CHANGES IN STRETCH-SHORTENING CYCLE AND JUMP HEIGHT IN COLLEGIATE CROSS-COUNTRY RUNNERS AFTER A COMPETITIVE TRAINING SEASON

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INTRODUCTION: Static jumps (SJ) and countermovement jumps (CM) are common performance tests used by sport scientists and strength and conditioning coaches to monitor training status and fatigue for a variety of sports (McGuigan et al. 2006; Spurrs et al. 2003; Winkelman 2011). While the SJ can be used as an index of concentric power and rate of force development, the CM represents the athlete's ability to utilize elastic components of the stretch shortening cycle (SSC) (Komi 2000). However, it is the relationship between the SJ and CM that can provide a more dynamic view of the athlete's ability to utilize the SSC throughout movements in their training (McGuigan et al. 2006; Spurrs et al. 2003; Winkelman 2011). The SSC is a three-part force producing mechanism consisting first of a rapid stretch or lengthening within the muscle, amortization, and then a concentric contraction (Komi 2000; Winkelman 2011). An important implication of the rapid stretch is the activation of the stretch reflex, which augments force production through enhanced storage and utilization of potential energy in actions such as running and jumping, such that the muscle behaves like a spring (Komi 2000). These spring-like properties, referred to as the stiffness of the muscle, can passively enhance concentric force production during the take-off phase of running gait, reducing the overall energetic cost of activity, leading to improved running economy (Craib et al. 1996; Komi 2000; Spurrs et al. 2003). The ability to store and utilize this potential energy can be enhanced by plyometric training in conjunction with traditional strength and power training (Spurrs et al. 2003). Increasing muscular stiffness is also important in reducing potential for injury by preventing excess transverse and frontal plane movement during ground contact (Spurrs et al. 2003). The ratio of SJ to CM is represented by the eccentric utilization ratio (EUR) and is representative of the athlete's ability to utilize stored potential energy of the elastic components in contrast to predominately contractile elements (McGuigan et al. 2006; Winkelman 2011). According to Winkelman (2011), an EUR of ≤ 1 indicates an athlete has adequate development of their SSC, strength of the lower body, and preparedness for competition, while an EUR of ≥ 1 is indicative of fatigue or a deconditioned state and lack of strength and preparedness. Therefore, the purpose of this study was to observe changes in EUR and jump height from the addition of a novel weight training stimulus in collegiate cross-country runners prior to and after a competitive training season.

METHODS: Nine NCAA DII cross-country (XC) runners with minimal weight training experience (women n=3; men n=6) were monitored for changes in jumping ability prior to and at the end of their 8-week competitive racing season. Athletes followed a running training program from their sport coach, and a strength program from the strength and conditioning specialist. For volume loads, see Figure 1. It should be noted that since athletes were inexperienced, their power phases did not contain plyometrics, but rather focused on increasing barbell velocity. Variables of interest from pre-and post-season were static jumps (SJ) and countermovement jumps (CM) both with unweighted (U) (0kg) and weighted (W) (20kg) conditions and were analyzed retrospectively using data from the sport science research repository. Jump data was converted into the Elastic Utilization Ratio (EUR) = (SJ/CM). Changes in mean difference of EUR from pre- to post-season as well as mean difference between SJ and CM for U and W jumps were analyzed using a paired samples t-test set at the alpha criterion level of 0.05 and descriptively through percent change. All athletes signed the informed consent document approved by the East Tennessee State University Institutional Review Board.

RESULTS: One athlete was excluded from the group data due to an extremely high improvement in jump height from pre-to post season. While this change indicates that the athlete was an extremely high-responder to the training, their data skewed the group means. Therefore, this athlete's data will be examined in a separate analysis. As a group, there was no significant difference at the 0.05 alpha level in EUR from PRE-to POST for U and W (p = 0.24 and 0.42, respectively). Mean differences (cm) for SJ and CM for both U and W conditions were all significant when comparing values from PRE-to POST season (p range = 0.01 – 0.03). Descriptive and statistical results can be seen in Tables 1 and 2.

DISCUSSION: These results indicate that EUR may not accurately capture initial increases in performance, in this case muscular stiffness, in collegiate distance runners who had minimal weight training experience. This is reflected not only in an increase in SJ and CM under weighted and unweighted conditions (3.63, 2.77, 2.71, and 1.97 cm for SJ (U), SJ (W), CM (U) and CM (W), respectively), but a paralleled improvement in all jumps, leading to a negligible net change in the EUR. It should be noted that these improvements in jump height may have some influence from a learning effect of the jump tests. However, since these runners did not perform plyometric training in conjunction with strength training, the observed results may also reflect the type of training performed (Markovich, 2007). Resistance training has been shown to improve both SJ and CM performances due to a general increase in lower body strength while plyometrics training has been shown to increase muscular stiffness and therefore the EUR ratio (Baker, 1996; Kubo et al., 2007). Since high-impact landing forces often seen with plyometric training increase risk of injury, Baker (1996) emphasized the establishment of general strength prior to undertaking a plyometrics program. Moreover, the development of general strength prior to the integration of technical components mirrors the philosophy of general to more specific training progression suggested by Deweese et al. (2015). Improvements in SSC ability from plyometric training can help bridge the gap between strength and speed - an important training concept as the primary goal of all runners is to run faster, and the shift from cross-country to indoor track places a greater emphasis on shorter duration, high speed events that are highly tactical. Since these distance runners have demonstrated improvements in general strength reflected by their improvements in jump performance, we recommend the addition of low-impact plyometric training to their subsequent training season as the running demand shifts from aerobic to more anaerobic, explosive, and tactical in nature with a greater reliance on the SSC.

Condition	Testing Session	Mean	N	SD	% Change
EUR Ratio (U)	PRE	0.87	8	0.04	-5.25
	POST	0.92	8	0.09	
EUR Ratio (W)	PRE	0.84	8	0.18	-7.36
	POST	0.90	8	0.05	
SJ Height (cm) (U)	PRE	19.31	8	5.47	18.80%
	POST	22.95	8	7.56	
SJ Height (cm) (W)	PRE	12.25	8	4.58	22.8
	POST	15.03	8	4.71	
CM Height (cm) (U)	PRE	22.26	8	6.42	12.2
	POST	24.98	8	7.21	
CM Height (cm) (W)	PRE	14.83	8	4.56	13.3
	POST	16.80	8	5.12	

Table 1.

EUR Index									
				95% CI					
	Condition	MEAN	SD	Lower	Upper	t	df	p	ES
EUR Ratio	U	0.05	0.10	0.13	0.04	1.29	7.00	0.24	0.45
	W	0.06	0.20	0.23	0.11	0.86	7.00	0.42	0.30
SJ									
				95% CI					
		MEAN	SD	Lower	Upper	t	df	p	ES
Change in JH (cm)	U	3.64	3.49	6.56	0.72	2.95	7.00	0.02	1.04
	W	2.78	2.27	4.67	0.88	3.46	7.00	0.01	1.22
CM									
				95% CI					
		MEAN	SD	Lower	Upper	t	df	p	ES
Change in JH (cm)	U	2.71	2.65	4.93	0.49	2.89	7.00	0.02	1.02
	W	1.98	2.13	3.76	0.19	2.62	7.00	0.03	0.93

Table 2.

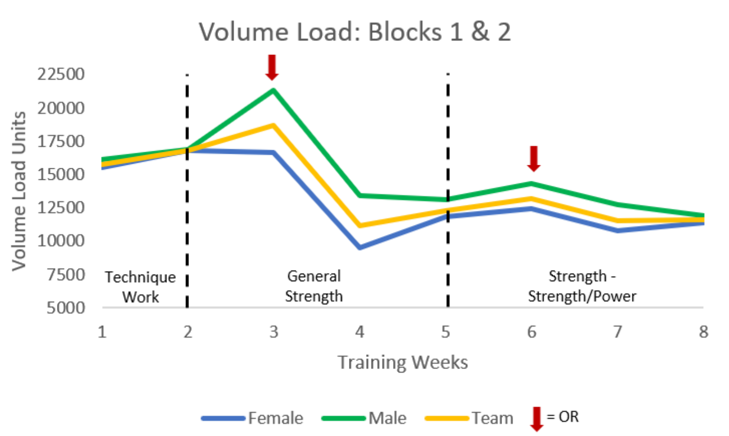

Figure 1.

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