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Variability in Preseason Jump Loads and Heart Rate Intensities in Division I Volleyball

Case Study

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Abstract

Introduction: Previous research on competitive volleyball athletes has aimed to quantify jump loads; however, research is limited regarding cardiovascular stress in high-level volleyball. The purpose of this case study was to assess heart rate intensities and jump loads throughout a division I volleyball preseason.

Methods: Three, division I volleyball players (18-22 years old) were monitored throughout a full preseason period consisting of 15 practices including a competitive preseason scrimmage. Heart rate intensities and time spent in five different heart rate zones were measured using chest-worn heart rate monitors. Athletes were also equipped with a wearable microsensor device to quantify jump loads.

Results: There were main effects of practice sessions on high intensity jumps, maximum heart rate (HR_{max}), HR_{zone3} and HR_{zone4} ($p \leq 0.001$). T-tests revealed significantly greater high intensity jumps (65 ± 25.9) during the scrimmage relative to practice (32.3 ± 19.3, $p < 0.036$). Conversely, HR_{max} and time spent in HR_{zone3} and HR_{zone4} were significantly lower in the scrimmage relative to preseason practice sessions ($p > 0.253$).

Conclusions: There was an inverse trend between heart rate intensities and high intensity jumps throughout preseason practices and a competitive scrimmage.

Key Words: Neuromuscular, cardiovascular, wearable technology, workloads

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Introduction

Volleyball is characterized by intermittent bouts of jumping, multidirectional movements, diving, blocking, and hitting[1,2]. The ability to engage in various jump intensities is critical when performing different volleyball related tasks such as, spiking, blocking, diving, and jump serving[3,4]. Multiple studies have reported athletes can engage in an exhilarating number of high intensity jumps throughout a five set match ranging from 65 to 136 high intensity jumps[3-5]. The combination of repetitive jumps, frequent high-intensity bouts of multidirectional movements and long total durations of an extended match suggests volleyball athlete's benefit from well-developed aerobic and anaerobic energy systems.

Jump loads have been well reported in research; however, less is known about the heart rate demands of collegiate volleyball as it relates to practice and competition, primarily during a preseason preparatory period in division I volleyball. A previous study found heart rate during practice averaged 134 beats·min^{-1}, while heart rate throughout a game averaged 139 beats·min^{-1} in a sample of non-elite volleyball athletes[6]. However, these finding were limited by the heart rate monitoring technology available in 1976[6]. Moreover, there are no recent studies to report heart rate intensities in preseason practice and in any type of a competitive environment against an opposing team. Therefore, the purpose of the case study was to assess both jumps loads and heart rate intensities throughout a division I volleyball preseason period.

Methods

Participants

A total of three division I female volleyball athletes (18-22 years old) were monitored with two different wearable microsensor devices throughout a full preseason training camp that consisted of 15 total practices, including a competitive preseason scrimmage. Prior to participation, athletes were cleared by the team physician and athletes read and signed an informed consent form prior to participation in the athletic season. The university Institutional Review Board approved the study and analysis.

Protocol

Prior to the first practice, athletes' height, weight, maximal vertical jump and maximal approach jump were measured before the first practice session. Athletes were then fitted with a wearable microsensor device (Catapult Sports, Melbourne Australia) that was secured to the upper back. Athletes were then fitted with a heart rate strap (Polar Global, Kempele, Finland) that secured tightly around their chest. The Catapult device utilized a 100Hz gyroscope, magnetometer, and tri-axial-accelerometer to detect indoor inertial movements (e.g., jump loads), while the heart rate device utilized a chest electrode and monitored heart rate intensities including time spent in five difference heart rate zones based on an peak heart rate. To enhance the accuracy of time spent in percent heart rate training zones, peak heart rates were assessed throughout the preseason conditioning test. After the test, heart rate was reported as beats·min^{-1} (BPM) and HR_{peak} was reported as the highest heart rate achieved at any point throughout the test. HR_{peak} was adjusted if an athlete achieved a greater heart rate throughout any practice or competition. Jump loads were categorized according to the manufacturers vertical displacement thresholds of low, moderate and high intensity jumps defined as 0-20 cm, 20-40 cm, and >40 cm, respectively. After the conditioning test, athletes participated in 14 practice sessions and then the preseason culminated in a competitive scrimmage against a different division I opponent.

Heart Rate Training Loads

Heart rate intensities were quantified based on time spent in five different heart rate training zones. Time spent in five heart rate zones ($HR_{Zone1-5}$) [7-10] were based on the athlete's individual HR_{peak} from the preseason conditioning test. Similar to previous research, the zones begin with HR_{Zone1} = time spent between 50—59% HR_{peak}, HR_{Zone2} = 60–69% HR_{peak}, HR_{Zone3} = 70-76% HR_{peak}, HR_{Zone4} = 77-84% HR_{peak}, HR_{Zone5} equal to 85-100% HR_{peak} [11].

Statistical Analysis

Descriptive statistics (means and standard deviations) for jump loads and heart rate intensity variables were calculated for practices and the preseason scrimmage. Multiple independent samples t-tests were utilized to assess if any differences existed in the dependent variables during practice compared to the competitive scrimmage. Then, random effects models were used to assess any main effects of time on jump loads and heart rate intensities throughout the 15 preseason sessions. Pairwise comparisons were made for all main effects of time. Statistics were analyzed using IBM SPSS 24.0 (Version 24.0, IBM Inc., Armonk, NY). The criterion for statistical significance was set a priori at $p \leq 0.05$.

Results

Physical Characteristics

The athlete's physical characteristics and testing results are presented in Table 1.

Table 1. Athletes' preseason physical and jump performance characteristics.

Age	19.3 ± 1.5
Height (cm)	178.6 ± 6.4
Weight (kg)	63.9 ± 2.5
Vertical Jump (cm)	52.5 ± 2.6
Max Height Approach Jump (cm)	292.1 ± 4.6

All data are presented as the mean ± SD.

Jump Loads

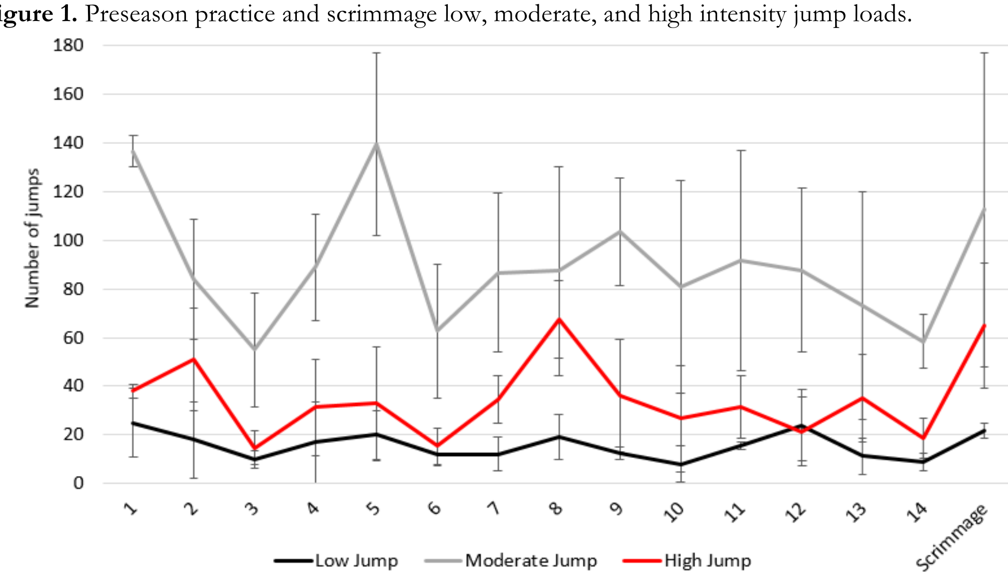
There was a main effect of time (practice session) on high intensity jump loads ($p = 0.015$, Figure 1), but not low and moderate jump loads ($p \geq 0.253$). High intensity jump loads significantly varied throughout the preseason, however, athletes engaged in the greatest number of high intensity jumps in practice number eight and the scrimmage. Then, when high intensity jumps in practice were compared to the scrimmage, athletes accumulated significantly more high intensity jumps in the scrimmage (Table 2).

Table 2. Work load and heart rate intensities for practices and the scrimmage

	Practice			Scrimmage			
Low Jumps	15	±	9.4	21.7	±	3.2	
Moderate Jumps	87.1	±	35.8	112.7	±	64.6	
High Jumps	32.3	±	19.3	65	±	25.9	*
HR_{avg}	131	±	12.3	142.7	±	8.5	
HR_{max}	200.5	±	27.4	182.3	±	1.5	*
HR_{Zone1}	39.4	±	19.3	24.5	±	7.3	
HR_{Zone2}	28.8	±	14.9	14.5	±	8	
HR_{Zone3}	25.5	±	18.3	12.5	±	10	*
HR_{Zone4}	12.6	±	14.1	5.9	±	6.2	*
HR_{Zone5}	3.6	±	7.2	2.1	±	3.6	

Data are means ± SD.
*Significantly different from practice, $p<0.036$.

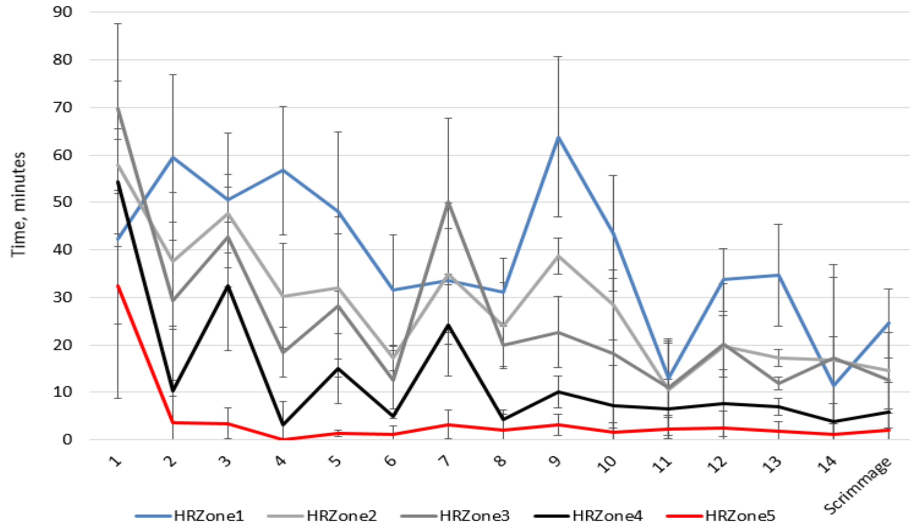
Figure 1. Preseason practice and scrimmage low, moderate, and high intensity jump loads.



Heart Rate Intensities

There was a main effect of time (practice session) on $HR_{zones1-5}$ ($p \leq 0.001$, Figure 2), but not average or maximum heart rate, ($p \geq 0.279$). When heart rate intensities in practice were compared to the scrimmage, athletes accumulated significantly less time in HR_{zone3} and HR_{zone4} in the scrimmage, which were moderate to high heart rate zones.

Figure 2. Preseason heart rate workloads.



Discussion

The case study revealed high intensity jump loads were 101% greater in a competitive scrimmage relative to preseason practice. However, maximum heart rate and time spent in HR_{zone3} and HR_{zone4} were significantly lower in the scrimmage relative to a preseason practice session. Interestingly, there was no difference in time accumulated in HR_{zone5} and HR_{avg} between practice and the scrimmage. The inverse trends between heart rate intensities and high intensity jump loads between practices and scrimmages, could reveal potential discrepancies in neuromuscular workloads (i.e., jump loads) and cardiovascular workloads (i.e., heart rate intensities). Based on these findings, identifying optimal neuromuscular and cardiovascular loading throughout a preseason period is paramount for future research.

While previous research has quantified game and practice jump demands in collegiate volleyball, the aerobic demands have been overlooked in the literature. Monitoring collegiate volleyball players heart rate workloads and jump loads can assist coaches and sports medicine staffs with information designed to better prepare volleyball athlete's for peak cardiovascular performance[3,4]. Currently, only average heart rates in practice and games have been cited in previous research[12] and average heart rate alone does not provide valuable physiological information[13]. Moreover, in the current study, there were no differences in HR_{avg} between practices and the scrimmage, however, HR_{max} was greater in practice than in the scrimmage. From a practical sense, HR_{avg} was nearly 12 BPM greater in the scrimmage while HR_{max} was 18 BPM less in the scrimmage relative to practices, further highlighting the need to assess and report time spent in heart rate training zones in volleyball. These findings suggest that athletes maintained an elevated cardiovascular workload in a competitive environment that could not have been detected by a simple assessment of average heart rates. Further research should aim to monitor neuromuscular and cardiovascular workloads throughout an entire competitive volleyball season including competitive games and days with multiple games.

Media-Friendly Summary

High intensity jumps were greater in a competitive scrimmage when compared to a preseason practice while time allocated to specific heart rate intensities were greater in practice relative to a preseason scrimmage. The discrepancy between these two trends warrants further research involving the monitoring of both heart rate and jump load intensities to establish best practices in volleyball training and preparation.

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