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

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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).The vertical jump, specifically countermovement jump (CMJ), is widely used as a measurement of performance and fatigue state, especially neuromuscular fatigue (Taylor, Chapman, Cronin, Newton, & Gill, 2012). Also, a recent study by Balsalobre-Fernandez, Tejero-Gonzalez, and del Campo-Vecino (2014) has shown that CMJ height (JH) was significantly correlated with salivary cortisol (r = -0.777) and training load variables, such as perceived exertion (r = -0.489), total distance covered (r = -0.593), and training zone (r = 0.437), of mid- & long-distance athletes. However, controversial reports also exist with regard to changes in CMJ performance depending on the competition or training phase (Freitas, Nakamura, Miloski, Samulski, & Bara-Filho, 2014). The block periodization model of resistance exercise training has been shown to produce superior performance by systematically manipulating the amount of work performed (volume load: VL) (Painter et al., 2012). While strength training VL is considered a measure of external training load, rating of perceived exertion training-load (RPETL) has been used to quantify internal training load. To the knowledge of the authors, a limited number of studies have investigated basketball athletes' CMJ JH changes associated with the different types of training load using a block periodization model. Therefore, the purpose of this study was to investigate the CMJ JH changes over the course of the pre-season with respect to block periodization training program of the collegiate level basketball athletes.

METHOD: 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 a practice-induced lower extremity injury. All data collection in this study occurred as part of an ongoing athlete monitoring program. This study was reviewed and approved by the East Tennessee State University Institutional Review Board.

Testing protocol: Countermovement jumps were performed on dual force plates (0.36 m x 0.36 m, PASCO Scientific PS-2142, Roseville, CA) embedded into a testing platform. Before CMJ trials, hydration status was estimated from urine specific gravity (≤1.020 to indicate euhydration) by a refractometer (Atago, Japan) (Stuempfle & Drury, 2003). After passing 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. Three trials were completed with 1-minute rest between trials in order to minimize confounding effects of acute fatigue on CMJ performance. Athletes held a PVC pipe, which is less than 1 kg, in a high bar back squat position to restrict arm action during jumps. The CMJ data collections were completed each Monday afternoon of weeks 1, 3, 7 and 10.

Data Collection: Vertical ground reaction forces during jumps were collected using dual force plates sampling at 1,000 Hz with Capstone software (Pasco, Roseville, CA, USA). Data processing was performed using a program designed with LabVIEW (ver. 2010, National Instruments, Austin, TX, USA), and CMJ JH was calculated from flight time (JH-FT). In addition to CMJ data, VL (repetition x weight lifted) was calculated from each lifting session and were subsequently averaged for each training week and block (VL-bk). A session rating of perceived exertion (sRPE) was obtained from the athletes following each lifting, conditioning, and practice sessions by asking the athlete to rank their level of perceived exertion on a Borg scale 0-10 (Borg, Ljunggren, & Ceci, 1985). Session RPETL was calculated by multiplying sRPE by the time of each lifting, conditioning, and practice sessions in minutes based on the method introduced by Foster et al. (2001). As with volume load, weekly and each training block's team RPETL average (RPETL-bk) were calculated.

Statistical Analysis: All data were expressed as mean ± SD (standard deviation). For the reliability of CMJ JH-FT within subject, coefficient of variation (CV%) and intra-class coefficient of variation (ICC) were calculated. To determine statistically significant differences between levels of the CMJ J, training block volume loads (VL-bk), and training block RPETL (RPETL-bk), three separate repeated measures analysis of variance (ANOVA) were used. If ANOVA revealed a significant difference, Tukey's *post hoc* procedure 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, Marshall, Batterham, & Hanin, 2009). 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 effect size calculations were performed using analysis package in R Studio (Boston, MA USA). Statistical significance was set at $\alpha = 0.05$.

RESULT: The reliability of each week's CMJ JH-FT was considered high (Table 1). A violation in assumption of sphericity by Mauchly's Test on VL-bk ($p = 0.001$, $\varepsilon = .595$) was detected, therefore Greenhouse-Geisser corrected test was reported for VL-bk. Repeated measures ANOVA results revealed statistically significant time effects for JH-FT, $F(3, 39) = 13.35$, $p < 0.001$, $\omega^2 = 0.10$; VL-bk: $F(1.19, 15.48) = 428.0$, $p < 0.001$, $\omega^2 = 0.96$; and RPETL-bk: $F(2, 12) = 22.89$, $p < 0.001$, $\omega^2 = 0.32$). *Post hoc* pairwise comparisons revealed that JH-FT week3 was significantly decreased from week1 ($p = 0.003$, d = 0.88) and then increased from week3 to week7 ($p = 0.010$, d = 0.62). However, there were no statistical differences for JH-FT between week 1, 7, and 10 (Figure 1). VL differences between each block were statistically significant ($p < 0.05$), as well as differences between RPETL-bk1 and –bk2, and RPETL-bk2 and –bk3 were also statistically significant ($p < 0.05$) (Table 2).

Table 1. CMJ JH-FT and Reliability Statistics.

	Mean ± SD (cm)	CV %	ICC
Week 1	39.12 ± 4.37	4.81	0.87
Week 3	34.71 ± 5.60*	3.55	0.99
Week 7	39.12 ± 5.26	3.34	0.96
Week 10	39.12 ± 4.90	3.13	0.96

* Statistically significant difference between Week 3 and Week1,7, & 10 (*p* <0.05)

Table 2. External(VL-bk) and Internal (RPETL-bk) Training Load.

	Block1 (Week1-3)	Block 2 (Week4-7)	Block 3(Week8-10)
VL-bk	22525.1 ± 3036.9*	11256.1 ± 1299.8*	8441.6 ± 1296.0*
RPETL-bk	2769.6 ± 545.5	3474.64 ± 450.64**	2778.12 ± 460.1 ***

* Statistically significant difference between all blocks. ($p < 0.05$)

** Statistically significant difference between Block 1 and 2 ($p < 0.05$)

*** Statistically significant difference between Block 2 and 3 ($p < 0.05$)

Table 3. Effect Size (ES) for pairwise comparisons in VL-bk and RPETL

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

VL-bk: Volume Load -Block, **RPETL-bk**: RPE training Load - Block.

DISCUSSION: The purpose of this investigation was to monitor CMJ JH-FT with respect to VL and RPETL. Consistent with the alterations in training load using a block periodization model, each block's average VL was significantly different from the other blocks (1-3; high to low VL, respectively). Team JH-FT was significantly decreased following training block 1 likely as a result of the fatigue induced by the high VL. Furthermore, as the VL was significantly decreased in block 2, JH-FT increased back to the original level of performance. This result was similar to previous research (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 the relatively high VL during the functional over-reaching week (5 sets x 5 reps) in week 8 (Figure 1 - **) might have caused a delayed fatigue effect on jump performance in week 10. In addition, because of the nature of RPETL, the beginning of team practice resulted in an increase in RPETL in week 3, which remained elevated in Block 2, then decreased in Block 3. The decrease in RPETL during block 3 was possibly due to the lower VL, physiological adaptation to the stressors. Athlete's RPETL might represent additional acute fatigue effects on CMJ JH-FT.

These findings suggest the usefulness of monitoring CMJ performance (JH-FT) as a potential indicator of fatigue caused by stressors stemming from lifting and at practice. Moreover, tracking VL and RPETL may also be beneficial in predicting performance outcomes. For the future consideration, investigating acute and chronic fatigue effects 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 strength training, basketball practice and conditioning on CMJ performance for athlete monitoring and performance enhancement.

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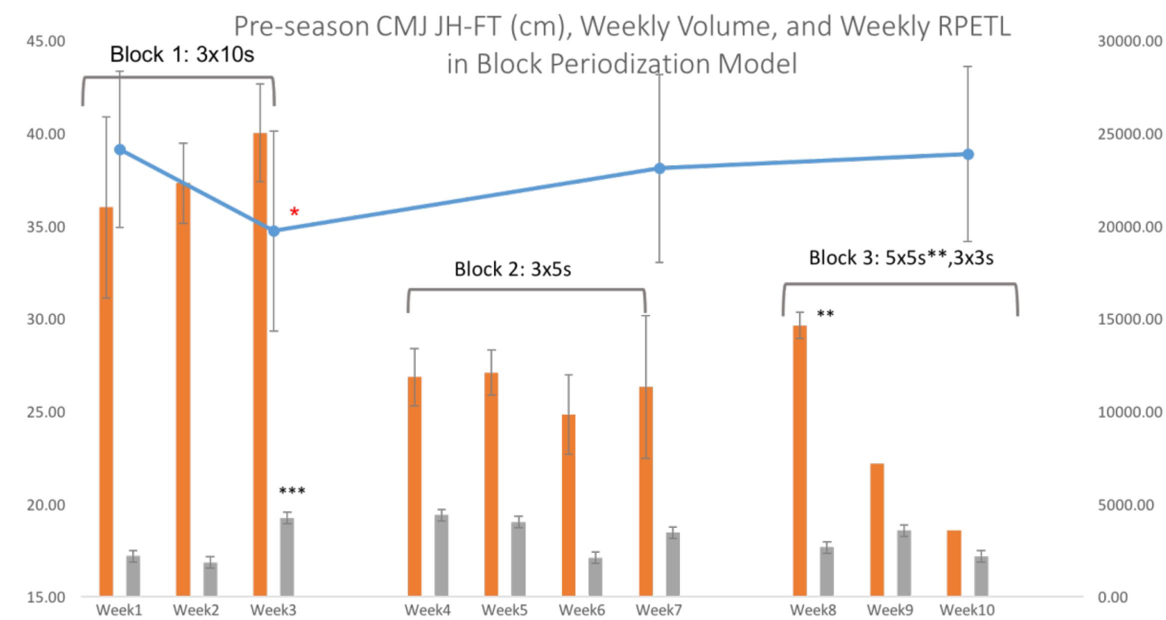

	Week1	Week2	Week3	Week4	Week5	Week6	Week7	Week8	Week9	Week10
VL	20985.43	22281.50	25003.00	11821.99	12069.24	9800.41	11289.34	14615.10	7137.35	3572.24
RPETL	2177.14	1823.08	4230.71	4380.00	3998.57	2087.14	3432.86	2634.21	3554.01	2146.15
JH-FT	39.12		34.71				38.09			38.87

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