Original Article

Activity profile of training and matches activities of women's beach volleyball players: A case study of a world top-level team

ALEXANDRE MEDEIROS[1,2,3], GEOVANI SILVA[1,2], MÁRIO SIMIM[1,2], FRANCISCO NETO[1,2,5], FÁBIO NAKAMURA[4], LUCAS PALERMO[5], ANA RAMOS[3], JOSÉ AFONSO[3], ISABEL MESQUITA[3]

[1]*Research Group in Biodynamic Human Movement. Institute of Physical Education and Sports. Federal University of Ceara. Fortaleza, Brazil.*
[2]*Master Program in Physiotherapy and Functioning. Federal University of Ceara. Fortaleza, Brazil.*
[3]*Centre for Research, Education, Innovation, and Intervention in Sport (CIFIbD). Faculty of Sport. University of Porto (FADEUP). Porto, Portugal.*
[4]*Research Center in Sports Sciences, Health Sciences and Human Development (CIDESD). University of Maia. Maia, Portugal.*
[5]*Praia Clube, Uberlândia. Minas Gerais, Brazil.*

ABSTRACT

Objective: To compare the physical demands among training and match activities in women beach volleyball players. Design: Cross-sectional study. Setting: World top-level beach volleyball team. Patients or Other Participants: One defender (24 years-old, and 8 years of professional experience) and one blocker (25 years-old, and, 9 years of professional experience) from the Brazilian National Women's Beach Volleyball participated in this study. Main outcome measure(s): Both players were monitored throughout on-field training sessions (N= 57) and matches (N=33) during the five months prior to the 2022 World Championship. Activities were categorized into formal-match (FM), match warm-up (MWU), physical training (PT), and tactical-technical (TT) training. We assessed field time, Player LoadTM, total jumps, total distance covered, and number of changes of direction to the right and left. Results: The defender and blocker players, showed large significant differences between the formal match and training activities. Both positions showed higher values of activity during formal matches than match warm-up and physical training activities. Also, tactical-technical training activities showed significant differences when compared to formal matches in both positions. Conclusions: Physical activities during formal matches were more demanding than during match warm-up and physical training activities. However, tactical-technical training activities were more demanding than formal-match activities. Coaches could use similar values (adjusted to their teams and competitive level) to distribute external load during the competitive period and better adjust the activity profile during training sessions. Future research should explore the relationship between the players' perceptions (i.e., qualitative approach) and these findings.
Keywords: Performance analysis of sport, Load monitoring, Motion analysis, Sand, External load.

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Corresponding author. *Research Group in Biodynamic Human Movement. Institute of Physical Education and Sports. Federal University of Ceara. Fortaleza, Brazil. https://orcid.org/0000-0002-0447-353X*
E-mail: alexandremedeiros@ufc.br
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INTRODUCTION

The physical demands of Beach Volleyball (BV) have been previously quantified across a range of different populations including adult men (Medeiros et al., 2014; Nakamura et al., 2022), adult women (Nunes et al., 2020; Oliveira et al., 2018) and youth players (Bellinger et al., 2021; Medeiros et al., 2014). Overall, BV is considered as an intermittent sport that includes short, high-intensity, and explosive efforts alternating with longer low-intensity recovery periods (Magalhães et al., 2011; Medeiros et al., 2014). Previous studies have investigated temporal indicators (e.g., number of rallies, rally time, time between rallies, total work and rest time, total set and match time) to describe the physical demands required to play BV. For example, Medeiros et al. (2014) identified that the duration of sets significantly increased from the U19 to senior category, in men BV players. However, to date there is a gap in the literature concerning the demands of different BV activities (e.g., physical training, match warm-up, formal match, etc.).

Given the broad physical, technical and tactical particularities of the BV game, the use of new tools have been crucial to collect and interpret new information. In fact, advances in technology have allowed the individual monitoring of movements and workload to maximize performance and understand live (i.e., on time) the matches activity profile of players (Li et al., 2016). For example, wearable sensors have provided a real-time method for monitoring the physiological and movement parameters during training and competitive contexts in different sports like soccer (Anderson et al., 2021; Passos Ramos et al., 2019), basketball (Fox et al., 2020; Leicht et al., 2019), and volleyball (Bozzini et al., 2021; Cardinale & Varley, 2017; Nakamura et al., 2022; Nunes et al., 2020). In addition, the use of technology to measure movement patterns such as the Global Positioning System (GPS), has been used to quantify the type, duration and frequency of movements that form the individual activity profile of each BV player (Vicente et al., 2021). From a practical viewpoint, this information has helped coaches, physical trainers, physiotherapist, and others to understand the movements performed by athletes and, in consequence, provide useful guidelines for developing specific training programs. To exemplify, the monitoring of total jumps and COD could allow the technical staff to program and adapt the training volume of the sessions.

To date, some studies have evaluated team sports demands during training and competition (Fox et al., 2020; Passos Ramos et al., 2019). For example, higher monthly training loads in netball shows to be related with higher game load and lower performance levels during formal competition (Simpson et al., 2022). Furthermore, according to Fox et al. (2020) in basketball, stronger relationships between GPS variables (total and high-intensity accelerations, decelerations, COD, and jumps and total low-intensity, medium-intensity, high-intensity) were more evident during training than games. Specifically in BV, investigations have identified differences between blockers and defenders. Thus, while defenders cover more space (i.e., total distance) than blockers during the match, the blockers jump higher and sprint faster (Nunes et al., 2020; Vicente et al., 2021). Additionally, the blockers may execute more high-intensity actions because they block every attack from the opponent, compared to the defender position, who has less displacements to position himself/herself to recover the ball (Medeiros et al., 2014; Palao et al., 2015).

Despite the undeniable contribution of these investigations, to date specific information from training and matches activities considering the players' position (i.e., blocker and defender) in BV remains scarce in literature. This information could be extremely useful to acknowledge the differences of competition and training demands for blocker and the defender and, in consequence, re-think and adapt the planning and design of training sessions. Thus, the aim of this study was to compare the physical demands between training and formal-match activities in women beach volleyball players.

METHODS

Participants

One defender (24 years-old, and 8 years of professional experience) and one blocker (25 years-old, and, 9 years of professional experience) from the Brazilian National Women's Beach Volleyball team that won World Championships (season 2022) participated in this study. The selected players are currently first placed in the BV world ranking (2022) and are considered a top-level team: i) they won the gold medal in the 2022 World Championships; ii) the defender received three individual awards (i.e., most outstanding, best offensive, and best hitter player) in the 2018 World Tour, and was U21 World champion (2016 and 2017), U19 World champion (2013, 2014 and 2016), Rookie of the year (2016), nineth place in the Tokyo Olympic Games (2020) and gold medallist at the Summer Youth Olympic Games (2014); iii) the blocker was the most effective blocker in the 2022 World Championship, U21 World champion (2016 and 2017), fifth place in the Tokyo Olympic Games (2020) and a gold medallist at the Summer Youth Olympic Games (2014).

The study followed the guidelines stated in the Declaration of Helsinki and was approved by the Institutional Research Ethics Committee of the first author's institution (CAAE: 3.990.485). Players were informed about the research scope, as well as the possibility to withdraw from the investigation at any time. Guarantees of confidentiality and anonymity were also explained. Afterwards, consents forms were signed by participants.

Variables

The variables assessed were field time (i.e., time in seconds that player stay on the court), Player Load™ (i.e., sum of the accelerations across all axes of tri-axial accelerometer during movement and divides by 100 (CATAPULT®), total jumps (i.e., sum of jumps in serve, block and spike actions), total distance covered (in meters), and number of changes of direction (COD) to the right and left.

Data collection

Both players were monitored throughout on-field training sessions (N= 57) and matches (N=33) during the five months prior to the 2022 World Championship (Rome). All the matches from Brazilian National Beach Volleyball Circuit, FIVB Beach Volleyball World Tour and World Championship (2022 season) were monitored. The players had their movement patterns recorded throughout various drills during on field-session training and matches. The demands of training activities were then compared with the demands of matches played by the same players during the data collection period.

Activities were registered by the coaches and classified into four categories: formal-match (Blocker and Defender = 33 observations), match warm-up (Blocker and Defender = 27 observations), tactical-technical training (Blocker = 57 and Defender = 56 observations) and physical training (Blocker and Defender = 26 observations). The variables of each set were summed to obtain the total match values. Match warm-up was split from the match values and included into a separate category. All the matches belonged to the Brazilian circuit and World Tour (season 2022). Only the first and second sets of the matches were monitored (intervals between the sets were not considered). The third set was not assessed since the number of points and rallies was significantly smaller than in the previous sets. This is a consequence of game rules, namely the number of points needed to win a set (Fédération Internationale de Volleyball, 2016).

All variables were assessed by a portable GPS device sampling (Vector, Catapult, Innovations, Melbourne, Canberra, Australia). The tracking device contained a GPS and LPS sensors (10 Hz), accelerometer (100 Hz), gyroscope (100 Hz), and magnetometer (100 Hz). The reliability and validity of these devices to capture player's physical workloads have been reported previously with root mean square error of 0.20 ± 0.05 m

(Hodder et al., 2020; Luteberget et al., 2018). After each practical session (training or match), data were downloaded into the manufacturer's software for further data processing (Catapult Sports Open Field software). All the players wore the same GPS unit over the entire training of match session, which was positioned between their scapulae using an elasticized harness worn underneath the playing attire and. Each device was activated at least 10 min before sessions. This allowed the unit to download ephemeris data from satellites used to calculate location and distance, and data collection was monitored in real time.

With the aim to exclude movements of vertical displacement of trunk, total jumps were recorded (by GPS) when performed more than 25 cm (reference value considered based on an exploratory performance analysis conducted at the training session since the beginning of the season).

Statistical analysis

Shapiro-Wilk test was used to assess the normality of distribution. All data violated the assumption of normal distribution, thereby nonparametric statistical procedures were used. Descriptive statistics were used to characterize the movement patterns during training and match sessions. Due to the non-normal distribution, medians and interquartile ranges were provided. The Kruskal-Wallis test was used to compare the physical demands between training and formal-match activities. Next, the Dwass-Steel-Critchlow-Fligner (DSCF) post-hoc test was used to identify the direction of effect following a significant testing result. The alpha-level was set at .05. Epsilon-squared was calculated to measure the effect size, which was labelled as: < .02 (very small), < .13 (small), < .26 (medium) and >=0.26 (large) (Ben-Shachar et al., 2020). All statistical analyses were performed using Jamovi® version 2.3.18.0 (Jamovi, 2022).

RESULTS

Table 1 shows the descriptive statistics of GPS variables for training and matches activities according to the specific position of each player (i.e., blocker and defender).

Table 1. Descriptive statistics of GPS variables for training and match activities according to players' position (i.e., blocker and defender).

GPS variable	Player role	Activity	Median	IQR	Minimum	Maximum
Field Time (s)	Defender	FM	2431.00	656.00	1732.00	4490.00
	Blocker		2372.50	606.25	1732.00	4490.00
	Defender	MWU	2283.00	447.500	1028.00	4939.00
	Blocker		2283.00	447.500	1028.00	4939.00
	Defender	PT	1935.00	1049.75	526.00	4203.00
	Blocker		1845.50	1224.750	349.00	4203.00
	Defender	TT	3612.00	1181.00	1974.00	5422.00
	Blocker		3621.00	1187.00	1732.00	5456.00
Player Load™ (AU)	Defender	FM	107.34	22.66	78.95	191.63
	Blocker		88.93	23.59	72.44	166.42
	Defender	MWU	104.54	31.65	42.21	229.58
	Blocker		71.06	15.85	48.52	144.13
	Defender	PT	121.44	52.20	24.74	309.66
	Blocker		92.70	53.72	14.99	233.42
	Defender	TT	179.34	49.45	95.64	295.86
	Blocker		162.17	59.03	62.71	301.89
COD Right (count)	Defender	FM	71.00	14.00	47	130
	Blocker		63.50	17.00	43	108

	Defender	MWU	23.00	8.00	9	57
	Blocker		30.00	9.50	18	58
	Defender	PT	32.50	63.75	0	113
	Blocker		38.00	62.00	0	146
	Defender	TT	91.00	36.75	25	199
	Blocker		113.00	47.00		241
COD Left (count)	Defender	FM	64.00	18.00	37	90
	Blocker		66.50	23.25	47	124
	Defender	MWU	27	9.50	9	62
	Blocker		26	14.00	13	60
	Defender	PT	47.00	58.25	0	94
	Blocker		36.50	65.75	1	145
	Defender	TT	83.50	36.00	30	180
	Blocker		114.00	49.00	36	192
Total jumps	Defender	FM	49.00	12.00	34	85
	Blocker		74.50	11.25	51	143
	Defender	MWU	41.00	16.50	12	90
	Blocker		31.00	9.50	15	56
	Defender	PT	34.00	47.25	0	149
	Blocker		36.00	49.50	0	145
	Defender	TT	66.00	36.25	3	166
	Blocker		82.00	47.00	1	150
Total distance (m)	Defender	FM	1459.35	208.04	1073.02	2725.44
	Blocker		1274.79	224.42	983.73	2453.93
	Defender	MWU	1412.62	344.19	563.03	2469.42
	Blocker		1038.80	229.33	484.87	1794.84
	Defender	PT	1372.05	632.48	185.88	3500.94
	Blocker		1145.07	854.50	127.04	3199.04
	Defender	TT	2091.75	587.43	992.07	3277.69
	Blocker		1885.75	582.63	674.71	3002.69

Note. IQR – Inter-quartile range. AU – Arbitrary units. FM – Formal match. MWU – Match warm-up. COD – Change of direction. PT – Physical training. TT – Tactical-technical training.

Table 2 presents Kruskal-Wallis and DSCF post-hoc results. Concerning the GPS variables, defender and blocker showed large significant differences between the different formal-match and training activities. Post-hoc test displayed comparisons per activity.

The analysis per player's position and activity revealed that the defender showed higher values of activity during formal matches than match warm-up and physical training activities. All significant results showed large effect sizes. When compared to match warm-up, activities during formal matches displayed significant differences in COD to the right and left ($p < .001$). Formal matches displayed significant differences in COD right ($p = .017$) compared to physical training. However, tactical-technical training showed significant differences when compared to formal matches: field time ($p < .001$), Player Load™ ($p < .001$), COD right ($p = .003$), COD left ($p < .001$), total jumps ($p < .001$) and total distance ($p < .001$). Tactical-technical training activities showed higher values than physical training: field time ($p < .001$), Player Load™ ($p < .001$), COD right ($p < .001$), COD left ($p < .001$), total jumps ($p < .001$) and total distance ($p < .001$). We found significant differences when compared tactical-technical training activities to match warm-up, field time ($p < .001$), Player Load™ ($p < .001$), COD right ($p < .001$), COD left ($p < .001$), total jumps ($p < .001$) and total distance ($p < .001$).

Table 2. Comparison of GPS variables between formal-match and training activities for the defender and blocker.

GPS Variable	Player role	Kruskal-Wallis	Post-hoc
Field Time (s)	Defender	$\chi2$ = 64.6; df =3; p < .001; $\varepsilon2$ = 0.458	FM vs MWU (w = 0.137; p = 1.000) FM vs PT (w =-3.584; p = .055) FM vs TT (w = 8.697; p < .001*) MWU vs PT (w = -3.045; p = 0.137) MWU vs TT (w = 6.860; p < .001*) PT vs TT (w = 8.977; p < .001*)
	Blocker	$\chi2$ = 68.2; df =3; p < .001; $\varepsilon2$ = 0.484	FM vs MWU (w = 0.237; p = .998) FM vs PT (w = -4.643; p = .006*) FM vs TT (w =8.488; p < .001*) MWU vs PT (w = -4.227; p = .015*) MWU vs TT (w = 6.928; p < .001*) PT vs TT (w = 9.206; p < .001*)
Player Load™ (AU)	Defender	$\chi2$ = 66.8; df =3; p < .001; $\varepsilon2$ = 0.474	FM vs MWU (w = 9.850; p < .001*) FM vs PT (w = 2.461; p = .303) FM vs TT (w = 9.850; p < .001*) MWU vs PT (w = 1.912; p = .530) MWU vs TT (w = 8.427; p < .001*) PT vs TT (w = 6.849; p < .001*)
	Blocker	$\chi2$ = 72.8; df =3; p < .001; $\varepsilon2$ = 0.516	FM vs MWU (w = -5.229; p = .001*) FM vs PT (w = 0.155; p = 1.000) FM vs TT (w = 9.274; p < .001*) MWU vs PT (w = 2.491; p = .292) MWU vs TT (w = 9.542; p < .001*) PT vs TT (w = 6.887; p < .001*)
COD Right	Defender	$\chi2$ = 72.9; df =3; p < .001; $\varepsilon2$ = 0.517	FM vs MWU (w = -9.280; p < .001*) FM vs PT (w = -4.160; p = .017*) FM vs TT (w = 4.850; p = .003*) MWU vs PT (w = 1.724; p = .615) MWU vs TT (w = 10.230; p < .001*) PT vs TT (w = 7.050; p < .001*)
	Blocker	$\chi2$ = 85.4; df =3; p < .001; $\varepsilon2$ = 0.606	FM vs MWU (w = -8.980; p < .001*) FM vs PT (w = -3.418; p = .074) FM vs TT (w = 8.260; p < .001*) MWU vs PT (w = 1.020; p = .889) MWU vs TT (w = 10.000; p < .001*) PT vs TT (w = 8.310; p < .001*)
COD left	Defender	$\chi2$ = 73.9; df =3; p < .001; $\varepsilon2$ = 0.524	FM vs MWU (w = -8.910; p < .001*) FM vs PT (w = -2.667; p = .234) FM vs TT (w = 6.520; p < .001*) MWU vs PT (w = 2.720; p = 0.218) MWU vs TT (w = 10.120; p < .001*) PT vs TT (w = 6.890; p < .001*)
	Blocker	$\chi2$ = 83.5; df =3; p < .001; $\varepsilon2$ = 0.592	FM vs MWU (w = -8.920; p < .001*) FM vs PT (w = -3.770; p = .038*) FM vs TT (w = 7.460; p < .001*) MWU vs PT (w = 1.938; p = .518) MWU vs TT (w = 10.150; p < .001*) PT vs TT (w = 8.090; p < .001*)

Total Jumps (> 25cm)	Defender	$\chi 2$ = 39.1; df =3; p < .001; $\varepsilon 2$ = 0.277	FM vs MWU (w = -2.461; p = .303) FM vs PT (w = -4.290; p = .013*) FM vs TT (w = 5.560; p < .001*) MWU vs PT (w = -2.558; p = .269) MWU vs TT (w = 6.220; p < .001*) PT vs TT (w = 6.670; p < .001*)
	Blocker	$\chi 2$ = 65.3; df =3; p < .001; $\varepsilon 2$ = 0.463	FM vs MWU (w = -9.279; p < .001*) FM vs PT (w = -7.991; p < .001*) FM vs TT (w = 0.786; p = .945) MWU vs PT (w = 0.995; p = .896) MWU vs TT (w = 8.311; p < .001*) PT vs TT (w = 6.966; p < .001*)
Total distance (m)	Defender	$\chi 2$ = 50.8; df =3; p < .001; $\varepsilon 2$ = 0.360	FM vs MWU (w = -0.683; p = .963) FM vs PT (w = -0.669; p = .965) FM vs TT (w = 8.504; p < .001*) MWU vs PT (w = -0.050; p = 1.000) MWU vs TT (w = 7.794; p < .001*) PT vs TT (w = 6.059; p < .001*)
	Blocker	$\chi 2$ = 58.4; df =3; p < .001; $\varepsilon 2$ = 0.414	FM vs MWU (w = -5.379; p < .001*) FM vs PT (w = -2.742; p = .212) FM vs TT (w = 7.533; p < .001*) MWU vs PT (w = 0.629; p = .971) MWU vs TT (w = 8.852; p < .001*) PT vs TT (w = 6.401; p < .001*)

*Note. AU – Arbitrary units. FM – Formal match. COD – Change of direction. PT – Physical training. MWU – Match warm-up. TT – Tactical-technical training; * – Significant difference.*

The blocker showed significant differences when compared formal matches with match warm-up and physical training activities. When compared to match warm-up, formal matches activities displayed significant differences in COD right (p < .001), COD left (p < .001), total jumps (p < .001) and total distance (p < .001). When compared to physical training activities, formal matches activities showed significant differences in field time (p = .006), COD left (p = .038) and total jumps (p < .001). Tactical-technical training activities presented significant differences when compared with matches: field time (p < .001), Player Load™ (p < .001), COD right (p < .001), COD left (p < .001) and total distance (p < .001). When compared to physical training, tactical-technical training activities showed higher values for field time (p < .001), Player Load™ (p < .001), COD right (p < .001), COD left (p < .001), total jumps (p < .001) and total distance (p < .001). In all analyses, the blocker match warm-up only presented significant differences in field time (p = .015) compared to physical training. In contrast, physical training had no significant differences for any comparison. On the other hand, tactical-technical training showed higher values for all GPS variables, activities, and player's role. The blocker's total jumps are the only exception when compared with matches (p = .945). We found significant differences when compared tactical-technical training activities to match warm-up, field time (p < .001), Player Load™ (p < .001), COD right (p < .001), COD left (p < .001), total jumps (p < .001) and total distance (p < .001).

DISCUSSION

Prior studies noted the importance of monitoring training load of elite BV players during specific training periods (Oliveira et al., 2018). However, to the best of our knowledge this is the first study that compared the physical demands between formal-match and training activities of a top-level women BV team. Throughout

five months, the timeline dedicated in preparing the 2022 world championship, the differences in the physical activities of the blocker and the defender were monitored at four different categories: formal matches, match warm-up, physical training and tactical-technical training. Overall, findings revealed that tactical-technical training provided the greatest external load, followed by formal match, match warm-up and physical training, respectively.

When compared to formal matches, match warm-up and physical training displayed significant differences for both positions. A possible explanation for that physical training has displayed the lowest demand comparing to the other categories may be the competitive period of the analysis. In detail, during the competitive period in analysis, the physical training demand was lower because the tactical-technical activities were the priority for the coaches. In accordance with the present results, a previous study has demonstrated less demands for warm-up than matches in a Brazilian Olympic Women soccer team (Passos Ramos et al., 2019).

It calls the attention the absolute duration (~38 min) of the warm-up undertaken by the players in preparation to the match. Such long warm-up can be related to fatigue accumulation, negatively affecting the following performance. For instance, after performing 25 min of warm-up, semi-professional soccer players presented worse performance in the 10- and 20-min sprint compared to shorter warm-ups, and 8 min warm-up even improved performance. In addition, longer warm-ups can increase rating of perceived exertion, and this effect can be detrimental to the subsequent match performance. In this sense, more studies are necessary in BV to optimize warm-up duration, taking into account its content (Yanci et al., 2019).

Tactical-technical training activities showed higher values than matches for all variables, the only exception was total jumps made by the blocker. A possible explanation for this might be that tactical-technical training had more field time than matches. Brazilian Olympic woman soccer team did not show this behaviour, but in the specific case of soccer the tactical-technical training had less field time than matches (Passos Ramos et al., 2019). Furthermore, only jumps of the blocker did not differ between match and tactical-technical. Partially, we can explain this because blockers perform jumps more times than defenders (Medeiros et al., 2014; Palao et al., 2014). These difference is not gender-dependent (Natali et al., 2019). Possibly the blocker had a greater jumping routine in his tactical-technical training and not significantly differing from the matches.

A possible limitation of this study is that we considered only jumps higher than 25 cm. This decision may be excluded some real jumps. Despite its limitation, the study certainly adds to our understanding of the physical demand in two elite players. Several questions remain unanswered at present. Future research should explore the relationship between the players' perceptions (i.e., qualitative approach) and these findings. Also, a natural progression of this work is to analyse the dynamics between the load of tactical-technical training and matches. For example, checking the intensity of actions during tactical-technical training and formal matches activities to get more details on load distribution between these activities.

CONCLUSION

We identified that formal matches activities had more demand than match warm-up (before the matches) and physical training activities. However, tactical-technical training activities showed more demand than matches. We can observe that the preparation of these players to the formal matches was accomplished with more volume during tactical-technical training than the formal matches itself. This study is a case study and generalization should be avoided.

Practical applications

The present findings are significant in, at least, two major respects. The coaches may be inspired by these values to inform the distribution of external load during competitive period and understand the activity profile of two players from the Brazilian National Women Beach Volleyball team that won World Championships. However, this is a case study, and therefore the logic behind this study is the key point, while the specific results obtained may have been idiosyncratic (i.e., specific to this team and/or the period of assessment). Tactical-technical training can have greater volume and load than any other activities independent of player's role. However, coaches can be careful to consider only volume without information about intensity.

AUTHOR CONTRIBUTIONS

Summary table about the authors' contribution:

Author's name	Conception and design of the study	Data collection	Data analysis and interpretation	Drafting the article and/or its critical revision	Final approval of the version to be published
A. Medeiros	√		√	√	√
G. Silva	√		√	√	√
M. Simim	√		√	√	√
F. Neto	√	√		√	√
F. Nakamura	√			√	√
L. Palermo	√	√		√	√
A. Ramos	√		√	√	√
J. Afonso	√		√	√	√
I. Mesquita	√		√	√	√

Note that all people who have made substantial contribution to the submitted manuscript (e. g., technical help, writing and editing assistance), yet who do not meet the criteria for authorship, are to be named in the Acknowledgments and shall provide the Authors with their written permission to be named.

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