COUNTERMOVEMENT JUMP PERFORMANCE CHANGES OVER THE COURSE OF COLLEGIATE BASKETBALL PRE-SEASON ASSOCIATED WITH BLOCK PERIODIZATION MODEL OF STRENGTH AND CONDITIONING PROGRAM

[1]Nobuhisa Yoshida, [1]Caleb D. Bazyler, [1]Takahiro Unebasami, [1]Stephen Wells, [1]Zachary Whitman, [1]Danielle Lee, [1]Mallory Stellhorn, [1]Kimitake Sato, & [1]Michael H. Stone

[1]Center of Excellence for Sport Science and Coach Education, Department of Exercise and Sport Sciences, East Tennessee State University, Johnson City, TN

INTRODUCTION: Athlete monitoring is a critical component of the training program for sports scientists and strength coaches. It is used to optimize the performance enhancement of the athlete (Stone, Stone, & Sands, 2007). Vertical Jump, specifically counter-movement jump (CMJ), is widely used as a measurement of performance and fatigue state, especially neuromuscular fatigue (Taylor et al., 2012). Also, a recent study by Balsalobre-Fernandez et al. (2014) has shown that CMJ height (JH) was significantly correlated with salivary cortisol and training load variables, such as perceived exertion, total distance covered, and training zone, of mid- & long-distance athletes training program. However, controversial reports also exist with regard to changes in CMJ performance to the phase of competition and training. (Freitas et al., 2014). The block periodization model of resistance exercise training has been shown to improve superior performance by the mean of manipulating the amount of work performed (volume load: VL) (Painter et al., 2012). This training paradigm could effectively enhance the recovery-adaptation for better performance. As VL is considered an external training load, rating of perceived exertion training-load (RPETL) is an alternative method of quantification of internal training load. To the knowledge of the authors, the limited number of studies have investigated the basketball athletes' CMJ JH changes associated with the different type of training load in block periodization model. Therefore, the purpose of this study was to investigate the CMJ JH changes over the course of pre-season with respect to block periodization training program of the collegiate level basketball athletes.

METHODS: Fifteen NAIA D-II men's basketball players participated in this investigation (age: 20.5y, height: 190.5cm, body mass: 89.3kg) over the course of a 10-week pre-season training period. One athlete dropped out from this investigation due to lower extremity injury.

CMJ was performed on dual force plates (0.36 m x 0.36 m, PASCO Scientific PS-2142, Roseville, CA) embedded into a testing platform. Three trials were completed and 1-minute rests were given between each trials to restrict acute fatigue effect on CMJ performance. Athletes held a PVC pipe, which is less than 1kg, right below their neck to restrict arm action during jumps. Vertical ground reaction forces (vGRF) during jumps were corrected at 1,000 Hz. Data process were performed using a program designed with LabVIEW (ver. 2010, National Instruments, Austin, TX, USA), and then, the highest 2 trials (out of 3 trials) of jump height from flight time (JH-FT) were used to calculate the mean. Before CMJ trials, hydration was estimated from urine specific gravity (≤1.020 to indicate euhydration) by refractometer (Atago, Japan) (Stuempfle & Drury, 2003). After the hydration test, all athletes underwent a standardized warm-up prior to testing, which consisted of 25 jumping jacks, dynamic stretches, skipping, and two sets of five body weight squats. After the warm-up, athletes performed one of each 50% and 75% warm-up CMJs. The CMJ data collections were completed in the following Monday afternoon of the week1, 3, 7 and 10. In addition to CMJ data, VL (repetition x weight lifted) was calculated from each lifting session as external load, and then, weekly and each training block's team average volume load (VL-wk & VL-bk, respectively), were also calculated. A session rating of perceived exertion (sRPE) was obtained from the athletes following each lifting, conditioning, and practice session by asking the athlete to rank their level of perceived exertion on a Borg scale 0-10. RPETL was calculated by multiplying sRPE by the time of each lifting, conditioning, and practice sessions in minutes as internal load based on the method introduced by Foster et al (2001). As with volume load, weekly and each training block's team RPETL average, RPETL-wk & RPETL-bk, respectively, were calculated. All data collection in this study occurred as part of an ongoing athlete monitoring program. (This study was reviewed and approved by the East Tendnessee State University Institutional Review Board.)

To determine statistically significant differences between levels of the CMJ JH-FT, training block volume loads (VL-bk), and training block RPETL (RPETL-bk), three separate repeated measures analysis of variance (ANOVA) was used. If ANOVA revealed a significant difference, Tukey's *post hoc* procedure with Bonferroni adjustment was used to locate the pairwise differences. For the power analysis, practical significance was assessed by Cohen's d Effect sizes (ES). ES < 0.2, 0.2-0.6, 0.6-1.2, 1.2-2, and 2.0-4.0 were considered as trivial, small, moderate, large and very large, respectively (Hopkins et al., 2009). For the reliability of CMJ JH-FT within subject, coefficient of variation (CV%) and intra-class coefficient of variation (ICC) were calculated. A CV of ≤ 10% was set as the criterion to declare a variable as reliable (Cronin, Hing, & McNair, 2004) All statistical analyses were performed using SPSS 23 (IBM, New York, NY), and power analyses were performed using customized Excel spread sheet (Microsoft Corp. Redmond, WA). Significance was set at $p = 0.05$.

RESULTS: The reliability of each week's CMJ JH-FT was considered high (shown in Table 1). A violation in assumption of sphericity by Mauchly's Test on VL-bk ($p = 0.001$, $\varepsilon = .621$) was detected. Although it might result in an increase in the type-1 error rate, due to the small sample size, RM ANOVA was used. Three separated RM ANOVAs showed statistically significant differences for all variables (JH-FT: $F(3, 11) = 9.934$, $p = 0.002$, VL-bk: $F(2, 12) = 346.143$, $p < 0.001$, RPETL-bk: $F(2, 12) = 22.89$, $p < 0.001$). *Post hoc* pairwised comparisons revealed that JH-FT week3 was significantly decreased from week1, and then increased at week7 ($p < 0.05$, Cohen's d ES = 0.88 and 0.62, respectively), however, there were no statistical differences for JH-FT between wk1, 7, and 10 (table 1). VL difference between each block were statistically significant ($p < 0.05$) (table 2), as well as differences between RPETL-bk1 and –bk2, and RPETL-bk2 and –bk3 were also statistically significant ($p < 0.05$) (Table 2)

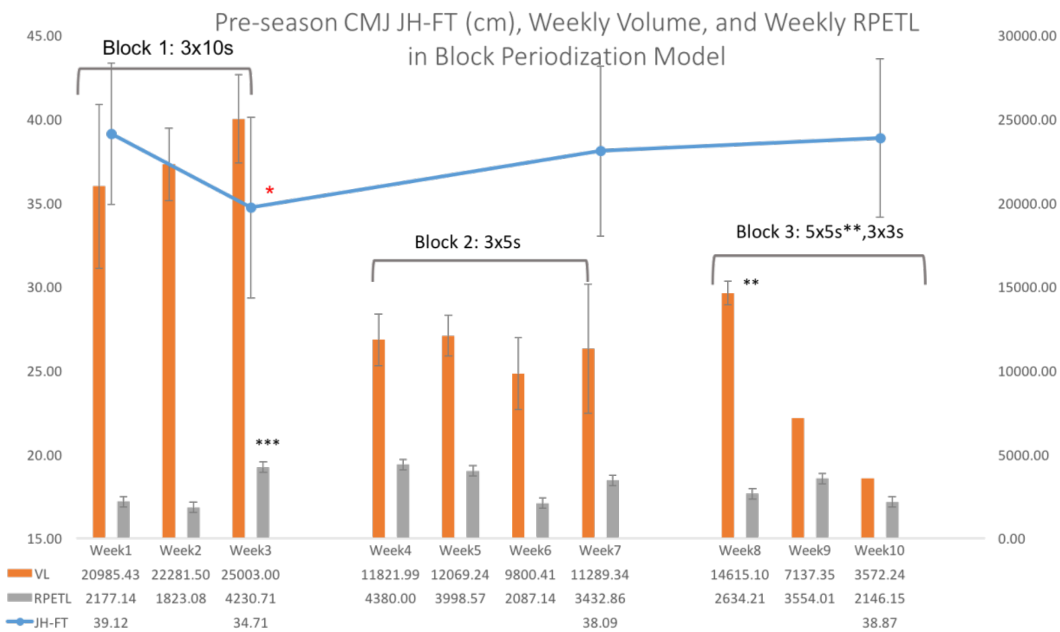

Figure 1: * Statistically significant difference in JH-FT (*p* < 0.05), ** Functional Overreaching week (5 sets x 5 reps), * Beginning of team Practice**

Table 1. CMJ JH-FT Data and Test Re-Test Reliability Statistics

	Mean ± SD (cm)	CV%	ICC
Week 1	39.12 ± 4.37	10.76	0.87
Week 3	34.71 ± 5.60 *	15.55	0.99
Week 7	39.12 ± 5.26	13.30	0.96
Week 10	39.12 ± 4.90	12.15	0.96

Note: * Statistically significant difference between Week 3 and Week 1, 7, & 10 ($p < 0.05$)

Table 2 Training Load Data (Mean ± SD) for Volume Load (VL) and RPETL

	Block 1 (week1-3)	Block 2 (Week4-7)	Block 3 (Week8-10)
VL - bk	22525.10 ± 3036.94 *	11256.07 ± 1299.84 *	8441.57 ± 1296.00 *
RPETL-bk	2769.64 ± 545.51**	3474.64 ± 450.64** ***	2778.12 ± 460.09 ***

Note: * Statistically significant difference between all Blocks ($p < 0.05$)
** Statistically significant difference between Block 1&2 ($p < 0.05$)
*** Statistically significant difference between Block 2&3 ($p < 0.05$)

Cohen's d Effect Size	VL-bk	RPETL-bk
Block 1 - 2	ES = 4.82	ES = 1.41
Block 2 - 3	ES = 2.17	ES = 1.53
Block 1 - 3	ES = 6.03	ES = 0.02

Table 3 Cohen's d Effect Size (ES) for pariwise comparisons in VL-bk: Volume Load – Block, and RPETL-bk: RPE training Load – BlocK.

DISCUSSION: The purpose of this investigation was to monitor CMJ JH-FT with respect to VL and RPETL. By the alteration in the volume of training in block periodization model, each block's average VL was significantly different from the other blocks (1-3; high to low VL, respectively.) JH-FT was significantly decreased from week 1 to 3, which is right after the highest VL training block was completed. Furthermore, as the VL was significantly decreased in block 2, JH-FT was, inversely, increased back to the original level of performance. This result was similar to previous studies (Andersen et al., 2005). Interestingly, there was no difference between JH-FT wk7 and JH-FT wk10. It is speculated as a possible reason that relatively high VL in "the functional over-reaching week" (5 sets x 5 reps) in week 8 (Figure 1 - **) might have caused delayed fatigue effect on jump performance in week10. In addition, because of the nature of RPETL, the beginning of team practice resulted in great increase in RPETL in week 3, and stayed high in Block2, then decreased in Block3, probably due to the lower VL, physiological adaptation to the stresses, and other factors. We speculate that RPETL might represent more acute fatigue effect on CMJ JH-FT.

For the future consideration, investigating acute and chronic fatigue effect and alternative CMJ force-time curve variables including peak and mean force and power, net impulse, rate of force development, and eccentric and concentric duration is needed to understand the impact of training protocol on CMJ performance for athlete monitoring and performance enhancement.

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