Baltic Journal of Health and Physical Activity

Volume 14 | Issue 2 Article 7

2022

External load in male professional volleyball: A systematic review

Marcel Frezza Pisa
Post-Graduate Program in Rehabilitation and Functional Performance, Ribeirão Preto Medical School, Univer-sity of São Paulo, São Paulo, Brazil, marcelpisa@usp.br

Arthur Marques Zecchin
Post-Graduate Program in Rehabilitation and Functional Performance, Ribeirão Preto Medical School, Univer-sity of São Paulo, São Paulo, Brazil

Leonardo Gaspar Gomes
School of Physical Education and Sport of Ribeirão Preto, University of São Paulo, Brazil

Enrico Fuini Puggina
Post-Graduate Program in Rehabilitation and Functional Performance, Ribeirão Preto Medical School, Univer-sity of São Paulo, São Paulo, Brazil; School of Physical Education and Sport of Ribeirão Preto, University of São Paulo, Brazil

Recommended Citation

Pisa MF, Zecchin AM, Gomes LG, Puggina EF. External load in male professional volleyball: A systematic review. Balt J Health Phys Act. 2022;14(2):Article7. https://doi.org/10.29359/BJHPA.14.2.07

External load in male professional volleyball: A systematic review

Abstract

Introduction. The objectives of this systematic review were to identify the volleyball external loads values in the literature and to verify the applicability of different means of quantification and monitoring of these variables during training sessions and matches. Material and methods: This systematic review was produced following the PRISMA statement recommendations, and the search for publications was carried out in the databases PubMed/NCBI, SportDiscus via EBSCOhost, SciELO. 12 studies meet the criteria and were included in this review. Results: The most used tool for quantification, monitoring and evaluation of external loads are video recording and manual or semi-automatic counting of jumps and distance covered and, more recently, the use of inertial measurements unit. The middle blocker has the highest high jump load, outside hitters jump closer to the maximum more often and setters have a high demand of medium height jumps. Conclusions: Match and training jump loads seem to be similar, and sessions that involve block or attack have a higher jump load. In professional male volleyball, training is planned with variation in training loads according to the period of the sea-son and according to the days of the week before and after games.

Keywords

volleyball, physical performance, external load, team sports, jump load

Baltic Journal
of Health and Physical Activity

e-ISSN 2080-9999

Review

External load in male professional volleyball: A systematic review

Marcel Frezza PISA[1]*, Arthur Marques ZECCHIN[2], Leonardo Gaspar GOMES[3], Enrico Fuini PUGGINA[4]

[1] Post-Graduate Program in Rehabilitation and Functional Performance, Ribeirão Preto Medical School, University of São Paulo, São Paulo, Brazil, ORCID 0000-0003-3768-3987
[2] Post-Graduate Program in Rehabilitation and Functional Performance, Ribeirão Preto Medical School, University of São Paulo, São Paulo, Brazil, ORCID 0000-0002-5970-9466
[3] School of Physical Education and Sport of Ribeirão Preto, University of São Paulo, Brazil, ORCID 0000-0002-8866-2054
[4] Post-Graduate Program in Rehabilitation and Functional Performance, Ribeirão Preto Medical School, University of São Paulo, São Paulo, Brazil; School of Physical Education and Sport of Ribeirão Preto, University of São Paulo, Brazil, ORCID 0000-0002-8379-2247

* Correspondence: Marcel Frezza Pisa, School of Physical Education and Sport of Ribeirão Preto, University of São Paulo, Brazil Bandeirantes Avenue, 3900 - Vila Monte Alegre, Ribeirão Preto – São Paulo Zip Code: 14030-680; e-mail: marcelpisa@usp.br; phone no: +55 16 992435678

Citation: Pisa MF, Zecchin AM, Gomes LG, Puggina EF. External load in male professional volleyball: A systematic review. Balt J Health Phys Act. 2022;14(2):Article7. https://doi.org/10.29359/BJHPA.14.2.07

Academic Editor: Agnieszka Maciejewska-Skrendo

Received: March 2021
Accepted: February 2022
Published: June 2022

Abstract: Introduction. The objectives of this systematic review were to identify the volleyball external loads values in the literature and to verify the applicability of different means of quantification and monitoring of these variables during training sessions and matches. Material and methods: This systematic review was produced following the PRISMA statement recommendations, and the search for publications was carried out in the databases PubMed/NCBI, SportDiscus via EBSCOhost, SciELO. 12 studies meet the criteria and were included in this review. Results: The most used tool for quantification, monitoring and evaluation of external loads are video recording and manual or semi-automatic counting of jumps and distance covered and, more recently, the use of inertial measurements unit. The middle blocker has the highest high jump load, outside hitters jump closer to the maximum more often and setters have a high demand of medium height jumps. Conclusions: Match and training jump loads seem to be similar, and sessions that involve block or attack have a higher jump load. In professional male volleyball, training is planned with variation in training loads according to the period of the season and according to the days of the week before and after games.

Keywords: volleyball, physical performance, external load, team sports, jump load.

1. Introduction

Volleyball is a sport played on a court of 162 m² separated by a net into two equal halves of 81 m² for each team. This characteristic and the specificity of volleyball rules mean that players do not have to run long distances during their actions [1], and in most cases, short and fast displacements are performed with vertical jumps that can be seen by the duration of the game rallies (4 to 10 s) in matches lasting 60 to 90 minutes on average [2, 3].

In professional volleyball, there are different game positions like setters (ST), outside hitters (OT) or receivers (RC), middle blockers (MB), opposites (OP) and liberos (LB), with different functions within the team, which generates different movement patterns and physical demands for the athletes [4, 5], due to the different frequency of attack and block jumps per set and anthropometric characteristics as well as important differences between the different positions [5].

The number of jumps, strikes, changes of direction and accelerations represent the physical demand practiced by a volleyball player during training, and games can be understood as a load related to the sport, more precisely an external load. Loads can be divided into internal loads (IL) and external loads (EL). The EL is related to the physical demands of the motor requirements inherent to the practice and which can be obtained through analysis of effort quantification, such as distance covered, number of jumps, training time, sprints and others. The IL is the athlete's psychophysiological responses to performing a certain EL [6]. The knowledge of the specific volleyball physical demands can allow coaches and the coaching staff to plan the training sessions inside the micro-, meso- and macrocycles more correctly, being able to better distribute the EL according to the period of the season and the difficulty of the next opponent [7].

Garcia-de-Alcaráz et al. [8] identified that volleyball athletes can perform more than 40 thousand vertical jumps in a training season and that the EL related to vertical jumps varies according to the player's position and the period within the training planning. Pawlik et al. [9] observed that MB and OP performed more total jumps than RC and ST. Related to the jump height, attack jumps followed by block jumps are performed closer to the maximum jump height than other types of jumps.

The objectives of this systematic review were to identify the volleyball EL values in the literature for better knowledge about the loads related to professional male volleyball. Moreover, it aims to verify if there is a similarity with the EL related to training and the game and to verify the applicability of the different means of quantification and monitoring of these variables during training sessions and games, thus serving as a parameter to guide the sports training plan.

2. Materials and Methods

This systematic review was produced following the PRISMA statement recommendations. The search for publications was carried out from March 28 to May 20, 2020 in the databases PubMed / NCBI, SportDiscus via EBSCOhost and SciELO using the acronym PICo to organize the descriptors in non-clinical research. The following descriptors were used: ((volleyball OR "volleyball indoor" OR "indoor volleyball" [Title]) AND ("physical performance" OR "physical demand" OR "training load" OR "load training" OR "workout load" OR "training dose" OR "load quantification" OR "external load" OR workload OR jumps OR "distance covered") AND (training OR game OR match OR match-play)) and their equivalents in the Portuguese language.

To manage the retrieved publications, identify any duplicates and organize references, the Mendeley Desktop software was used (Mendeley Ltd. New York, NY, USA).*2.1.*

Selection of Studies

In the initial search, 143 articles (Figure 1) were found. Using the software to manage the references, duplicates were excluded, leaving 61 studies with a summary available for reading. The eligibility of the studies was carried out by two independent evaluators, and when there was disagreement, a third evaluator was consulted. Eligibility followed the inclusion criteria: (1) original articles; (2) abstracts available for viewing; (3) sample composed of male professional athletes; (4) publications in peer-reviewed journals; (5) publications from January 2000 to May 2020; (6) publications in English or Portuguese; (7) studies that include at least the quantification of a variable related to external loads in volleyball matches or training; and the exclusion criteria were: (1) studies with female athletes; (2) studies with non-professional athletes or young athletes; (3) results obtained in field or laboratory tests that do not characterize a real training session or sessions or a sport match; (4) studies with beach volleyball or sitting volleyball; (5) studies where the descriptors used for the research do not appear in the title, abstract or keywords; (6) articles without sample categorization.

We opted for the specified selection period (2000 Jan to 2020 May) to comprise the period after the main changes to the rules of volleyball implemented by the FIVB in 1998 with the libero inclusion and the change in counting points [1, 10].

After selecting the studies, the Kappa coefficient (Cohen 'd') was used to determine the degree of agreement on the risk of bias evaluation in eligibility of the studies. The result showed good agreement between the evaluators (k = 0.87, 95% CI [0.80, 0.93], percentage of agreement = 91.03%), and 21 studies were selected for full reading. An evaluator read the studies. 10 studies were withdrawn because, after detailed reading, they did not fit the selection criteria. In the inspection of references, 1 more study that the search strategy did not reach was identified and included. In the total, 12 studies met the criteria and were included in this review.

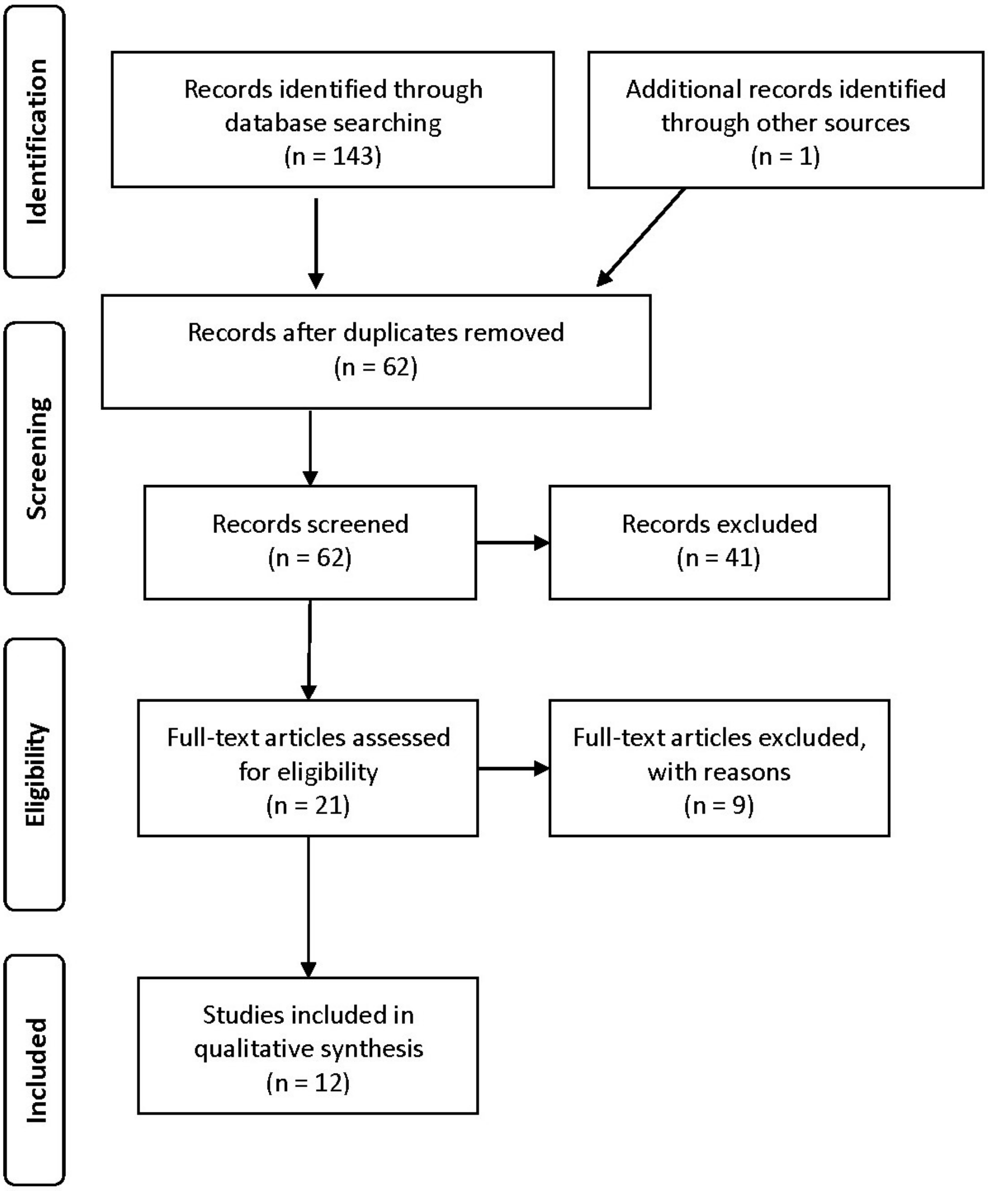

Fig. 1. Screening and selection of studies [11].

To extract data from graphics when they were not presented in the text or tables, the evaluator used the GetData Graphic Digitizer software (version 2.26.0.20). In the statistical analysis, we chose to use the qualitative and quantitative approach due to the heterogeneity of the methods and designs of the studies that do not allow using an inferential method.

Methodological Quality

For the study bias risk, specific evaluation criteria for collective sports research previously used by Saw, Main, and Gastin [11] and Simim et al. [12] were applied. The criteria evaluate studies with scores from 0 (high risk of bias) to 9 (low risk of bias), and studies with a score of < 4 are rejected. No study was excluded due to low scores; 1 study (8.3%) obtained 6 points, 3 (25%) obtained 7 points, 7 (58.3%) obtained 8 points, and 1 (8.3%) obtained 9 points.

3. Results

The 12 studies included in this systematic review comprising data of 336 professional male athletes and their main results can be seen in Table 1.

Table 1. Summary of studies included in this systematic review.

Authors	Population	Participants	Context	Methods	Outcomes
Sheppard, Gabbett, Stanganelli [5]	ARG, CAN, AUS National teams	71	Official matches and training	Video recorder	Mean frequency of attack and block jumps for middles was significantly greater than for setters and outsides.
Wnorowski et al. [13]	Polish National Team	5	Official matches	Video recorder (AS-4 software)	Trendlines show that the highest values of jump height were reported at the beginning and end of each set. Throughout the match, the players jumped the highest in the first set and stabilized their performance at a lower level in the subsequent sets.
Mroczek et al. [1]	Polish League	28	Official matches	Video recorder	The total distance covered by a player during a top-level volleyball match depends on factors such as the number of played sets, the player's function on the court, area of the court, set scores, the number and duration of individual rallies, and number of types of actions in a rally.
Horta et al. [19]	Brazil 1st Division	15	Training	Video recorder	The number of vertical jumps as well as the characteristics of jumps influences the IL load of volleyball athletes from different positions. However, the vertical jump alone may not reflect the stress imposed on the athlete's body in general.
Skazalski et al. [16]	Qatar 1st division	14	Official matches and training	Video recorder and IMU (Vert)	Vert IMU is confinable to monitor jumps and external load but not to jump height.
Skazalski, Whiteley, Bahr [17]	Qatar 1st division	14	Official matches and training	IMU (Vert)	Substantial session, weekly, and within-player jump volume differences existed in the present study. OP performed more high intensity jumps than other position groups.
Rabello et al. [18]	Deuce league	18	Official matches and training	Video recorder and IMU (Zephyr)	Measuring IL, in addition to EL, may provide valuable insights into the relationship of tendon load in this population.
Lima, Palao, Clemente [14]	Portugal 1st division	7	Official matches	Video recorder and IMU (Vert)	Players of different playing positions execute different types of jumps with varying frequency and at different intensities. No differences in the jumps executed in different game sets were found. Attack and block jump average height was 70–80% max.
Lima et al. [15]	Portugal 1st division	5	Training	IMU (Vert)	ST made a significantly greater number of jumps than MB and OT, with similar intensity and uniform distribution throughout the training practice. However, MB and OT accumulated their jumps in specific moments.
Pawlik et al. [9]	2014 FIVB Volleyball Men's World Championship	140	Official matches	Video recorder	MB and OP performed more total jumps than RC and ST. Attack followed by block jumps are performed closer to the maximum jump height than other types of jumps.

Authors	Population	Participants	Context	Methods	Outcomes
Lima et al. [16]	Portugal 1st division	8	Training	IMU (Vert)	The highest EL and IL were registered on MD-2. Meanwhile, the lowest loads were recorded on MD-1. Regarding the association between El and IL, small positive correlations were found between RPE, sRPE and the number of jumps.
García-de-Alcaráz et al. [8]	Spain 1st division	11	Training	Video recorder	A significant and moderate higher number of jumps performed by MB regardless the type of macro- or micro-cycle, the micro-cycle phase, the type of training and the quality of match opposition. By contrast, the ST performed the least jump load in all variables analyzed.

ARG = Argentina, AUS = Australia, CAN = Canada, EL = external load, IMU = inertial measurement unit, IL = internal load, MB = middle blocker, MD = match day, OP = opposite, OT = outside hitter, RC = receiver, sRPE = session rating of perceived exertion, ST = setter.

Analysis of Variables Related to External Load

To quantify the EL experienced by athletes in training sessions or matches, the most frequently used tools are video recording and manual or semi-automatic counting of jumps and distance covered [1, 5, 8, 9, 13] and, more recently, the use of inertial measurement units (IMU), such as accelerometers and gyroscopes alone or together with video recording [14–20] (Table 2).

Table 2. Descriptive characteristics of jumps related to external load in matches and training sessions.

	Jumps in a match/ set						Jumps in a training session					
	Mean	Jumps/m	Middle	Setter	Opposite	Outside	Mean	Jumps/m	Middle	Setter	Opposite	Outside
Wnorowski et al. [13]	378											
Sheppard et al. [5]	52.42*		24.33	11.94		16.15						
Lima, Palao, Clemente [14]	498.66		20.7	31.7		13.3						
Pawlik et al. [9]			91	37	71	60						
Skazalski et al. [17]	124	4.98					840.33	12.35				
Skazalski, Whiteley, Bahr [18]	89.4*	3.72	23.2	25.6	23	17.6	350	4.46	92	121	75	62
Lima et al. [15]							444.9	4.76	123.3	179.9		141.7
Garcıa-de-Alcaraz et al. [8]							254.8		82.4	42.9	68.9	60.6
Rabello et al. [19]							269	0.43*				
Lima et al. [16]							148.7	1.58*	123.3	179.9		141.7
Horta et al. [20]							87.2*					

*Jumps/m = jumps per minute, *refer to jumps per player*

Distance Covered

Regarding the distance covered by 28 players during 4 official matches, Mroczek et al. [1] found that, on average, players cover 1221 ±327 m in 3-set games and 1757 ±462 m in 4-set games ($p < 0.005$). The distance covered tended to increase during the sets (409 ±119 to 446 ±118 m), and the average distance covered in each rally was 10.92 ±0.9 m (9.12 to 12.56 m). In the analysis by player positions, ST cover 1630 ± 170 m, followed by RC (1448 ±112 m), OP (1383 ± 102 m) and LB (1372 ±103 m) with a significant difference ($p < 0.005$) for MB (788 ±92 m).

Jumps Performed

Thanks to video recording and specific software, Wnorowski et al. [13] found that in a volleyball match 35% (133) of the jumps were performed in the block, 23% (87) in the attack, 22% (83) in the serve and 20% (77) in the setting. Regarding the jump height, it was observed that athletes in the 1st set reach 94.7% of the maximum jump height in the attack, 93.4% in the block, and 92% in the serve, and the performance tends to decrease in the following sets ($p < 0.05$). For the jumps performed in the setting, the average was 77.6% of the maximum height.

Analyzing 16 international men's volleyball competition matches, Sheppard, Gabbett and Stanganelli [5] found that MB have the highest demand for jumps of different player positions, perform more block jumps per set (11.0 ±3.14) compared to ST (6.25 ±2.87) and OT (6.50 ±3.16, $p < 0.001$) and more attack jumps (7.75 ±1.88) than OT (5.75 ±3.25, $p < 0.01$) and ST (0.38 ±1.06, $p < 0.001$). There were no differences for serve jumps and dives.

According Horta et al. [20], athletes performed an average of 87.2 ± 37.9 jumps per training session, 10.7 ±12.6 serve jumps and 36.3 ±22.5 block jumps. The hitters (RC, OP and MB) performed an average of 32.1 ±17.4 attack jumps and the ST 80.1 ±44.5 setting jumps. According to their functions on the court, the MB performed more block jumps (48.3 ±24.5), and the ST had a higher total average of jumps (119.2 ±48.5) ($p < 0.05$). The training sessions that presented the highest average of jumps per player were "Block + Tactical + Attack accuracy" (124.7 ±46.7), "Block + Tactical" (113.4 ±23.4), "Service + Attack accuracy + Block" (99.5 ±35.9) and "Tactical + Attack accuracy" (94.7 ±35.3). These data refer to 15 athletes in 30 training sessions.

Garcia-de-Alcaráz et al. [8] showed that, in a season of 32 weeks of training, the MB reach 41,432 jumps, the RC 40,694, the OP 22,997 and the ST 13,226 jumps, with an average of 83.60 ±2.40, 61.29 ± 2.40, 69.42 ±2.40, 42.48 ±2.40 jumps per training session, respectively. The researchers identified that the transformation macrocycle showed the highest EL related to the number of jumps followed by the performing macrocycle, and the first phase of the micro cycles (beginning of the week) and the shock micro cycles showed greater demand for jumps compared to other periods.

Skazalski, Whtiteley and Bahr [18] analyzed 108 training sessions, 27 official games and 7 friendly matches and found that the ST performed the highest number of jumps per session (121), followed by the MB (92), OP (75) and RC (62). The ST had the highest frequency of jumps in training (92 jumps/h) and in games (67 jumps/h) despite the average jump height performed being 41% of the maximum jump height, followed by the MB (70 and 57 jumps/h), OP (58 and 53 jumps/h) with an average of 69% of the maximum jump height, and RC (49 and 47 jumps/h). Regarding the game demand, the ST had an average of 100 jumps per game, ranging from 76 jumps in games of 3 sets to 128 in games of 5 sets and average height of 56%, the OP realize 82 jumps, between 59 and 116 and height average of 76%, MB 85 jumps, between 67 and 115 and average height of 64% and RC 68 jumps, between 55 and 88 and average height of 62%.

Lima et al. [15] observed that more jumps were performed in training 2 days before the game (142.6 ±58.6, $p = 0.003$) compared to training 1 day before (107.3 ±41.5) and with no differences in training 3 or 4 days before the game. No differences were observed in the frequency of jumps (1.57 jumps/m) nor in the average (~52%) and maximum jump height (~80%) between training sessions. The EL showed a weak correlation with the rating of perceived exertion (RPE) ($r = 0.17$), moderate with session RPE ($r = 0.49$) and with the duration of the session ($r = 0.60$).

Evaluating only official matches, Lima, Palao and Clemente [14] found that MB perform 20.7 jumps per set (50.2 jumps/h) with greater demand for block jumps (11), ST perform 31.7 jumps (76.8 jumps/h) with 18.8 setting jumps and OS perform 26.6 (32.2 jumps/h) with greater demand for blocking (10.3) and attack (8.9). The researchers also observed that the jumps performed by MB in the attack and in the block reach an average of 71.7 and 67% of the maximum jump height, respectively, with an overall average of 66.2%. The setting jumps performed by ST are on average 57.2% and the average jumping height of the position is 73.7%. OS jump on average closer to the maximum height (76.2%) with better performance in attack jumps reaching 78.1% of the maximum height. There were no differences in the analysis between the sets.

4. Discussion

Professional volleyball players reach more than 40 thousand vertical jumps in a training season [8]; however, with the analyzed studies, it was not possible to characterize reference values for this variable due to the heterogeneity between the experimental designs and the different planning of the researched teams.

In consensus, ST seem to experience the greatest demand for vertical jumps in training and games. However, it is worth noting that most jumps performed by ST occur in the setting situation and that these jumps are of lesser intensity than block, attack and serve jumps [14, 15, 18]. MB have the highest demand for block and attack jumps, followed by OS. As regards the jump height, jumps performed in the attack, mainly by OS, are closer to the maximum height than those performed in the block, serve and setting [5, 13, 14, 18, 20]. Although the MB experience a higher load of jumps, this cannot be assumed to be greater physiological stress, because in this category these players are replaced by the LB in the positions of the defense zone and this reduces the playing time and the total load of these athletes [5].

The jump load seems to vary according to the period of the season and intra week, as shown by Skazalski, Whtiteley and Bahr [18], who observed increases of 10% in the load of the team jumps in subsequent weeks in one third of the weeks analyzed and at least 30% in 6 of the 27 weeks. In the characterization of training sessions, sessions that involve tactical + block together or not other elements have the highest demand for vertical jumps [20] and should be considered within the weekly training schedule [21]. According to Issurin [22], the load reduction feature towards the end of the week or before the game day is a normal strategy used in sports with a long period of competition and it can be considered as tapering. For the monitoring and evaluation of the jump's variable, Lima et al. [16] suggest the use of metrics for total jumps, as well as jumps/time, jump intensity, rest between jumps and arbitrary jump units.

According to Wnorowski et al. [13], the relative height of the jump performed during the matches are related to the result of the sets and the performance may decrease with the course of the game depending on the athletes' physical conditioning. These data show us that volleyball athletes' physical preparation must be thought to improve the absolute and relative vertical jump performance and in such a way that the performance is maintained throughout the game; thus, knowing the total demand and the one related to the situations of play is essential to plan training. Competitions are a peak stimulus for athletes due to the characteristics of intensity, and physical and psychological stress, and they should be included in the process of monitoring TLs [22].

In this review, 2 studies investigated the interaction of the EL and IL of the training sessions [16, 20]. The integrated analysis of IL and EL evaluates the psychophysiological stress experienced by an athlete in the context of the EL completed in the training session and it can be used to assess the athlete's training status. If, for the same EL, the athlete has an increase in the IL, this may represent fatigue or a decrease in physical fitness; on the other hand, if there is a decrease in the IL for the same EL, this may represent an increase in physical fitness [24]. An association between El and IL measures can provide information about athlete's adaptation and ability to support the training and matches physical demands [24, 25]. 5.

5. Conclusions

In the analysis of EL, the use of IMU technologies is growing and following a promising path in helping to quantify and better understand the physical stress that athletes experience. It will be interesting to develop new studies involving an interaction between the EL performed and the response generated in the IL, as proposed by Delaney et al. [26].

The MB perform the highest number of high jumps, but the OP jumps closer to the maximum more often, and the ST have a high demand for setting jumps, which are mostly medium height jumps. It cannot be said that the greater demand for jumps reflects a greater IL, because other variables such as the characteristics and game functions of the player position, the fact that the MB is replaced by the libero in the defense zone, also by the duration of the training and game have a great influence on the session RPE value.

It was not possible to analyze the similarity between the jump load performed in training and games due to the heterogeneity of the studies, but it seems that there are similarities. As mentioned above, other metrics such as jumps per minute, relative intensity and density of jumps should be used to better understand this variable, especially in training sessions with drills that involve block + tactic and attack + tactic that have a higher jump load and should be thought of within the weekly schedule.

References

1. Mroczek D, Januszkiewicz A, Kawczynski AS, Borysiuk Z, Chmura J. Analysis of male volleyball players' motor activities during a top-level match. J Strength Cond Res. 2014;28(8):2297–2305. DOI: 10.1519/JSC.0000000000000425
2. Gabbett TJ, Georgieff B. Physiological and anthropometric characteristics of Australian junior national, state, and novice volleyball players. J Strength Cond Res. 2007;21(3):902–8. DOI: 10.1519/R-20616.1
3. García-de-Alcaráz A, Valadés D, Palao JM. Evolution of game demands from young to elite players in men's volleyball. Int J Sport Physiol Perform. 2017;12(6):788–795. DOI: 10.1123/ijspp.2016-0027
4. Marques MC, Tillaar R, Gabbett T, Reis VM, González-Badillo JJ. Physical fitness qualities of professional volleyball players: determination of positional differences. J Strength Cond Res. 2009;23:1106–11. DOI: 10.1519/JSC.0b013e31819b78c4
5. Sheppard J, Gabbett T, Stanganelli LC. An analysis of playing positions in elite international men's volleyball: considerations for competition demands and physiological characteristics. J Strength Cond Res. 2009 Sep;23(6):1858–66. DOI: 10.1519/JSC.0b013e3181b45c6a
6. Impellizzeri FM, Rampinini E, Marcora SM. Physiological assessment of aerobic training in soccer. J Sports Sci. 2005;23(6):583–92. DOI: 10.1080/02640410400021278
7. Afonso J, Mesquita I. Determinants of block cohesiveness and attack efficacy in high-level women's volleyball. Eur J Sport Sci. 2011;11(1):69–75. DOI: 10.1080/17461391.2010.487114
8. García-de-Alcaráz A, Ramírez-Campillo R, Rivera-Rodríguez M, Romero-Moraleda B. Analysis of jump load during a volleyball season in terms of player role. J Sci Med Sport. 2020;23(10):973–8. DOI: 10.1016/j.jsams.2020.03.002
9. Pawlik D, Kawczyński A, Chmura J, Maćkała K, Kutrzyński M, Mroczek D. Jumping flying distance and jump performance of elite male volleyball players at FIVB Volleyball Men's World Championship. Appl Sci (Switzerland). 2020;10(6):1–10. DOI: /10.3390/app10062045
10. FIVB, International Volleyball Federation. FIVB. Official volleyball rules: 2017–2020. Available from: http://www.fivb.org/en/refereeing-rules/documents/FIVB-Volleyball_Rules_2017-2020-EN-v06.pdf
11. Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. DOI:doi:10.1371/journal.pmed1000097
12. Saw AE, Main LC, Gastin PB. Monitoring the athlete training response: subjective self-reported measures trump commonly used objective measures: A systematic review. Br J Sport Med. 2016;50(5):281–91. DOI: 10.1136/bjsports-2015-094758
13. Simim MA, Mello MT, Silva BC, Rodrigues DF, Rosa JP, Couto BP, et al. Load monitoring variables in training and competition situations: A systematic review applied to wheelchair sports. Adapt Physiol Act Q. 2017;34(4):466–83. DOI: 10.1123/apaq.2016-0149.
14. Wnorowski K, Aschenbrenner P, Skrobecki J, Stech M. An assessment of a volleyball player's loads in a match on the basis of the number and height of jumps measured in real-time conditions. Balt J Health Phys Act. 2013;5(3):199–206. DOI: 10.2478/bjha-2013-0019
15. Lima RF, Palao JM, Clemente FM. Jump performance during official matches in elite volleyball players: A pilot study. J Hum Kinetics. 2019;67(1):259–69. DOI: 10.2478/hukin-2018-0080
16. Lima, RF, Palao, J, Castro, H, Clemente, FM. Measuring the training external jump load of elite male volleyball players: An exploratory study in Portuguese League. Retos. 2019;36(2):454–58. DOI: 10.47197/retos.v36i36.68321

17. Lima RF, Silva A, Afonso J, Castro H, Clemente FM. External and internal load and their effects on professional volleyball training. Int J Sport Med. 2020;41(7):468–474. DOI: https://doi.org/10.1055/a-1087-2183
18. Skazalski C, Whiteley R, Hansen C, Bahr R. A valid and reliable method to measure jump-specific training and competition load in elite volleyball players. Scand J Med Sci Sport. 2018;28(5):1578–85. DOI: https://doi.org/10.1111/sms.13052
19. Skazalski C, Whiteley R, Bahr R. High jump demands in professional volleyball-large variability exists between players and player positions. Scand J Med Sci Sport. 2018;28(11):2293–98. DOI: https://doi.org/10.1111/sms.13255
20. Rabello LM, Zwerver J, Stewart RE, Akker-Scheek IV, Brink MS. Patellar tendon structure responds to load over a 7-week preseason in elite male volleyball players. Scand J Med Sci Sport. 2019;29:992–999. DOI: 10.1111/sms.13428
21. Horta TA, Bara Filho MG, Miranda R, Coimbra DR, Werneck FZ. Influência Dos Saltos Verticais Na Percepção Da Carga Interna de Treinamento No Voleibol. Revista Brasileira de Medicina Do Esporte. 2017;23(5):403–6. DOI: 10.1590/1517-869220172305172132
22. García-de-Alcaráz A, Ramírez-Campillo R, Rivera-Rodríguez M, Romero-Moraleda B. Analysis of jump load during a volleyball season in terms of player role. J Sci Med Sport. 2020;23(10):973–8. DOI: https://doi.org/10.1016/j.jsams.2020.03.002
23. Issurin VB. New horizons for the methodology and physiology of training periodization. Sport Med. 2010;40(3):189–206. DOI: 10.2165/11319770-000000000-00000
24. Clemente FM, Mendes B, Palao J, Silverio A, Carrico S, Calvete F, et al. Seasonal player wellness and its longitudinal association with internal training load: Study in elite volleyball. J Sport Med Phys Fitness. 2019;59(3):345–51. DOI: 10.23736/S0022-4707.18.08312-3
25. Bourdon PC, Cardinale M, Murray A, Gastin P, Kellmann M, Varley MC, et al. Monitoring athlete training loads: Consensus statement. Int J Sport Physiol Perform. 2017;12:161–70. DOI: 10.1123/IJSPP.2017-0208
26. McLaren SJ, Macpherson TW, Coutts AJ, Hurst C, Spears IR, Weston M. The relationships between internal and external measures of training load and intensity in team sports: A meta-analysis. Sport Med. 2018;48(3):641–658. DOI: 10.1007/s40279-017-0830-z
27. Delaney JA, Duthie GM, Thornton HR, Pyne DB. Quantifying the relationship between internal and external work in team sports: development of a novel training efficiency index. Sci Med Football. 2018;2(2):149–56. DOI: 10.1080/24733938.2018.1432885

Author Contributions: Study Design, MFP, AMZ; Data Collection, MFP, LGG; Statistical Analysis, not applicable; Data Interpretation, MFP, LGG; Manuscript Preparation, MFP, EFP; Literature Search, MFP; Funding Acquisition, not applicable. All authors have read and agreed to the published version of the manuscript.

Acknowledgements: Not applicable.

Funding: This work was not supported by any Funding Agency.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.