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Effect of Level of Competition and Drill Typology on Internal and External Load in Male Volleyball Players During the Preseason Period

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Purpose: This study aimed at evaluating the effect of level of competition and drill typology on loads during the preseason period in male volleyball players. ***Methods:*** Internal (percentage of peak heart rate [HR] and summated HR zone) and external (PlayerLoad per minute, total and high accelerations per minute [tACCmin and hACCmin], decelerations per minute [tDECmin and hDECmin], and jumps per minute [tJUMPmin and hJUMPmin]) loads were monitored across a 5-week preseason period in 12 Division 1 (age: 22.5 [3.9] y; stature: 188 [6.2] cm; body mass: 85 [11.6] kg; training experience: 9.4 [4.2] y) and 12 Division 2 (age: 20.7 [2.9] y; stature: 186 [6.2] cm; body mass: 77.8 [9.6] kg; training experience: 5.6 [2.3] y) male volleyball players. Furthermore, differences in load were assessed for each drill typology (warm-up, conditioning, technical, tactical, and integral). ***Results:*** No effects ($P > .05$) of level of competition on the internal (except for summated HR zone, $P = .05$) and external loads (except for tJUMPmin, $P = .002$) were found. Differently, drill typologies showed an effect ($P < .001$) on all the investigated internal- and external-load measures. The main post hoc results revealed higher ($P < .05$) percentage of peak HR, summated HR zone, PlayerLoad per minute, and tACCmin in warm-up and conditioning drills, while higher ($P < .05$) hDECmin and hJUMPmin were found in tactical and integral drills. ***Conclusions:*** These results suggest that volleyball coaches use warm-up and conditioning drills when aiming at increasing the internal loads, PlayerLoad per minute, and tACCmin, while tactical and integral drills should be preferred to enhance the number of hDECmin and hJUMPmin.

Keywords: monitoring training load, volleyball training, inertial measurement unit, accelerations, decelerations, jump

In its operational definition, training load accommodates a variety of measures of various nature and can be quantified using indicators of external and/or internal load.[1] Monitoring training load for team-sport coaches is important to determine whether players are adapting to the provided training programs.[2–5] During the preseason period, team-sport coaches design training programs with the aim of maximally preparing their athletes for the upcoming in-season period.[6] In volleyball, preseason periods are characterized by training loads higher than the in-season period (session rating of perceived exertion [sRPE] = 3492.7 [2320.7] AU vs 3207.0 [2423.0] AU in elite male volleyball players),[7] with training programs tailored on players' individual capacity to improve their physical fitness and abilities.[2,3,8] Moreover, the training load experienced by volleyball players during the preseason period could vary between teams competing at different levels. In fact, coaches can design different training plans for higher and lower level players based on several factors such as players' fitness levels, gym availability (particularly for nonprofessional teams), and the structure of the upcoming in-season period characterized by higher or lower congested match periods. When considering other team sports such as basketball, it has been documented that professional players accumulate almost double load measured via sRPE compared with semiprofessional players[9] during the preseason period. Additionally, Conte and Kamarauskas[10] showed that first-division basketball players competing at the European level reported statistically higher ($P = .002$) sRPE-load values compared with first-division players competing only in the championship during a 5-week preseason period. To the best of authors' knowledge, no previous investigation assessed the differences in load between higher and lower level teams in volleyball. These outcomes could be important for volleyball coaches and practitioners in providing benchmarks about the internal and external loads experienced by players participating in different competitive levels. Therefore, describing the internal and external loads accumulated during the preseason period in different level volleyball players is warranted.

Monitoring the internal and external loads during volleyball training sessions is important to design subsequent training sessions prescribing a training load considered adequate based on specific training aims.[11] Considering that each training unit is composed of various drills (eg, technical, tactical, game-based drills, etc), having a full understanding of the load imposed by each drill typology can be important for volleyball coaches to appropriately design the load of each training unit. For instance, identifying the intensity characterizing the load each volleyball drill typology can provide important feedback for coaches and practitioners to decide whether to implement it in the coming training session. In this regard, de Faria et al[12] showed a higher internal load measured via sRPE in technical and tactical drills compared with strength-training drills ($P < .05$; large effect size [ES]) in professional male volleyball players during a full season. However, this study compared only the internal load of the investigated drills, while a deeper analysis including external-load measures would provide more detailed information for volleyball coaches and practitioners.

Overall, detailing the load experience by volleyball players competing at different levels during the preseason with a special

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emphasis on the description of the load required by each drill typology can provide new insights for volleyball coaches and practitioners. Specifically, it can help in improving the specificity of the training program for higher and lower level players and in selecting drills based not only on their technical and tactical aims, but also on their physical demand to prescribe appropriate training sessions according to the athlete's needs. Therefore, the aim of this study was to quantify the internal and external loads experienced by volleyball players during the preseason period. Specifically, this study aims at evaluating the effects of different levels of competition and drill typologies on the internal and external load measures during the pre-season period in male volleyball players.

Methods

Participants

Twelve players (mean [SD], age: 22.5 [3.9] y; stature: 188 [6.2] cm; body mass: 85 [11.6] kg; training experience: 9.43 [4.19] y) from a team participating in the "Top Sport" Lietuvos Vyrų Tinklinio Čempionatas (Lithuanian Men Volleyball Championship), which represents the highest league in Lithuania (Division 1), and 12 players (age: 20.7 [2.9] y; stature: 186 [6.2] cm; body mass: 77.8 [9.6] kg; training experience: 5.58 [2.29] y) from a team participating in the "Top Sport" Lietuvos Vyrų Tinklinio 1 Lyga (Lithuanian Men Volleyball 1st league), which represents the Lithuanian second division (Division 2), were recruited for this study during the 2021/2022 season. Both Division 1 and Division 2 teams were composed by 4 outside hitters, 2 liberos, and 2 opposites. Additionally, Division 1 team was composed also by 2 middle blockers and 2 setters, while Division 2 team was composed by 3 middle blockers and 1 setter. During the preseason period, all recruited players were free from injuries and participated in at least 50% of practices with all players training at least once a week. Before the commencement of the monitoring period, all the participants (and their parental guardian in case of underage players) received clear explanations of the study aim, procedures, possible risks and benefits of the study, providing written consent was obtained before participation. Ethical approval was obtained from the Social Science Ethical Committee review board of the Lithuanian Sports University (no. SMTEK-123).

Design

This study encompasses a descriptive design with data collected across 5 weeks of the preseason period of the 2021/2022 season (September 13th–October 17th for Division 1 team and September 15th–October 19th for Division 2 team). During the monitored period, Division 1 team completed 15 training sessions (ie, 3 weekly sessions), while Division 2 team completed 14 training sessions (ie, 3 weekly sessions and 1 week with 2 training sessions), with each training session lasting ∼90 minutes for both teams (Table 1). Furthermore, each team played one friendly game across the monitored period. Friendly games have been included in the data and divided by drill typologies warm-up (part without the ball), technical (pepper, spikes over the net and services), and integral (3vs3 to 6v6). Finally, the Division 1 team performed 2 weekly strength and conditioning sessions in the gym, which were not monitored in the present study, while no gym sessions were carried out by the Division 2 team. Each training session was planned by the coaching staff without any influence from the research staff, which was only involved in the monitoring process.

Methodology

Internal and external training loads were monitored for each training session, which were composed of 5 typologies: warm-up, conditioning, technical, tactical, and integral. Each drill typology was defined by the research and coaching staff as indicated in Table 2. Interruptions during training sessions (ie, between-drills breaks, water breaks, and drill explanations) were removed from the analysis, while the entire drill execution with resting phases were included in the analysis.

Internal training load was objectively measured using heart-rate (HR) chest belts (Polar H10, Polar Electro). Players' peak HR was defined using the peak HR reached during the full preseason training sessions and friendly games. Players' HR were then expressed as percentage of the HR peak (%HR_{peak}) and summated heart rate zone (SHRZ), which was calculated as follows: (duration in zone 1×1) + (duration in zone 2×2) + (duration in zone 3×3) + (duration in zone 4×4) + (duration in zone 5×5), where zone 1 = 50% to 59.9% of HR_{peak}, zone 2 = 60% to 69.9% HR_{peak}, zone 3 = 70% to 79.9% HR_{peak}, zone 4 = 80% to 89.9% HR_{peak}, zone 5 = 90% to 100% HR_{peak}, and duration is time in minutes.[13]

Before each training session players were equipped with triaxial accelerometers T6 (Catapult Innovations) sampling at 100 Hz to calculate instantaneous movement demands (in arbitrary units) to assess their external load measures. Players wore neoprene vests with accelerometers placed in a pocket positioned between the scapulae at the thoracic level. Each player was monitored with the same device across the full preseason period to avoid problems of interunit reliability.[14] Various external load measures were collected and reported relative to the training session duration in minutes. PlayerLoad was calculated as $[\sqrt{(Ac1_n - Ac1_{n-1})^2 + (Ac2_n - Ac2_{n-1})^2 - (Ac3_n - Ac3_{n-1})^2}]/100$, where Ac1, Ac2, and Ac3 are the orthogonal components measured from the triaxial accelerometer and 100 is the scaling factor,[15] and reported per minute (PLmin). This measure has been previously used in volleyball players.[16] Furthermore, acceleration per minute (ACCmin) and deceleration per minute (DECmin) were measured and classified as total (tACCmin and tDECmin) and high intensity (hACCmin and hDECmin), which refer to the total inertial movements registered in a forward acceleration and deceleration vector within the high band (≥3.5 $m \cdot s^{-2}$ and <−3.5 $m \cdot s^{-2}$ for hACC and hDEC, respectively). Moreover, total jumps per minute (tJUMPmin) and high jumps per minute (hJUMPmin) performed within the high band (≥0.4 m) were registered.[17] The selected measures of external load calculated from the inertial movement units showed good reliability in previous studies investigating team sports.[18] All internal and internal load data were processed using OpenField software (version 1.18, Catapult Innovations) and downloaded for statistical analysis.

Statistical Analysis

Mean and SD were calculated as descriptive statistics. For the data analysis, 136 training samples for Division 1 and 129 training samples for Division 2 were used. Data were individually analyzed by using linear mixed models to assess the differences in internal and external load measures having level of competition (Division 1 vs Division 2) and drill typology as fixed effects, and players as random effect considered with random intercept and fixed slope. All linear mixed models produced an Akaike information criterion ranging from −673.333 to 12,982.902 and a Bayes information criterion ranging from −611.264 to 13,045.695. The assumption of normality for residual values was checked using Kolmogorov–Smirnov test. Post hoc analysis with Bonferroni correction was used in case of significant differences. Cohen *d* ESs were also

Table 1 Plan of the Training Sessions for Both Divisions During the Preseason

	Division 1								Division 2						
Session	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**
Typology	C & TE	C & TE	C & TE	C & TE	C & TE	TE & TA	TE & TA	TE & I	C & TE	C & TE	C & TE	C & TE	C & TE	TE & TA	TA & I
Duration, min	81	80	83	85	83	81	82	58	93	101	105	98	89	110	99
Session	**S9**	**S10**	**S11**	**S12**	**S13**	**S14**	**S15**		**S8**	**S9**	**S10**	**S11**	**S12**	**S13**	**S14**
Typology	FG	TA & I	TA & I	TE & I	I	TE & TA	TE & I		TA & I	TA & I	TA & I	FG	TA & I	TE & I	TE & I
Duration, min	134	79	83	80	102	77	80		94	99	95	126	107	92	93

Abbreviations: C, conditioning sessions (ie, training sessions with the majority of time spent executing conditioning exercises); FG, friendly games; I, integral sessions (ie, training sessions with the majority of time spent executing volleyball-game-based situations from 3vs3 to 6vs6); S, session; TA, tactical sessions (ie, training sessions with the majority of the time spent executing defensive and offensive systems based on volleyball-game-like situations); TE, technical sessions (ie, training sessions with the majority of time spent executing fundamental individual or group volleyball technique improving specific drills).

calculated for statistically significant post hoc analyses using the following formula: $2t\sqrt{\text{degrees of freedom}}$. Cohen d ESs were interpreted as follows: trivial ≤ 0.20, small = 0.20 to 0.59, moderate = 0.60 to 1.19, large = 1.20 to 1.99, and very large ≥ 2.00.[19] An alpha level of $P \le .05$ was set a priori for statistical significance. All data were analyzed using Jamovi software (version 2.3.21, 2023).

Results

Internal Load

Results revealed no effect for division ($P = .159$) and interaction ($P = .423$) in $\%HR_{peak}$, while an effect for drill typology was found ($P < .001$) (Table 3). Post hoc analysis considering drill typology indicated higher $\%HR_{peak}$ for conditioning compared with warm-up ($P < .001$; ES = 0.63, moderate), technical ($P < .001$; ES = 0.61, moderate), tactical ($P < .001$; ES = 0.40, small), and integral ($P < .001$; ES = 0.55, moderate). Moreover, a difference between tactical and warm-up was found ($P = .001$; ES = 0.21, small).

SHRZ values showed an effect for both division ($P = .050$), drill typology ($P < .001$), and their interaction ($P < .001$) (Table 3). Post hoc analysis considering drill typology showed that conditioning was higher compared with warm-up ($P < .001$; ES = 0.63, moderate), technical ($P < .001$; ES = 0.61, moderate), tactical ($P < .001$; ES = 0.40, small), and integral ($P < .001$; ES = 0.55, moderate). Furthermore, lower SHRZ values were shown in warm-up compared with technical ($P < .001$; ES = 0.40, small), tactical ($P < .001$; ES = 0.91, moderate), and integral ($P < .001$; ES = 0.95, moderate). Moreover, technical drills showed lower SHRZ compared with tactical ($P < .001$; ES = 0.67, moderate) and integral ($P < .001$; ES = 0.69, moderate) drills. Post hoc analyses for interactions are displayed in Table 4.

External Load

The results of the external load measures showed no effect ($P > .05$) of division for all the investigated measures except for tJUMPmin ($P = .002$) (Table 5). Differently, a drill typology effect was found for all the investigated external load measures ($P < .001$; Table 5).

Table 2 Description of Drill Typologies

Drill typology	Drill description
Warm-up	Specific warm-up drills aiming at increasing body temperature and preparing the body for the subsequent activities using dynamic stretching exercises. Volleyball conditioning, technical, tactical, and integral drills were not included in these drills.
Conditioning	Drills simulating volleyball movement patterns, organized in stations, and focusing on the development of the main volleyball physical qualities (ie, sprinting, changing of direction, acceleration, deceleration, jumping, etc). For instance, peppering drills with players in pairs executing passing/setting/spiking to each other and conditioning exercises in-between the technical executions.
Technical	Drills used for technical development with players organized individually or in groups and focusing on one or more technical fundamentals. These drills have no continuity and usually no more than 2 volleyball actions involved. For instance, in the technical drill to improve the serve technique, players only perform serve (eg, to a target). In case of drills focusing on more than one skill (ie, serve-reception), some players were performing serve only and other players receive only. For example, the drills involving defense and set encompass players or coaches performing spikes from the net (possibly on a box) to one or more defensive players. The player defending the spike has to take the right position to defend the ball, and the player not defending the spike has to set the ball (for instance to a target), prepare for next defense, and set actions.
Tactical	Drills used for tactical development of the offensive and defensive systems based on game-like situations. Most of the time these drills do not have continuity and usually more than 2 volleyball actions are performed. For instance, if a defensive system is trained, the coach starts the drill reproducing a possible opponent attack (ie, tip or attacking action from various spot on the other side of the net) and players are in defensive and blocking positions to perform the defense. Successively, players start the transition phase, set the ball, and perform an attack to opponents' side. If an offensive system is performed, most of the time the team starts from side-out position, pass, set, and create attacks to the opponent's side. In case of continuity of the action, the drill continues until the point is scored (or when the spike situation is over).
Integral	Game-based drills from 3v3 to 6v6. These drills differentiate from other drill typologies because they always have 2 teams involved in a competition fashion, always start from the service, and are more game-based than technical and tactical drills, mainly focusing on specific scenarios. For instance, in 3v3 to 5v5 games-based drills, side-out situations are mostly played where the service team must win the point against the receiving team to go to the other side of the net. The 6v6 games usually start when one team serves and plays the point until the end. After this scenario, extra 2–4 situations (1 defense situation for each team, and free ball for last situation winner) might be added by the coach. Depending on the scoring system, points are collected.

Table 3 Mean (SD) for Internal-Load Variables With Statistical Differences for Drill Typology, Division, and Their Interactions

Internal-load measure	Division	Warm-up	Conditioning	Technical	Tactical	Integral	P		
							Drill	Division	Interaction
HR_{peak}, %	1	74.86 (6.55)	81.63 (5.23)	76.18 (6.24)	77.30 (6.72)	77.20 (5.93)	<.001	.159	.423
	2	72.96 (7.60)	79.36 (6.33)	73.76 (7.07)	75.01 (6.39)	73.61 (7.51)			
SHRZ, AU	1	21.63 (11.62)	83.31 (41.80)	39.79 (21.77)	55.83 (29.53)	66.67 (23.95)	<.001	.050	<.001
	2	24.67 (12.61)	92.77 (42.23)	37.94 (26.40)	79.50 (25.28)	58.78 (25.81)			

Abbreviations: HR_{peak}, peak heart rate; SHRZ, summated heart-rate zone; AU, arbitrary units.

Table 4 Post Hoc Analyses for the Summated-Heart-Rate-Zone Interactions

		D1					D2				
	Drill	Warm-up	Conditioning	Technical	Tactical	Integral	Warm-up	Conditioning	Technical	Tactical	Integral
D1	Warm-up		/	/	/	/	/	/	/	/	/
	Conditioning	↑$P < .001$; ES = 0.94, moderate		/	/	/	/	/	/	/	/
	Technical	↑$P < .001$; ES = .34, small	↓$P < .001$; ES = 0.73, moderate		/	/	/	/	/	/	/
	Tactical	↑$P < .001$; ES = .52, small	↓$P < .001$; ES = 0.38, small	↑$P < .001$; ES = 0.27, small		/	/	/	/	/	/
	Integral	↑$P < .001$; ES = 0.80, moderate	↓$P < .001$; ES = 0.27, small	↑$P < .001$; ES = 0.55, small			/	/	/	/	/
D2	Warm-up		↓$P < .001$; ES = 1.90, large	↓$P < .05$; ES = 0.68, moderate	↓$P < .001$; ES = 0.99, moderate	↓$P < .001$; ES = 1.76, large		/	/	/	/
	Conditioning	↑$P < .001$; ES = 2.76, very large		↑$P < .001$; ES = 2.50, very large	↑$P < .001$; ES = 1.17, moderate	↑$P < .001$; ES = 1.14, moderate	↑$P < .001$; ES = 0.98, moderate		/	/	/
	Technical	↑$P < .001$; ES = 0.95, moderate	↓$P < .001$; ES = 2.04, very large		↓$P = .001$; ES = 0.78, moderate	↓$P < .001$; ES = 1.82, large	↑$P = .001$; ES = 0.23, small	↓$P < .001$; ES = 0.94, moderate		/	/
	Tactical	↑$P < .001$; ES = 2.11, very large		↑$P < .001$; ES = 1.74, large	↑$P < .001$; ES = 0.71, moderate		↑$P < .001$; ES = 0.77, moderate	↓$P < .05$; ES = 0.19, trivial	↑$P < .001$; ES = 0.68, moderate		/
	Integral	↑$P < .001$; ES = 1.94, large	↓$P < .001$; ES = 1.02, moderate	↑$P < .001$; ES = 1.28, large			↑$P < .001$; ES = 0.56, small	↓$P < .001$; ES = 0.55, small	↑$P < .001$; ES = 0.43, small	↑$P < .001$; ES = 0.33, small	

Abbreviations: ↑, higher compared with the conditions on top of the table; ↓, lower compared with the conditions on top of the table; AU, arbitrary units; D1, Division 1; D2, Division 2; ES, effect size.

Table 5 Mean (SD) for External-Load Variables with Statistical Differences for Drill Typology, Division, and Their Interactions

Measure	Division	Warm-up	Conditioning	Technical	Tactical	Integral	*P* Drill	*P* Division	*P* Interaction
PLmin, AU·min^{-1}	1	8.46 (3.06)	6.42 (1.19)	4.92 (1.41)	4.83 (1.38)	4.92 (1.44)	<.001	.267	<.001
	2	6.46 (1.51)	6.43 (1.41)	4.95 (1.17)	5.06 (0.66)	4.87 (0.99)			
hACCmin, n·min^{-1}	1	0.21 (0.26)	0.17 (0.17)	0.17 (0.24)	0.11 (0.13)	0.13 (0.11)	<.001	.613	.229
	2	0.20 (0.23)	0.18 (0.24)	0.15 (0.19)	0.15 (0.12)	0.15 (0.13)			
tACCmin, n·min^{-1}	1	1.50 (1.06)	1.90 (0.83)	1.47 (0.88)	1.34 (0.71)	1.33 (0.69)	<.001	.588	.068
	2	1.54 (0.71)	1.86 (0.88)	1.18 (0.77)	1.33 (0.61)	1.22 (0.52)			
hDECmin, n·min^{-1}	1	0.06 (0.13)	0.04 (0.06)	0.05 (0.10)	0.06 (0.07)	0.06 (0.07)	<.001	.110	<.001
	2	0.05 (0.08)	0.05 (0.20)	0.06 (0.14)	0.15 (0.23)	0.11 (0.15)			
tDECmin, n·min^{-1}	1	1.42 (1.02)	1.34 (0.62)	1.26 (0.73)	1.90 (1.29)	1.56 (0.89)	<.001	.589	.882
	2	1.41 (0.80)	1.47 (1.03)	1.30 (0.74)	1.97 (0.74)	1.65 (0.78)			
hJUMPmin, n·min^{-1}	1	0.73 (0.76)	0.58 (0.64)	0.43 (0.58)	0.44 (0.68)	0.31 (0.44)	<.001	.214	<.001
	2	0.11 (0.15)	0.02 (0.05)	0.99 (1.09)	1.06 (0.48)	0.90 (0.64)			
tJUMPmin, n·min^{-1}	1	1.60 (1.53)	1.41 (1.14)	0.71 (0.77)	0.66 (0.78)	0.55 (0.76)	<.001	.002	<.001
	2	1.27 (1.07)	1.17 (0.72)	1.76 (1.21)	1.74 (0.63)	1.38 (0.72)			

Abbreviations: hACCmin, high accelerations per minute; hDECmin, high decelerations per minute; hJUMPmin, high jumps per minute; PLmin, PlayerLoad per minute; tACCmin, total accelerations per minute; tDECmin, total decelerations per minute; tJUMPmin, total jumps per minute.

Post hoc analyses for drill typology showed higher PLmin for conditioning compared with technical ($P < .001$; ES = 0.66, moderate), tactical ($P < .001$; ES = 0.53, small), integral ($P < .001$; ES = 0.66, moderate), and lower compared with warm-up ($P < .001$; ES = 0.40, small). Moreover, warm-up drills showed higher PLmin values compared with technical ($P < .001$; ES = 1.20, moderate), tactical ($P < .001$; ES = 0.94, moderate), and integral ($P < .001$; ES = 1.16, moderate) typologies.

Considering accelerations, higher hACCmin for warm-up compared with technical ($P < .05$, ES = 0.16, trivial), tactical ($P < .05$; ES = 0.21, small), and integral ($P < .001$; ES = 0.24, small) were found. Furthermore, tACCmin showed higher values for conditioning compared with warm-up ($P < .001$; ES = 0.27, small), technical ($P < .001$; ES = 0.47, small), tactical ($P < .001$; ES = 0.38, small), and integral ($P < .001$; ES = 0.49, small). Moreover, warm-up typology indicated higher tACCmin values compared with technical ($P < .05$; ES = 1.17, trivial) and integral ($P < .05$; ES = 0.21, small) typologies.

When calculating post hoc analysis for drill typology for decelerations, lower hDECmin for conditioning compared with tactical ($P < .001$; ES = 0.24, small) and integral ($P < .05$; ES = 0.21, small) typologies were found. Moreover, integral drill typology showed higher hDECmin values compared with warm-up ($P < .05$; ES = 0.17, trivial) and technical ($P < .05$; ES = 0.18, trivial) typologies, while tactical drills showed higher hDECmin compared with warm-up ($P < .05$; ES = 0.21, small) and technical ($P = .001$; ES = 0.22, small) typologies. Tactical typology showed a higher tDECmin compared with warm-up ($P < .001$; ES = 0.34, small), conditioning ($P < .001$; ES = 0.34, small), technical ($P < .001$; ES = 0.48, small), and integral ($P < .001$; ES = 0.24, small) typologies. Furthermore, integral drills showed higher tDECmin compared with technical typology ($P < .001$; ES = 0.30, small).

The post hoc analysis of jumps revealed lower hJUMPmin for conditioning compared with technical ($P < .001$; ES = 0.39, small), tactical ($P < .001$; ES = 0.35, small), and integral ($P < .001$; ES = 0.28, small) drill typologies. Moreover, warm-up drills showed lower hJUMPmin values compared with technical ($P < .001$; ES = 0.30, small), tactical ($P < .001$; ES = 0.27, small), and integral ($P < .05$; ES = 0.18, trivial) drill typologies. Post hoc analysis also revealed integral drills with lower tJUMPmin values compared with warm-up ($P < .001$; ES = 0.31, small), conditioning ($P < .05$; ES = 0.20, trivial), and technical ($P < .05$; ES = 0.21, small) typologies. Finally, the analysis of the interaction for external load measures showed an effect for PLmin ($P < .001$), hDECmin ($P < .001$), hJUMPmin ($P < .001$), and tJUMPmin ($P < .001$). Post hoc analysis results are show in Tables 6, 7, and 8 for PLmin, hDECmin, and jumps (hJUMPmin and tJUMPmin), respectively.

Discussion

This is the first study comprehensively quantifying the internal and external loads of male volleyball players during the preseason period, and specifically assessing the effects of level of competition and drill typology on players' loads. The main results revealed no effect of level of competition on most of the investigated external load measures, while Division 2 team showed a statistically ($P = .05$) higher SHRZ compared with Division 1 team. Additionally, an effect of drill typology was found in all the internal and external load measures with overall highest values of $\%HR_{peak}$ and SHRZ in conditioning drills. Furthermore, the highest PLmin and tACCmin were found in warm-up drills, while the highest hDECmin were registered in tactical and integral drills. The tJUMPmin was the only variable differentiating between both level of competition and drill typology with Division 2 players performing more jumps across the preseason period and with the highest values recorded in technical, tactical, and integral drills for Division 2 and warm-up and conditioning drills for Division 1. These results can provide useful indication for volleyball coaching staff to design their training sessions during the preseason.

The analysis of the level of competition indicated no differences in most of the monitored external load measures between Division 1 and Division 2 teams. This outcome indicates a similar training prescription from the coaching staffs of both teams across the preseason period. Interestingly, when considering the internal

Table 6 Post Hoc Analyses for the PLmin Interactions

	Drill	D1 Warm-up	D1 Conditioning	D1 Technical	D1 Tactical	D1 Integral	D2 Warm-up	D2 Conditioning	D2 Technical	D2 Tactical	D2 Integral
D1	Warm-up		/	/	/	/	/	/	/	/	/
	Conditioning	↓$P < .001$; ES = 0.57, small		/	/	/	/	/	/	/	/
	Technical	↓$P < .001$; ES = 1.26, large	↓$P < .001$; ES = 0.48, small		/	/	/	/	/	/	/
	Tactical	↓$P < .001$; ES = 0.99, moderate	↓$P < .001$; ES = 0.40, small			/	/	/	/	/	/
	Integral	↓$P < .001$; ES = 1.19, moderate	↓$P < .001$; ES = 0.47, small				/	/	/	/	/
D2	Warm-up	↓$P < .001$; ES = 1.69, large		↑$P = .001$; ES = 1.46, large	↑$P < .05$; ES = 1.22, large	↑$P = .001$; ES = 1.43, large		/	/	/	/
	Conditioning	↓$P < .001$; ES = 1.72, large		↑$P < .05$; ES = 1.43, large	↑$P < .05$; ES = 1.19, moderate	↑$P = .001$; ES = 1.40, large			/	/	/
	Technical	↓$P < .001$; ES = 3.50, very large	↓$P < .05$; ES = 1.32, large				↓$P < .001$; ES = 0.47, small	↓$P < .001$; ES = 0.46, small		/	/
	Tactical	↓$P < .001$; ES = 2.76, very large	↓$P < .05$; ES = 1.01, moderate				↓$P < .001$; ES = 0.36, small	↓$P < .001$; ES = 0.35, small			/
	Integral	↓$P < .001$; ES = 3.44, very large	↓$P < .05$; ES = 1.34, large				↓$P < .001$; ES = 0.48, small	↓$P < .001$; ES = 0.46, small			

Abbreviations: ↑, higher compared with the conditions on top of the table; ↓, lower compared with the conditions on top of the table; D1, Division 1; D2, Division 2; ES, effect size; PLmin, PlayerLoad per minute.

Table 7 Post Hoc Analyses for the High-Decelerations-per-Minute Interaction

		D1					D2				
	Drill	Warm-up	Conditioning	Technical	Tactical	Integral	Warm-up	Conditioning	Technical	Tactical	Integral
D1	Warm-up		/	/	/	/	/	/	/	/	/
	Conditioning			/	/	/	/	/	/	/	/
	Technical				/	/	/	/	/	/	/
	Tactical					/	/	/	/	/	/
	Integral						/	/	/	/	/
D2	Warm-up							/	/	/	/
	Conditioning								/	/	/
	Technical									/	/
	Tactical	↑$P < .05$; ES = 0.82, moderate	↑$P < .05$; ES = 0.92, moderate	↑$P < .05$; ES = 1.00, moderate	↑$P < .05$; ES = 0.74, moderate	↑$P = .05$; ES = 0.81, moderate	↑$P < .001$; ES = 0.30, small	↑$P < .001$; ES = 0.29, small	↑$P < .001$; ES = 0.30, small		/
	Integral						↑$P < .05$; ES = 0.21, small	↑$P < .05$; ES = 0.19, trivial	↑$P < .05$; ES = 0.20, small		

Abbreviations: ↑, higher compared with the conditions on top of the table; D1, Division 1; D2, Division 2; ES, effect size.

Table 8 Post Hoc Analyses for the tJUMPmin and hJUMPmin Interactions

Variable		Drill	D1					D2				
			Warm-up	Conditioning	Technical	Tactical	Integral	Warm-up	Conditioning	Technical	Tactical	Integral
hJUMPmin	D1	Warm-up		/	/	/	/	/	/	/	/	/
		Conditioning			/	/	/	/	/	/	/	/
		Technical	↓$P < .05$; ES = 0.22, small			/	/	/	/	/	/	/
		Tactical					/	/	/	/	/	/
		Integral	↓$P < .001$; ES = 0.29, small					/	/	/	/	/
	D2	Warm-up	↓$P < .001$; ES = 1.09, moderate	↓$P < .05$; ES = 0.71, moderate					/	/	/	/
		Conditioning	↓$P < .001$; ES = 1.23, large	↓$P < .001$; ES = 0.83, moderate	↓$P < .05$; ES = 0.85, moderate					/	/	/
		Technical		↑$P < .05$; ES = 0.77, moderate	↑$P < .001$; ES = 1.58, large	↑$P < .001$; ES = 1.01, moderate	↑$P < .001$; ES = 1.73, large	↑$P < .001$; ES = 0.60, small	↑$P < .001$; ES = 0.66, moderate		/	/
		Tactical		↑$P < .05$; ES = 0.66, moderate	↑$P < .001$; ES = 1.17, moderate	↑$P < .001$; ES = 0.83, moderate	↑$P < .001$; ES = 1.29, large	↑$P < .001$; ES = 0.54, small	↑$P < .001$; ES = 0.58, small			/
		Integral			↑$P < .05$; ES = 1.22, large	↑$P < .05$; ES = 0.80, moderate	↑$P < .001$; ES = 1.39, large	↑$P < .001$; ES = 0.52, small	↑$P < .001$; ES = 0.57, small			
tJUMPmin	D1	Warm-up		/	/	/	/	/	/	/	/	/
		Conditioning			/	/	/	/	/	/	/	/
		Technical	↓$P < .001$; ES = 0.47, small	↓$P < .001$; ES = 0.33, small		/	/	/	/	/	/	/
		Tactical	↓$P < .001$; ES = 0.39, small	↓$P < .001$; ES = 0.29, small			/	/	/	/	/	/
		Integral	↓$P < .001$; ES = 0.51, vsmall	↓$P < .001$; ES = 0.37, small				/	/	/	/	/
	D2	Warm-up					↑$P < .05$; ES = 0.91, moderate		/	/	/	/
		Conditioning								/	/	/
		Technical			↑$P < .001$; ES = 2.04, very large	↑$P < .001$; ES = 1.44, large	↑$P < .001$; ES = 2.12, very large	↑$P = .001$; ES = 0.24, small	↑$P < .001$; ES = 0.28, small		/	/
		Tactical			↑$P < .001$; ES = 1.36, large	↑$P < .001$; ES = 1.05, moderate	↑$P < .001$; ES = 1.44, large	↑$P = .05$; ES = 0.18, trivial	↑$P < .05$; ES = 0.22, small			/
		Integral			↑$P < .05$; ES = 1.21, large	↑$P < .05$; ES = 0.89, moderate	↑$P < .001$; ES = 1.35, large			↓$P < .05$; ES = .22, small		

Abbreviations: ↑, higher compared with the conditions on top of the table; ↓, lower compared with the conditions on top of the table; D1, Division 1; D2, Division 2; ES, effect size; hJUMPmin, high jumps per minute; tJUMPmin, total jumps per minute.

load measures, while no differences were shown in the $\%HR_{peak}$, Division 2 team showed a statistically higher SHRZ compared with Division 1 team across the investigated period. It is possible that Division 2 players had a lower fitness level compared with the Division 1 players, and this might have provoked higher internal responses to a similar external load. Indeed, previous investigations showed lower anaerobic[20,21] and aerobic[22] capacities in lower-level compared with higher level male volleyball players. However, it should be noted that the difference in SHRZ was supported by a *P* value = .05, and that no differences were shown for the $\%HR_{peak}$ (*P* = .159) indicating that our results should be taken with caution and that further investigations are necessary to assess whether a difference in competition level applies in internal load measures during the preseason period. Overall, this outcome highlights the importance of monitoring both internal and external load measures across the preseason period in volleyball players to assess whether their physiological responses are in line with those expected and with the proposed external load.

Another aspect to consider when monitoring training load is the different drill typologies implemented during the training sessions. Indeed, our results showed an effect of drill typology on all the studied internal and external load measures. With regard to $\%HR_{peak}$ and SHRZ, it is interesting to note that the highest values were recorded in the conditioning drills with values of ~80% HR_{peak} in both divisions and with SHRZ values ranging between 83 and 93 AU. These results were expected since these drills were specifically developed with the aim of inducing a high internal response to stimulate an increase in players' fitness levels during the preseason period. Nevertheless, it is interesting to note that while high $\%HR_{peak}$ was recorded for the warm-up drills in both levels of competition (~74% HR_{peak}), the SHRZ scores represented the lowest values (~24 AU). Specifically, warm-up drills showed lower SHRZ values (*P* < .001; ES = small to very large) compared with other drill typologies in both Division 1 and Division 2 teams. This outcome is quite interesting since it might indicate that players were mainly in the lower zones (zone 1 = 50%–59.9% HR_{peak}, zone 2 = 60%–69.9% HR_{peak}, zone 3 = 70%–79.9%) used to calculate the SHRZ, which seems more sensitive to reduce training intensities than the $\%HR_{peak}$. If we consider that, during warm-up drills, the overall external load intensities (ie, PLmin) reached the highest values conversely than SHRZ (players reached the lowest SHRZ scores), we can speculate a low commonality between these 2 load measures. While various investigations assessed the relationship between internal and external load measures across various team sports,[23–25] and specifically in volleyball,[26] no information is available in the current literature between the variables studied in our study encompassing various external load measures and objective internal load measures in volleyball calling for further studies.

The analysis of the difference between drill typologies in external load measures showed that warm-up and conditioning drills documented the highest value in PLmin and tACCmin compared with the other drill typologies. Moreover, an interaction effect (*P* < .001) between drill typologies and division was found for PLmin indicating that warm-up represented the highest values for all between and within comparisons, except between warm-up for Division 2 players, and conditioning drills in Division 1. The different intensity of the drills can be explained by the nature of the proposed drill typologies. Overall, during the warm-up and conditioning drills, all players are concomitantly active on the court and without long breaks between different actions. Differently, during the technical, tactical, and integral drills, not all players were active on the court including resting phases between different actions. For instance, in technical drill including receiving and setting actions, only 4 players at the time with specific positions (eg, receiver and setter) were involved (2 in each side of the court). Additionally, considering hACCmin and tACCmin, the highest values found in warm-up and conditioning drills compared with other typologies can be explained by the proposed actions in these drills. Indeed, during warm-up and conditioning drills, players were mostly required to accelerate as fast as possible starting from a standing position over very short distances ~5 m, which is a typical activity required during volleyball matches[27] due to a reduced court dimension similarly to other court-based team sports.[28,29]

When considering decelerations, a previous investigation using the same inertial measurement units as in our study showed that decelerations represent an important part for volleyball players with women's collegiate players performing an average of 94.8 (52.9) and 66.0 (39.7) decelerations during training sessions and matches, respectively.[30] However, these data involve only absolute values, while an analysis of the number of decelerations per minute can provide a better indication of the external load intensities during training sessions. In our study, we investigated the number of tDECmin and hDECmin, which indicated higher values in tactical drills compared with the other drill typologies except for similar values reported between integral and tactical drills in hDECmin. An interaction in hDECmin was also found between division and drill typology with post hoc analyses mostly showing higher hDECmin in tactical drills in Division 2 players compared with all other drill typologies for both levels of competition players (small-to-moderate ESs), while no differences were found within Division 2 players between tactical and integral drills. The high intensities found when considering deceleration movements in tactical and integral drills can be explained due to the volleyball-specific movements performed during these drill typologies. Indeed, during tactical and integral drills, players were required to accelerate to the net for blocking or spiking actions and were successively required to decelerate their movements due to the small court size in volleyball and to avoid rules violation. For instance, players cannot touch the net and cross the middle line after spiking, which in turn likely increases the deceleration phase at the end of the spiking action. Moreover, in these drills, there is a high cognitive component, which makes players perform various accelerations and decelerations. For instance, when the setter is handling the ball, 3-to-4 players are preparing (ie, accelerating and subsequently decelerating) for the spike since they do not know where the ball will be set. Differently, during technical drills, which are mostly performed in individual fashion or in pairs with lower cognitive components, players were aware of where the ball will arrive so that could adjust to perform their technical actions without the necessity of high acceleration and decelerations.

Considering jumping actions, it has been previously found an effect of level of competition on jumping abilities with Division 1 players reporting higher jump height across various testing procedures compared with Division 2 male volleyball players.[21] However, although the better jumping ability, our findings demonstrated Division 1 players were jumping less frequently than their Division 2 counterparts across the preseason period and particularly during technical, tactical, and integral drills. The possible reason for this outcome could be the difference in training experience between the 2 investigated teams (9.43 [4.19] y and 5.58 [2.29] y for Division 1 and Division 2 players, respectively). Possibly, more experienced players were able to read better the game-based activities avoiding unnecessary jumps, for instance not jumping on poor sets or while blocking on players faking the spike. Future studies should also assess not only the jump frequency but also the heights of the jump reached during various drills across different competitive levels.

Although this study provides useful insights for volleyball coaches, some limitations should be mentioned. First, it was not possible to collect sRPE data for each drill, which could have provided additional information about the internal load perceived by the volleyball athletes. Additionally, our sample was representative of male teams competing in the Division 1 and Division 2 of the Lithuanian Men's Volleyball Championships making our results unlikely generalizable to other teams competing in different leagues and likely exposed to different training schedules. Finally, the recruited teams were only monitored across the preseason period, while the training drills might be different during the in-season period and could lead to different internal and external load responses. Therefore, future studies should focus on the analysis of volleyball teams competing in other championships and across various parts of the season.

Practical Applications

From a practical standpoint, our results provide an interesting snapshot of the load accumulated by male volleyball players, competing in different divisions and across different drill typologies during the preseason. Overall, our study showed an effect of drill typology on both internal and external load measures, indicating that volleyball coaches and practitioners should adopt an efficient monitoring system during their training sessions. Indeed, the quantification of the load of each drill typology can better assist coaches in the planning of their training sessions and microcycles during the preseason periods. Specifically, coaches should use warm-up and conditioning drills when aiming at increasing the internal loads (% HR_{peak} and SHRZ), tACCmin, and overall PLmin, while they should prefer tactical and integral drills when intending to focus on the number of hDECmin and hJUMPmin during their training sessions. Additionally, we found that the proposed drills provided similar outcomes in most of the investigated training load measures in both levels of competition allowing coaches to plan training sessions similarly for these 2 competition levels.

Conclusions

In conclusion, our results provide a description of the load experienced by Division 1 and Division 2 male volleyball players during the preseason period. No effects of level of competition were found on the internal (except for SHRZ) and external loads (except for tJUMPmin). Differently, drill typologies showed an effect on all the investigated internal- and external-load measures with the main results showing higher $\%HR_{peak}$, SHRZ, PLmin, and tACCmin in warm-up and conditioning drills, while higher levels of hDECmin and hJUMPmin were found in integral and tactical drills. These results indicate the necessity to monitor the training load according to drill typologies to better plan and design the training units during the preseason period in volleyball.

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