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Positional Differences in External Load in Professional Male Volleyball Players

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Abstract Quantifying training loads as the amount of stress that athletes are exposed to during a practice session and/or game has received increased attention in recent years. The inertial measurement unit (IMU) has become one of the most commonly implemented technologies for monitoring external loads in volleyball. Thus, the purpose of the present study was to examine differences in the external load variables obtained via Vert™ IMU between different playing positions (e.g., setter, middle blocker, outside, and opposite hitter) in professional male volleyball players. Eighteen athletes competing in one of the top European volleyball leagues volunteered to participate in the present study. The average of the following external load variables was obtained across three practice sessions: *Stress*, *Jumps*, *Jumps 15+*, *Jumps 20+*, *Highest Jump*, and *Average Jump Height*. The results of the present study indicated that outside hitters had a significantly greater number of *Jumps 20+* as well as a greater *Highest Jump* when compared to the setters, while opposite hitters had significantly greater *Highest Jump* than both setters and middle blockers. In addition, setters demonstrated lower *Average Jump Height* when compared to the outsides and opposites. These findings may help strength and conditioning practitioners and volleyball coaches to develop position-specific training regimens and eventually decrease the likelihood of overuse injuries.

Keywords: *team sports, accelerometry, coaching, performance, vertical jump, workload*

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1. Introduction

Quantifying training loads as the amount of stress that athletes are exposed to during a practice session and/or game has received increased attention over the last couple of years. One of the most commonly implemented technologies that allow sports scientists and strength and conditioning practitioners to obtain direct insight into an athlete's external load measures (i.e., number of jumps, total running distance, high-speed distance) is the inertial measurement unit (IMU) [1,2]. Previous research has documented that the IMU device is capable of effectively detecting sport-specific skills and accurately quantifying external training loads in team sports such as basketball, volleyball, and soccer [3-8].

Vlantes and Readdy [9] quantified external training loads during National Collegiate Athletic Association (NCAA) Division-I female volleyball competitions using an IMU device (i.e., Catapult™) and found that setters had the greatest number of jumps when compared to outside hitters, opposite hitters, middle blockers, and defensive specialists. In addition, the number of submaximal jumps was greatest for the setters, while the highest stress values from maximal jumping were observed for middle blockers [9,10]. Reina-Roman et al. [11] used a similar IMU device (i.e., Wimu™) to examine differences in training loads between practice sessions and games as well as different playing positions in female basketball players. Greater loads were observed during competition when compared to the practice sessions, with centers having the lowest impacts and smallest number of jumps, and power forwards having the greatest external load values [11]. However, when examined in male basketball players (i.e., Catapult™), greater external loads were observed during 5-vs-5 training tasks when compared to the actual game [8]. Also, unlike female basketball athletes, male power forwards had the lowest external load values when compared to all other playing positions (i.e., centers, point guards, and small forwards) [12].

One of the most commonly used IMU devices for the assessment of external load in volleyball is Vert™ [1,3,6]. Borges et al. [3] found that maximal vertical jump heights assessed via Vert™ during volleyball blocking and attacking motions were strongly correlated with values obtained from Vertec™ as a criterion measure (r=0.75). Skazalski et al. [6] used systematic video analysis to examine the accuracy of Vert™ for the assessment of the total number of jumps across multiple practice sessions and games in professional men's volleyball players. The authors found that Vert™ accurately counted 99.3% of the

total number of volleyball-specific jumps (i.e., block jump, attack jump, jump serve, jump set) [6]. Similarly, when examining a cohort of junior male volleyball players, Charlton et al. [1] found that Vert™ demonstrated excellent jump count precision with a low number of false positives.

To help sports scientists and strength and conditioning practitioners obtain additional insight into on-court volleyball-specific training demands, the purpose of the present study was to examine differences in the external loads between different playing positions (e.g., setter, middle blocker, outside hitter, opposite hitter) in professional male volleyball players.

2. Methods

2.1. Participants

Eighteen professional male athletes ($\bar{x}$ ±SD; playing experience= 12.1±2.8 years, body mass= 89.0±8.3 kg, height= 198.6±7.7 cm, age= 21.4±2.9 years) competing at one of the top European volleyball leagues (e.g., *Super-League*) participated in the present study. The cohort of participants was composed of five middle blockers, seven outside hitters, three opposite hitters, and three setters. Each athlete was free of musculoskeletal injuries and was cleared by the respective sports medicine staff to fully participate in the team training activities. All testing procedures performed were approved by the University's Institutional Review Board and all participants signed an informed consent document (IRB #00148619).

2.2. Procedures

Upon arrival at the volleyball facility, athletes performed a warm-up protocol consisting of dynamic stretching exercises administered by their strength and conditioning coach. After the completion of the warm-up, each athlete was given a Vert™ IMU device (Mayfonk Athletic, Fort Lauderdale, FL, USA) to place around the waist (i.e., iliac crest) and secure with an elastic band, as recommended by the manufacturer. The data was wirelessly collected at 1000 Hz via the Vert™ Coach application installed on an iPad (Apple Inc., Cupertino, CA, USA) from the beginning to the end of the team practice session. Each athlete wore the same Vert™ IMU throughout three consecutive practice sessions (i.e., 18:00-19:30 hours) that included volleyball-specific drills (e.g., passing, blocking, serving, attacking motions) for an approximate duration of 30 minutes, followed by a 60-minute scrimmage.

2.3. Variables

External load variables observed in the present study were *Stress* (i.e., an algorithm-derived metric used to quantify a percentage of high-impact movements; <15% low, 16-21% medium, >22% high), *Jumps* (i.e., the total number of jumps above 6 in), *Jumps 15+* (i.e., the total number of jumps above 15 in), *Jumps 20+* (i.e., the total number of jumps above 20 in), *Highest Jump* (i.e., a single highest jump recorded during a training session), and *Average Jump Height* (i.e., the average jump height across all jumps performed during a training session). The average of three consecutive training sessions was calculated for each dependent variable.

2.4. Statistical Analysis

Descriptive statistics, means and standard deviations ($\bar{x}$ ±SD), were calculated for each dependent variable. Shapiro-Wilk's test was used to test if the assumption of normality was violated. After confirming that all dependent variables were normally distributed, a one-way analysis of variance (ANOVA) with Tukey post-hoc adjustment was used to test for statistically significant differences in external load measures between different volleyball positions. Statistical significance was set a priori to $p<0.05$. All statistical analyses were performed in the SPSS statistical software (Version 27.0; IBM Corp., Armonk, NY, USA).

3. Results

Descriptive statistics for all dependent variables examined in the present study are presented in Table 1. The ANOVA revealed statistically significant differences in *Jumps 20+* (F=3.783, p=0.035), *Highest Jump* (F=12.104, $p<0.001$), and *Average Jump Height* (F=7.462, p=0.003) between different playing positions. No statistically significant differences were present for *Stress* (F=1.487, p=0.261), *Jumps* (F=2.552, p=0.097), and *Jumps 15+* (F=1.183, p=0.352) external load metrics.

Pairwise comparisons revealed that outside hitters displayed significantly greater values for *Jumps 20+* (p=0.049) and *Highest Jump* (p=0.016) when compared to the setters. Opposite hitters had significantly greater *Highest Jump* values when compared to the setters ($p<0.001$) and middle blockers (p=0.002). Setters demonstrated significantly lower *Average Jump Height* magnitudes when compared to the outside hitters (p=0.007) and opposite hitters (p=0.013).

Table 1. Descriptive statistics, mean and standard deviation ($\bar{x}$ ±SD), for each external load variable examined in the present study.

	Stress	Jumps	Jumps 15+
Middle Blockers	25.9±1.7	103.9±12.9	69.3±18.7
Outside Hitters	24.1±3.9	82.4±21.2	68.5±17.7
Opposite Hitters	24.9±2.8	92.9±15.9	73.9±20.2
Setters	20.8±4.4	123.1±39.4	48.7±16.8
	Jumps 20+	Highest Jump	Avg. Jump Height
Middle Blockers	32.2±29.4	26.1±2.8†	22.3±3.2
Outside Hitters	57.9±16.3*	29.5±1.7*	25.4±1.2*
Opposite Hitters	58.1±25.7	33.9±3.1*	26.9±3.9*
Setters	14.9±2.7	23.9±1.5	19.7±1.6

Note: *significantly different when compared to setters; †significantly different when compared to opposite hitters. ($p<0.05$).

4. Discussion

This study aimed to examine differences in external loads between different playing positions (e.g., setters, middle blockers, outside hitters, opposite hitters) in

professional male volleyball players with the Vert™ IMU device. The results of the present investigation indicated that outside hitters had a significantly greater number of *Jumps 20+* as well as a greater *Highest Jump* when compared to the setters, while opposite hitters had significantly greater *Highest Jump* than both setters and middle blockers. In addition, setters demonstrated lower *Average Jump Height* when compared to the outsides and opposites. These findings most likely reflect the fact that during the game outside and opposite hitters implement various front and back row attacks and block jumps that require greater vertical displacements than the jump set motion performed by setters [13]. Moreover, the discrepancy in *Highest Jump* magnitudes observed between opposites and middles may be attributed to the on-court playing demands of middle blockers to repeatedly perform simulation (i.e., a player serves as a decoy for the opposing team) and block jumps, which are considered to have lower jump heights than the regular attacking motions [13].

No significant differences in *Jumps* were detected between different playing positions. However, it can be observed that setters' jump count (≈123 jumps) was the highest across all positions examined in the present investigation, with middle blockers performing a somewhat lower number of jumps (≈104 jumps). In line with these findings, Skazalski et al. [14] found that on a professional male volleyball team, setters and middle blockers performed the greatest number of jumps during training sessions (i.e., 121 and 92 jumps, respectively). Similarly, when examining female volleyball athletes, Vlantes & Readdy [9] revealed that setters demonstrated the greatest jump counts across 15 volleyball matches. Therefore, it may be of critical importance for strength and conditioning practitioners and volleyball coaches to individually monitor athletes and take into account the uniqueness of different positions when designing training regimens.

Besides the aforementioned external load variables, the Vert™ IMU device provides an algorithm-based variable that resembles the overall amount of *Stress* placed on the athlete during a practice session and/or competition. This variable is related to the landing impact that is calculated as the acceleration resulting from forces upon landing [15]. In a sport such as a volleyball that is composed of jumping and landing sequences, the use of wearable devices may help decrease the occurrence of injuries caused by overreaching and/or overtraining (i.e., long-term impairments in athlete's performance) [2]. Verhagen et al. [16], tracked 44 male and female volleyball teams throughout the entire season and found that overuse injury is one of the most common types of injuries in volleyball, with shoulder, back, and knee being the most prevalent injury sites. Although the findings of the present study did not detect any significant differences in *Stress* between different playing positions, it can be observed that all athletes regardless of the playing position demonstrated medium to high *Stress* scores throughout the training sessions (i.e., >20%). Due to higher *Stress* levels, it is possible that athletes could be exposed to an increased risk of developing an overuse-related injury. Thus, besides solely monitoring athletes with commercially available technology, coaches should track players' recovery and readiness levels as well as adjust their training protocols according to the *Stress* scores and specific individual playing positions.

While the findings of the present study allow volleyball coaches to obtain additional insight into the external loads to which athletes are exposed during regular training sessions, it is not without limitations. The overall sample size could have been larger, as well as the number of players per position. Also, the internal load measures were not assessed in the present investigation. Thus, to establish the optimal levels of training loads placed on the athletes and assure adequate development of position-specific training programs, future studies should focus on studying both external (e.g., jump count) and internal measures (e.g., heart rate) of training load as well as how they change throughout the full in- and post-season competitive periods.

5. Conclusions

In conclusion, the findings of the present investigation revealed that outside hitters had a significantly greater number of *Jumps 20+* as well as a greater *Highest Jump* when compared to the setters, while opposite hitters had significantly greater *Highest Jump* than both setters and middle blockers. Setters demonstrated lower *Average Jump Height* when compared to the outsides and opposites. However, no significant positional differences were found in the number of *Jumps* and *Jumps 15+*, as well as the overall amount of *Stress*. These findings may help strength and conditioning practitioners and volleyball coaches to develop position-specific training regimens and eventually decrease the likelihood of overuse injuries.

References

[1] Charlton, P.C., Kenneally-Dabrowski, C., Sheppard, J., and Spratford, W, "A simple method for quantifying jump loads in volleyball athletes," J Sci Med Sport, 20(3), 241-245, 2016.

[2] French, D. and Ronda, L.T, *NSCA's Essentials of Sport Science*, Human Kinetics, Champaign, 2021, 123-136.

[3] Borges, T.O., Moreira, A., Bacchi, R., Finotti, R.L., Ramos, M., Lopes, C.R., and Aoki, M.S, "Validation of the VERT wearable jump monitor device in elite youth volleyball players," Biol Sport, 34(3), 239-242, 2017.

[4] Chambers, R., Gabbett, T.J., Cole, M.H., and Beard, A, "The use of wearable microsensors to quantify sport-specific movements," Sports Med, 45(7), 1065-1081, 2015.

[5] Scott, B.R., Lockie, R.G., Knight, T.J., Clark, A.C., and Janse de Jonge, X.A.K, "A comparison of methods to quantify in-season training load of professional soccer players," Int J Sports Psychol Perform, 8(2), 195-202, 2013.

[6] Skazalski, C.M., Whiteley, R., Hansen, C., and Bahr, R, "A valid and reliable method to measure jump-specific training and competition load in elite volleyball players," Scand J Med Sci Sport, 28(5), 1578-1585, 2018.

[7] Svilar, L., Castellano, J., and Jukic, I, "Load monitoring systems in top-level basketball team: relationship between external and internal training load," Kinesiology, 50(1), 25-33, 2018.

[8] Svilar, L., Castellano, J., and Jukic, I, "Comparison of 5vs5 training games and match-play using microsensor technology in elite basketball," J Strength Cond Res, 33(7), 1897-1903, 2019.

[9] Vlantes, T.G. and Readdy T. "Using microsensor technology to quantify match demands in collegiate women's volleyball," J Strength Cond Res, 31(12), 3266-3278, 2017.

[10] Sheppard, J.M., Gabbett, T.M., and Stanganelli, L.C.R, "An analysis of playing positions in elite men's volleyball: considerations for competition demands and physiologic characteristics," J Strength Cond Res, 23(6), 1858-1866, 2009.

[11] Reina Roman, M., García-Rubio, J., Feu, S., and Ibáñez, S. J, "Training and competition load monitoring and analysis of women's amateur basketball by playing position: approach study," Front Psychol, 9, 2689, 2019.

[12] Vázquez-Guerrero, J., Suarez-Arrones, L., Gómez, D.C., and Rodas, G, "Comparing external total load, acceleration and deceleration outputs in elite basketball players across positions during match play," Kinesiology, 50(2), 228-234, 2018.

[13] Lima, R.F., Palao, J.M., and Clemente, F.M, "Jump performance during official matches in elite volleyball players: a pilot study". J Hum Kinet, 67(1), 259-269, 2019.

[14] Skazalski, C.M., Whiteley, R., and Bahr, R, "High jump demands in professional volleyball-large variability exists between players and player positions," Scand J Med Sci Sport, 28(11), 2293-2298, 2018.

[15] Damji, F., MacDonald, K., Hunt, M.A., Taunton, J., and Scott, A, "Using the VERT wearable device to monitor jumping loads in elite volleyball athletes," PloS One, 16(1), e0245299, 2021.

[16] Verhagen, E.A.L.M., Van der Beek, A.J., Bouter, L.M., Bahr, R.M., and Van Mechelen, W, "A one season prospective cohort study of volleyball injuries," Br J Sports Med, 38(4), 477-481, 2004.