20 S and 868 R	+ *	World Tour (2016) (4)
Nunes et al., 2020	To analyse and compare the match activities and percentage time spent in selected HR intensity zones in a top-level blocker and defender	A B	99 M	*	Olympic Games (2016) (5)
Bozzini et al., 2021	To evaluate internal and external training loads through a competitive season and to quantify the performance characteristics of NCAA Division I	A B	6 weeks	*	NCAA (2020) (4)
João et al., 2021	To quantify the physical demands of female BV competition regarding player position, set, and match outcome	A B	30 M and 50 S	*	Portuguese athletes (3)
Schmidt et al., 2021	To evaluate the accuracy of a commercially available inertial measurement device in VB for jump count and height in laboratory conditions	Validity	4 M, 4 S and 20 laboratory jumps	+	German senior and U19 athletes (2)

Bellinger et al., 2021	To determine the external output of female BV players during tournament match play, and to assess the effect of competition level, margin of score differential and alterations of external output within matches	A B C	30 M and 130 S	*	Australian athletes (3/4)
Da Costa et al., 2021	To compare temporal and physical indicators by considering the competition phase, set result, and role	A B	8 M, 16 S and 556 R	*	World Ch U21 (2019) (4)
Freire et al., 2022	To compare the physical attributes of male and female volleyball and BV athletes	A B	10 men and women	+ *	National athletes (3)
Da Costa et al., 2022	To compare temporal indicators according to the type of set and final score difference	A B	21 M, 42 S and 1,374 R	+	Developmental athletes (2)

*Notes. BV: beach volleyball; Ch: Championship; A: descriptive design; B: comparative design; C: correlation; n: sample size and unit of measures; G: gender; +: male; *: female; M: matches; S: sets; R: rallies; (**) following McKay et al. (2022).*

Table 2. Methodological risk of bias assessment using MINORS checklist.

Study	1	2	3	4	5	6	7	8	9	10	11	12	Score
Perez-Turpín et al., 2008	1	1	2	1	2	1	2	0	-	-	-	-	10/16
Batista et al., 2008	2	2	2	2	1	2	2	0	0	2	1	2	18/24
Perez-Turpín et al., 2009	1	1	2	1	2	1	2	0	-	-	-	-	10/16
Riggs & Sheppard, 2009	2	2	2	2	1	2	2	0	0	2	1	2	18/24
Magalhães et al., 2011	2	2	2	2	1	2	2	0	-	-	-	-	13/16
Palao et al., 2012	2	2	2	2	2	2	2	0	0	1	1	2	18/24
Medeiros et al., 2014	2	2	2	2	2	2	2	0	0	1	1	2	18/24
Palao et al., 2015	2	2	2	2	2	2	2	0	0	2	1	2	19/24
Hank et al., 2016	2	1	2	2	2	2	2	0	0	2	2	2	19/24
Oliveira et al., 2018	2	2	2	2	2	2	2	0	0	2	2	2	20/24
Natali et al., 2019	2	2	2	2	2	2	2	0	0	2	1	2	19/24
Nunes et al., 2020	2	2	2	2	2	2	2	0	0	2	2	2	20/24
Bozzini et al., 2021	2	2	2	2	2	2	2	0	0	2	1	2	19/24
João et al., 2021	2	2	2	2	2	1	2	0	0	2	2	2	19/24
Schmidt et al., 2021	2	2	2	2	1	2	2	0	-	-	-	-	13/16
Bellinger et al., 2021	2	2	2	2	1	2	2	0	0	2	2	2	19/24
Da Costa et al., 2021	2	2	2	2	2	2	2	0	0	2	2	2	20/24
Freire et al., 2022	2	2	2	2	1	2	2	0	0	2	1	2	18/24
Da Costa et al., 2022	2	2	2	2	2	2	2	0	0	2	1	2	19/24

Notes. The items are sore; 2= Reported and adequate; 1= Reported but inadequate; 0= Not reported. Methodological items (1) A clearly stated aim; (2) Inclusion of consecutive patients; (3) Prospective collection of data; (4) Endpoints appropriate to the aim of the study; (5) Unbiased assessment of the study endpoint; (6) Follow-up period appropriate to the aim of the study; (7) Loss to follow up less than 5%; (8) Prospective calculation of the study size; (9) An adequate control group; (10) Contemporary groups; (11) Baseline equivalence of groups; (12) Adequate statistical analyses, The total ideal score being 16 for non-comparative studies and 24 for comparative studies following Slim et al. (2003).

Results of individual studies

A total of 12 studies aimed to describe the game demands in terms of effort/rest time, points played (n=7) (Da Costa et al., 2021; Da Costa et al., 2022; Hank et al., 2016; Medeiros et al., 2014; Natali et al., 2019; Palao et al., 2012, 2015), and the number of jumps and hits performed (n=5) (Medeiros et al., 2014; Natali et al., 2019; Palao et al., 2015; Perez-Turpin et al., 2009; Perez-Turpin et al., 2008) (Tables 3 and 4).

Overall, male matches had a higher duration than females (Palao et al., 2012). The set and rally duration increased as males moved to higher categories, with a higher effort and rest time in the set (Table 3). Besides, a higher number of points, jumps, and hits were performed, although a higher difference was found in jumps compared to hits in terms of the player role (blocker vs. digger) (Medeiros et al., 2014) (Table 4). A similar set work-time and rally duration was found in females compared to males (Natali et al., 2019) (Table 3). Most studies were done with top-level athletes (tiers 4 and 5) (Tables 3 and 4).

Table 3. Game demands in terms of the time of effort/rest (match, set or rally), and points played per set.

Authors	Level	Duration		Work time		Rest time		Points/set
		Match (min:sec)	Set (min:sec)	Set (min:sec)	Rally (sec)	Set (min:sec)	Rally (sec)	
Male								
Palao et al., 2012	4,5	41.7±14 (2 sets); 42±2 (3 sets)	-	-	-	-	-	-
Medeiros et al., 2014	4,5	-	16:19±2:26 (U19); 18:02±3:05 (U21); 18:52±2:28 (SEN)	4:41±0:49 (U19); 4:55±0:38 (U21); 5:05±0:35 (SEN)	7±1 (U19); 7±1 (U21); 8±1 (SEN)	11:38±1:54 (U19); 13:31±2:46 (U21); 13:46±2:06 (SEN)	21±3 (U19); 20±2 (U21); 21±3 (SEN)	35.8±4.4 (U19); 38.1±4.8 (U21); 37.3±2.8 (SEN)
Natali et al., 2019	4	-	-	-	6.9±4	-	22.6±16; 19.1±7.4 (no TO)	38.3±6.6
Da Costa et al., 2022	2	-	Set 1: 13:42±1:56; Set 2: 14:1±2:34	Set 1: 3:56±0:52; Set 2: 4:08±0:56	Set 1: 7.19±0.99; Set 2: 7.61±1.14	Set 1: 9:45±1:10; Set 2: 10:01±1:47	Set 1: 18.55±1.74; Set 2: 19.1±1.99	-
Female								
Palao et al., 2012	4,5	39±18 (2 sets); 40±17 (3 sets)	-	-	-	-	-	-
Palao et al., 2015	5	-	-	4:51±1:96	6.46±4.17	15:84±6:98	22.69±7.06	-
Hank et al., 2016	4	-	-	-	7.27±3.4	-	-	-
Natali et al., 2019	4	-	-	-	7.1±3.9	-	23±17.9; 19.3±9.8 (no TO)	38±3.6
Da Costa et al., 2021	4	G: 28:31±6:03; F: 31:47±1:2	G: 14:15±2:58; F: 15:53±1:11	G: 3:12±0:33; F: 3:26±0:24	G: 5.76±0.47; F: 5.74±0.71	G: 11:03±2:29; F: 12:27±0:59	G: 20.27±1.59; F: 21.43±2.01	G: 33.5±5.45; F: 36±2.56

Notes. F: final phase; G: group phase; TO: time-out.

Table 4. Game demands in terms of jumps and hits.

Authors	Level	Jumps									Hits			
		Match				Set				Rally	Set			
		Total	Serve J	Spike J	Block J	Total	Blocker	Digger	Universal	Total	Total	Blocker	Digger	Universal
Male														
Perez-Turpin et al., 2008	4	219.0±7.4	36.5±3.2 (17%)	96.0±3.4 (44%)	86.5±2.3 (39%)	100.5±19.6	-	-	-	4.4±1.0	-	-	-	-
Medeiros et al., 2014	4,5	-	-	-	-	95.8±19.6 (U19); 105.4±18.2 (U21); 112.6±11.4 (SEN)	60±18.2 (U19); 64.4±13.4 (U21); 66.8±10.3 (SEN)	35.8±11 (U19); 41.4±14.1 (U21); 45.8±8.1 (SEN)	-	-	78±11.1 (U19); 82.4±11.7 (U21); 81.9±8.2 (SEN)	39.7±10 (U19); 38.9±10 (U21); 38.7±7.8 (SEN)	38.3±8.7 (U19); 43.5±11.5 (U21); 43.3±7.8 (SEN)	-
Natali et al., 2019	4	-	-	-	-	29.9±11.1	-	-	-	5.8±0.2	21.2±6.3	-	-	-
Female														
Perez-Turpin et al., 2009	4	167.5±38.5	15.88±9.99 (9 %)	118.88±32.83 (71%)	32.75±4.87 (20%)	74.5±5.9	-	-	-	-	-	-	-	-
Palao et al., 2015	5	-	-	-	-	-	37.1±52.19	27.46±53.95	29.81±16.77	-	-	24.48± 14.03	24.42± 13.19	23.35± 11.37
Natali et al., 2019	4	-	-	-	-	30.7±10.7	-	-	-	5.8±0.2	22.1±4.7	-	-	-

Notes. J: jump.

Table 5. Mechanical outcomes in laboratory tests.

Authors	Sample (n)	Level	Sur	Game actions Jump				Squat Jump (SJ)				Countermovement Jump (CMJ)				Abalakov Jump	
				Spike H	Block H	Spike R	Block R	Height	Force peak (N)	RFDmax (KN/s)	PP (W)	Height	Force peak (N)	RFDmax (KN/s)	PP (W)	Height	PP (W)
Male																	
Batista et al., 2008	10/G1	4	S	-	-	334.4 ±7.9	317.9 ±7.7	-	-	-	-	-	-	-	-	-	-
Batista et al., 2008	10/G2	4	S	-	-	326.3 ±10	308.4 ±9.1	-	-	-	-	-	-	-	-	-	-
Riggs & Sheppard, 2009	14	3	R	-	-	-	-	44.45± 4.73	1,961.12 ±103.9	7.76± 1.92	2,639.2 ±247.57	46.86 ±3.81	2,157.29 ±161.73	12.93 ±4.37	2,588.15 ±284.13	-	-
Maglhães et al., 2011	16	3	R	-	-	-	-	-	-	-	-	56±4	-	-	-	-	-
Schmidt et al., 2021	11	2	R	47.7± 7.2	49.4± 5.1	-	-	-	-	-	-	-	-	-	-	-	-
Freire et al., 2022	10	3	R	-	-	-	-	43.3± 8.3	*N/BW* 1.21±0.16	-	-	44.7 ±7.9	*N/BW* 1.3±0.23	-	-	-	-
Female																	
Riggs & Sheppard, 2009	16	3	R	-	-	-	-	36.13± 6.26	1,422.37 ±100.54	5.10± 1.47	1,665.28 ±298.91	38.58 ±5.77	1,629.65 ±175.9	10.7 ±4.28	1,824.4 ±621.57	-	-
Oliveira et al., 2018	2	5	R	-	-	-	-	-	-	-	-	48± 1.1(D); 40.6± 0.8(B)	-	-	-	-	-
Bozzini et al., 2021	20	3	R	60.11± 7.1	-	-	-	-	-	-	-	49.11 ±5.5	-	-	4,020.48 ±440.1	54.06 ±7.6	4,321.12 ±558.1
Freire et al., 2022	10	3	R	-	-	-	-	29.4± 4.8	*N/BW* 1.14±0.10	-	-	32.6 ±4.1	*N/BW* 1.21±0.20	-	-	-	-

Notes. Sur: surface; R: rigid surface (mat or force platform); S: sand surface; H: height; R: reach; PP: power peak; G1: top-ten ranked players; G2: rest of the sample; D: digger; B: blocker; N/BW: Newtons/Body weight.

Table 6. Kinematic results in test(1) and match conditions(2).

Authors	Sample (n)	Level	Sprint		Distance (m)	Relative distance (speed)	
			7.5 m	15 m		Blocker	Digger
Male							
Magãlhaes et al., 2011(1)	16	3	1.38±0.05	2.43±0.06	-	-	-
Female							
Hank et al., 2016(2)	8	4	-	-	64.4% of TD <10 m; 18.8% <5m	-	-
Nunes et al., 2020*(2)	2	5	-	-	-	LIR (7-11 m/s): 216.6±83.5; MIR (11-15 m/s): 35.3±25.4; HIR (15-19 m/s): 4.8±9.4	LIR: 196.5±77.4; MIR: 19.1±13.3; HIR: 2.1±8.5
Bozzini et al., 2021*(2)	20	4	-	-	around 25 km in a training week	-	-
João et al., 2021*(2)	12	3	-	-	-	TD: 539.2±201.5; LIR (0-4 m/s): 95.4±4.1%; MIR (4-7 m/s): 4.4±3.8%; HIR (7-13 m/s): 0.1±0.5%	TD: 543.1±195.6; LIR: 85.4±21.6%; MIR: 13.1±18.7%; HIR: 1.4±3.1%
Bellinger et al., 2021*(2)	20	3/4	-	-	-	Senior: TD: 570.98; zone 1 (0-1 m/s): 16.91; zone 2 (1-2 m/s): 15.33; zone 3 (+2 m/s): 3.99 U23: TD: 552; zone 1: 18.96; zone 2: 13.7; zone 3: 3.39	

*Notes. TD: total distance; LIR: low intensity running; MIR: medium intensity running; HIR: high intensity running; * GPS technology data.*

Table 7. Kinetic (accelerations/decelerations) results during match conditions.

Authors	Sample (n)	L	Accelerations									Decelerations								Acc/ min	Dec/ min
			Zone 1 (0.5-0.99 m·s^{-2})			Zone 2 (1-1.99 m·s^{-2})			Zone 3 (2-2.99 m·s^{-2})			Zone 1 (0.5-0.99 m·s^{-2})			Zone 2 (1-1.99 m·s^{-2})			Zone 3 (2-2.99 m·s^{-2})				
			T	B	D	T	B	D	T	B	D	T	B	D	T	B	D	T	B	D		
Female																					
Nunes et al., 2020 *	2	5	-	336.6± 129.8	288.5± 103.5	-	187.6 ±66.6	194.3 ±61.8	-	18.9 ±9	17.9 ±8	-	370.3± 119.9	343.1± 120.9	-	208.5 ±84.3	208.5 ±70.3	-	19± 10.4	16.5± 11.1	-	-
Bozzini et al., 2021 *	20	4	240 ±28	-	-	112 ±10	-	-	19 ±5	-	-	307 ±18	-	-	108± 13	-	-	17±4	-	-	-	-
João et al., 2021 *	12	3	-	(%) L: 61.6±16, M: 22.5±10.5, H: 15.8±12.5	(%) L: 61.7±17.1, M: 21.3±10.4, H: 16.9±13.1	-	-	-	-	-	-	-	(%) L: 62.4±13.6, M: 25.2±9.8, H: 12.2±11.3	(%) L: 57.9±15, M: 27.7±12.1, H: 14.2±13.3	-	-	-	-	-	-	-	-
Bellinger et al., 2021 *	20	3/4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	S- z1: 6.19; z2: 7.19; z3: 2.78; z4: 2.16 U23- z1: 6.28; z2: 7.28; z3: 2.72; z4: 2.09	S- z1: 6.19; z2: 7.19; z3: 2.78; z4: 2.16 U23- z1: 6; z2: 6.12; z3: 1.99; z4: 1.34

*Notes. * GPS technology data; L: level of performance; T: team; B: blocker; D: digger; L: low; M: medium; H: high; Acc: acceleration; Dec: decelerations; S: senior category; z1: zone 1 (1-2 m·s^{-2}); z2: zone 2 (2-3 m·s^{-2}); z3: zone 3(3-4 m·s^{-2}); z4: zone 4(>4 m·s^{-2}).*

Analysing the physical capacities in laboratory conditions (out of the court), seven studies focused on mechanical athletes' features (Batista et al., 2008; Bozzini et al., 2021; Freire et al., 2022; Magalhaes et al., 2011; Oliveira et al., 2018; Riggs & Sheppard, 2009; Schmidt et al., 2021) (Table 5), meanwhile, a unique study focused on kinematics variables such as a short sprint (Magalhaes et al., 2011) (Table 6). A higher performance was found in the countermovement jump (CMJ) compared to the squat jump (SJ), with superiority in male players. Only the studies of Bozzini et al. (2021) and Schmidt et al. (2021) gave an approach in a more specific jump technique (spike, block or Abalakov movement), but on a rigid surface. The oldest study was the only one that offered results on the specific sand surface (Batista et al., 2008).

Coming back to the match context, five studies aimed to analyse kinematic variables such as distance and speed ranges (Bellinger et al., 2021; Bozzini et al., 2021; Hank et al., 2016; João et al., 2021; Nunes et al., 2020) (Tables 6). In all the cases, the lower the running intensity, the higher the distance covered. Finally, another four studies showed kinetic variables like accelerations and decelerations (Bellinger et al., 2021; Bozzini et al., 2021; João et al., 2021; Nunes et al., 2020) (Table 7). Different ranges of values were used to define different running intensities, so comparing studies remains difficult. More consensus in metrics is found in acceleration and decelerations. Thus, the blocker showed a higher impact in the lowest and highest intensity ranges.

DISCUSSION

This study aimed to display the current state-of-the-art related to BV physical demands. Overall, a similar rally length is found between genders, meanwhile, males showed higher match and set duration, with a greater increase in top-level categories. Moreover, a greater number of points, jumps, and hits are performed in male players, with a greater number of jumps, accelerations and decelerations performed by blockers, and hits in the case of defenders.

Concerning the game demands, the rally duration was similar between genders (less than 0.5 seconds of difference). Only one study reported this comparison from the same competitive level (Natali et al., 2019). The rest of the studies offer information from different competitive contexts, so the performance level is an important feature for a proper data comparison. Delving into this aspect, higher rally duration was found in women's indoor volleyball compared with men when the same competitive context was analysed (Hileno et al., 2023). The lack of information on youth categories is especially important. In this sense, Da Costa et al. (2021) comprised an international top-level context in female category, meanwhile, another study analysed male national players (Da Costa et al., 2022). This continuum in the analysis of game demands in BV could draw a proper picture of the player development process (from initial tiers to the top-level -tiers 4 and 5-).

Despite the similar time of effort in a rally, the game actions performed show a higher number of points, jumps and hits performed in male athletes, with a greater number of jumps performed by blockers and hits done by defenders (Medeiros et al., 2014). However, in the same competitive context, the difference indicated another trend, with a greater number of jumps and hits in female players (Natali et al., 2019), although no information about players' roles is reported. The comparison between players' roles should be analysed carefully. In this venue, the players' or teams' strategies and performance during the game could change this tendency because the server can "*almost choose*" the opponent who prefers in the attack by forcing the reception. Thus, Link and Wenninger (2019) found how the players reduce and change their performance after a spiking error in the side-out phase, with differences between genders (male tend to change to a strong spike while female players tend to change to a soft spike).

Going to an analysis of physical features in the laboratory, some information about the reach height achieved in a jump, as well as the force applied during the kinematic phase, could be used as reference values, especially in the top-level scenarios. This reference data can be obtained not related to competition characteristics but using standardised tests to obtain data about maximum jump performance capacity (e.g., countermovement jump), or trying to simulate as much as possible competition performance with similar specific conditions (e.g., technique or sand surface). However, studies by Bozzini et al. (2021) and Schmidt et al. (2021) gave an approach to a specific jump technique (spike, block or Abalakov movement) but on a rigid surface. Contrarily, the oldest study was the only one that offered results on the specific sand surface (Batista et al., 2008). This gap should be considered for future studies.

No studies reporting the jump height during the competition were found, although a comparison between player roles was made by João et al. (2021), showing a quantity of jumps according to height ranges. However, no specific information about each jump or its relationship with specific game actions was shown. In this sense, the kinetic and kinematic variables analysed in a real context are more related to the horizontal movements such as distance covered, sprints, accelerations or decelerations. Difficulties in data analysis come from the different ranges established by the authors. Despite these difficulties, the accelerations and decelerations are usually defined in the same range, and the blockers appear like the players that collect higher impact in all the intensity ranges. The blockers' function could address not only jumping more but also doing explosive movements in short ranges, although this hypothesis could be addressed in future studies. In this sense, using new technologies opens a new horizon to discover new variables that define the players' performance.

Future research lines are suggested after this systematic review based on gaps in knowledge. Thus, wider samples, especially in national or initial levels, as well as in female players, should be considered due to the lack of information related to different performance levels. To better contextualise, the environmental features like the wind, temperature, humidity, or rain may be considered due to the strong influence on players' performance and also the surface (i.e. more solid sand after rainy weather). In this sense, the tournaments are played worldwide, so the sand's density and characteristics should be considered because of its influence on jumping mechanical properties (Giatsis et al., 2004). Furthermore, other situational variables like the match status and quality of opposition should be considered in future analyses.

In terms of the methodological bias displayed in the studies, one of the main limitation is concerned to the lack of a minimum sample size. Thus, the generalization of the results should be addressed carefully due to specific or punctual assessments. Moreover, there were not control groups because of the descriptive nature of the studies. Specially in laboratory conditions, if the studies recruit a higher sample, the inclusion of a control group could be done. For a more precise comparison, higher number of teams and competitions allow a proper baseline equivalence between groups. Therefore, although more studies are needed in this topic, an improvement in the methodological features is requested.

CONCLUSION

This study offers a comprehensive overview of the current state-of-the-art regarding the physical-conditional demands of BV and provides practical implications. It highlights that, while rally durations are similar between genders, male players have longer matches and set durations and perform more points, jumps, and hits. It also notes that blockers execute more jumps, and defenders perform more hits. The analysis emphasises the need for further research, especially in youth categories, female players, and the impact of environmental

and contextual variables. The standardisation of new technology parameters, as well as the contextualisation of physical-conditional tests, is recommended.

AUTHOR CONTRIBUTIONS

Joaquín Martín Marzano-Felisatti: Study design/planning, literature analysis/search/review, data collection, data analysis, methodological quality, manuscript writing, editing and revision. José Pino-Ortega: Study design/planning, methodological quality, and manuscript revision. Jose Ignacio Priego-Quesada: Study design/planning, methodological quality and manuscript revision. José Francisco Guzmán-Luján: Study design/planning, methodological quality and manuscript revision. Antonio García-de-Alcaraz: Study design/planning, literature analysis/search/review, data collection, data analysis, methodological quality, manuscript writing, editing and revision.

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