KENNESAW STATE UNIVERSITY

INFLUENCE OF TRAINING VOLUME ON COUNTERMOVEMENT JUMP CHARACTERISTICS IN DIVISION II CROSS-COUNTRY RUNNERS

Grazer J[1], Olmstead S[2], Martino M[3]

[1]Department of Exercise Science and Sport Management, Kennesaw State University, Kennesaw, GA

[2]Flagler Intercollegiate Athletics Department, Flagler College, St. Augustine, FL

[3]School of Health and Human Performance, Georgia College & State University, Milledgeville, GA

INTRODUCTION

Along with the many reported benefits, there are several risks associated with distance running including overtraining and overuse injuries. Research has shown that 60% of participating elite male and female runners had experienced NFOR in their lifetime (Morgan, 1987). In the same study, it was found that 33% of nonelite female runners had experienced NFOR in their lifetime.

Some of the most common force-time variables to monitor during CMJ assessment protocols are peak and mean velocity, peak and mean power, peak force, relative peak power, net impulse, and jump height (Taylor, 2012; Claudino et al, 2017). Time related jump variables such as eccentric duration and total duration have also demonstrated changes when exposed to neuromuscular fatigue (Gathercole, Sporer, Stellingwerff, & Sleivert, 2015a). Rate of force development (RFD) may also be an important variable to monitor as there is a strong association between RFD and endurance running performance (Bazyler, Abbott, Bellon, Taber, & Stone, 2015).

While CMJ assessment is a common tool to monitor neuromuscular status, most research typically only uses CMJ assessment to monitor resistance training protocols (Taylor, 2012; Joffe et al., 2020) or team sport athletes (Gathercole et al., 2015a; Gathercole et al., 2015b; Heishman, Daub, Miller, Freitas, & Bemben, 2020). There are only a handful of studies that utilize CMJ assessment to assess neuromuscular status in endurance related sports (Balsalobre-Fernández, Tejero-González, & del Campo-Vecino, 2014).

PURPOSE

The purpose of this study was to assess the impact of training volume on lower-body power performance throughout a competitive cross-country season.

METHODS

A total of twenty-three NCAA Division II collegiate cross-country runners (males, n = 11, females, n = 12) participated in this study. Of the twenty-three, seven were excluded from the statistical analysis because they failed to attend 75% of the testing sessions. This left 16 total athletes for the final data analysis (males, n = 7, females, n= 9). Subject demographics are listed in Table 1.

Table 1 – Subject Demographics

Demographic	Males (8k)	Females (5k)
Height (cm)	176.7 ± 5.8	163.7 ± 6.0
Weight (kg)	68.3 ± 7.8	58.0 ± 6.7
Age (years)	19.4 ± 1.5	20 ± 1.6
Best Performance (min)	27.53 ± 1.60	21.51 ± 2.14

A countermovement jump (CMJ) assessment was performed once per week in the Sports Performance lab of the participating institution. The assessment took place during the team's weekly resistance training session.

The athletes were instructed to jump with their hands on their hips, dip to a self-selected depth, and explode up towards the ceiling. Each athlete performed two jumps with three minutes rest in between to minimize chances of fatigue influencing performance in standardized footwear.

Force-time data was collected using PASCO biaxial force plates (PS-2142), with a sampling frequency of 1000 Hz. The data was collected using Capstone software (version 2.3.1) in a closed lab setting. The force-time data was analyzed using Microsoft Excel, using calculations provided by Chavda et al. (2017)..

RESULTS

- **RM ANOVA:** For the male athletes, a statistically significant decrease was observed for TV (T2-T3, $p \le 0.05$, 100 ± 16 km vs. 87 ± 11 km) JH (T1-T3, $p \le 0.05$, 0.324 ± 0.053 m vs. 0.308 ± 0.54 m) and RPP (T1-T2, 51.02 ± 6.65 W/kg vs. 48.8 v 6.31 W/kg, T1-T3, 51.02 ± 6.65 W/kg vs. 48.31 ± 5.34 W/kg) For the female athletes, there were no statistical significances between time points for any variable ($p > 0.05$).
- **Effect Sizes:** Moderate effect sizes were observed for the male athletes for TV between T2-T3 (d = 0.92), and in TD and ECCDUR between T1-T2 and T1-T3 (d = 0.60-1.20). For the female athletes, trivial to small effect sizes were observed for each variable (d = 0.00-0.48).

Table 2. Mean ± SD and Effect Sizes for Jump Variables and Training Volume

Males

Variable	1 Mean ± SD	2 Mean ± SD	3 Mean ± SD	(1-2) ES	(1-3) ES	(2-3) ES
Total Volume (km)	95 ± 21	100 ± 16	87 ± 11 #	0.25	0.50	0.92
Jump Height (m)	.324 ± .053	.303 ± .062	.308 ± .054 *	0.36	0.30	0.09
Net Impulse (N*s)	171.88 ± 19.32	168.88 ± 20.85	169.87 ± 19.64	0.15	0.10	0.05
Total Duration (s)	.605 ± .050	.663 ± .113	.665 ± .086	0.66	0.85	0.02
Eccentric Duration (s)	.369 ± .033	.414 ± .074	.415 ± .065	0.79	0.89	0.01
RSImod (AU)	.544 ± .093	.490 ± .118	.500 ± .078	0.51	0.51	0.10
Relative Peak Power (W/kg)	51.02 ± 6.65	48.79 ± 6.31	48.31 ± 5.34 ^ *	0.34	0.45	0.08
Braking RFD ($N \cdot s^{-1}$)	5367.1 ± 1025.8	5973.0 ± 1415.7	5925.2 ± 1473.6	0.49	0.44	0.03
Body Mass (kg)	68.6 ± 7.7	69.8 ± 7.2	69.5 ± 7.8	0.17	0.12	0.04

Females

Variable	1 Mean ± SD	2 Mean ± SD	3 Mean ± SD	(1-2) ES	(1-3) ES	(2-3) ES
Total Volume (km)	61 ± 14	68 ± 21	60 ± 14	0.28	0.20	0.44
Jump Height (m)	.217 ± .026	.215 ± .020	.209 ± .026	0.09	0.31	0.26
Net Impulse (N*s)	119.09 ± 14.25	118.65 ± 13.78	116.74 ± 14.10	0.03	0.16	0.14
Total Duration (s)	.640 ± .109	.710 ± .173	.645 ± .145	0.48	0.04	0.41
Eccentric Duration (s)	.405 ± .089	.453 ± .114	.419 ± .134	0.47	0.12	0.27
RSImod (AU)	.364 ± .063	.345 ± .088	.363 ± .078	0.25	0.01	0.22
Relative Peak Power (W/kg)	39.19 ± 3.70	39.51 ± 3.56	38.43 ± 4.20	0.09	0.19	0.28
Braking RFD ($N \cdot s^{-1}$)	6641.4 ± 2606.5	6219.7 ± 2865.6	6593.2 ± 2506.1	0.15	0.02	0.14
Body Mass (kg)	57.9 ± 7.1	57.8 ± 6.3	57.9 ± 7.3	0.02	0.00	0.01

1 = Beginning of Season
2 = Middle of Season
3 = End of Season

^ Statistical significance between time points 1 and 2
* Statistical significance between time points 1 and 3
\# Statistical significance between time points 2 and 3

Trivial	<.2
Small	(.2 - .6)
Moderate	(.6 - 1.2)

CONCLUSIONS

It appears that time-related variables, such as eccentric and total duration are more sensitive to increases in training volume than force-related variables. This may indicate that measuring time related variables may be of greater importance and force related variables or simply reporting jump height. Time-related variables are important to monitor because of the correlation between running economy and ground contact time. The longer an individual spends on the ground during the stance phase in the gait cycle, the less economical they become (Mooses et al., 2021). Lastly, the utilization of an effective load management strategy was expressed through the minimal changes in jump performance expressed from mid-season to the end of the season.

PRACTICAL APPLICATIONS

Practitioners that train and monitor endurance athletes may be able to utilize countermovement jump assessments to assess changes in lower-body power performance to potentially identify readiness and performance in conjunction with training volume to evaluate effectiveness of training load management strategies.

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